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Propusnost ispuna korijenskog kanala kod različitih tehnika punjenja

Leakage of Different Canal Obturation Techniques

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Sažetak
Svrha rada bila je ispitati propusnost ispuna korijenskih kanala izrađenih tehnikom hladne lateralne kondenzacije, tehnikom tople lateralne kondenzacije (Touch'n Heat) i tehnikom Thermafil. Za pokus je rabljen uzorak od 70 jednokorijenskih trajnih zuba. Korijenski kanali svih zuba obrađeni su tehnikom "step-back". Slučajnim odabirom zubi su podijeljeni u tri skupine po 20 uzoraka i ispunjeni su gore navedenim tehnikama. Deset uzoraka bilo je u kontrolnoj skupini. Nakon petnaestodnevnog stvrdnjavanja u sterilnoj fiziološkoj otopini uzorci su izvađeni, osušeni, premazani izolacijskim lakom te stavljeni u kušalicu uz dodatak boje. Nakon sedam dana podvrgnuti su procesu bistrenja. Prozirnost zuba postignuta je demineralizacijom u dušičnoj kiselini, dehidracijom u etilnom alkoholu i uranjanjem zuba u metil-silicilat. Prodor boje očitan je stereomikroskopom. Rezultati su statistički obrađeni dvosmjernom analizom varijance s "post hoc" LSD testovima. Temeljem dobivenih rezultata statistički znatno manji prodor boje izmjeren je kod uzoraka punjenih tehnikom Touch'n Heat (0,63 mm ±0,35) i Thermafilom (0,71 mm ±0,57) u usporedbi s tehnikom hladne lateralne kondenzacije (1,31 mm ±0,75).

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Ključne riječi
Tehnika hladne lateralne kondenzacije, Touch'n Heat, Thermafil, propusnost, prodor boje.

Uvod

Svrha punjenja instrumentiranog korijenskog kanala jest spriječiti propuštanje iz usne šupljine ili periradikularnog područja u endodontski prostor i onemogućiti djelovanje iritansa iz korijenskog kanala koji se ne mogu ukloniti biomehaničkom obradom. Mikroorganizmi i njihovi toksini najvažniji su čimbenici koji dovode do bolesti zubne pulpe, a kasnije i produkti razgradnje pulpnog tkiva pridonose iritaciji periapikalnog područja.

Do danas su razvijene mnogobrojne tehnike punjenja.

Lateralna kondenzacija se najčešće rabi za punjenje korijenskih kanala. Njezine prednosti su raz-

Introduction

The purpose of root canal obturation is to prevent leakage from the oral cavity or periradicular space into endodontic space as well as the prevention of irritants that could not be removed form the root canal by biomechanical methods to affect surrounding tissues. Microorganisms and their toxins are the key factors in the development of pulp disease; the products of pulp tissue decomposition also contribute to the periapical tissue irritation. It is therefore necessary to perform correctly all the prior work-phases which enable proper three-dimensional root canal filling. A number of filling techniques was developed in the attempt to secure the best possible obturation of the endodontic space.

mjerno jednostavna izvedba i kontrolirano unošenje materijala. Nedostatak je, pak, to što oduzima relativno puno vremena, a također je dokazano da punjenje nije tako homogeno kao što izgleda na radiogramu (1). Iako je tehnika hladne lateralne kondenzacije jednostavna i učinkovita, razvile su se tehnike koje pri zagrijavanju omekšavaju gutaperku i tako nastoje postići bolje prilijeganje uz stijenku korijenskog kanala.

Tehnika Thermafil danas se često primjenjuje u kliničkoj praksi zbog jednostavnosti i brzine. Najveći nedostatak te tehnike u usporedbi s tehnikom hladne lateralne kondenzacije jest prepunjenost korijenskog kanala (2, 3). Thermafil je zbog termoplastičnosti gutaperke teško kontrolirati u području apeksa, ako je prohodan. Gutman i suradnici (4) te Clark i ElDeeb (2) pokazali su znatno veću incidenciju prepunjenosti tehnikom Thermafil u usporedbi s hladnom lateralnom kondenzacijom. No, Dummer i suradnici (5) nisu našli znatnu razliku u prepunjenosti kod zavijenih korijenskih kanala. Promatranjem ispuna pod mikroskopom uočeni su ispunjeni lateralni i akcesorni kanalići, ali je vidljivo odvajanje gutaperke od plastične jezgre obturatora (4).

Tehnika tople lateralne kondenzacije uvedena je u uporabu kako bi se objedinile prednosti tehnike hladne lateralne i vruće vertikalne kondenzacije te izbjegli nedostatci obiju tehnika punjenja. Električno grijani potiskivač koji se rabi tijekom punjenja s toplom lateralnom kondenzacijom, omogućuje homogeniju masu gutaperke. Zagrijana gutaperka se također bolje adaptira na stijenke korijenskog kanala. Vrijeme punjenja tehnikom tople lateralne kondenzacije skraćeno je u usporedbi s vrućom vertikalnom kondenzacijom, a i nekontrolirani izvor topline je zamijenjen električno grijanim potiskivačem. Silver i suradnici (6) su ispitivanjem Touch'n Heata i System B tehnike utvrdili da nema prepunjenosti korijenskih kanala ispod apikalnog suženja.

Svrha ovog rada bila je ispitati propusnost kanalnog ispuna prodorom boje kod uzoraka ispunjenih tehnikom hladne lateralne kondenzacije te tehnikom Thermafil i Touch'n Heat.

Materijali i postupci

Ispitivanje je provedeno na 70 jednokorijenskih trajnih zuba. Rabljeni su srednji sjekutići gornje čeljusti i očnjaci obiju čeljusti. Zubi su dobiveni od Zavoda za oralnu kirurgiju Stomatološkog fakulteta Sveučilišta u Zagrebu i Doma zdravlja Sinj. Spol, dob i razlozi vađenja zuba nisu poznati. Prije obrade zubi su se čuvali u 10% formalinu. Nakon meha-

Lateral condensation is the most frequent root canal filling technique. Its advantages include simple execution, conservative canal preparation and controlled filling. The main disadvantages are high time consumption and impossibility to visualize non-homogeneities radiographically (1). Although cold lateral condensation is simple and effective, in other techniques gutta-percha is softened with heat, to improve better fitting to the root canal wall.

Thermafil technique is widely used in clinical practice, due to its simplicity and speed. The main disadvantage, compared to cold lateral condensation, is over-filling of the root canal (2,3). Due to gutta-percha thermoplasticity, it is difficult to control the filling of the apical part of canal. Gutman et al. (4) and Clark and ElDeeb (2) have shown that there is a significantly higher incidence of over-filling when using Thermafil, compared to cold lateral condensation technique. Still, Dummer et al. (5) have found no significant differences in overfilling bent root canals. Microscopic analysis has shown filled lateral and accessory canals, but also separation of gutta-percha from plastic obturator core (4).

Warm lateral condensation was introduced hoping for the advantages of both cold lateral and hot vertical condensation and to avoid disadvantages of both techniques. Electrically heated spreader used for warm lateral condensation enables more homogeneous gutta-percha mass. Heated gutta-percha adapts better to root canal walls. The filling time using warm lateral condensation is shorter when compared to hot vertical condensation, and the uncontrolled heat-source is replaced with electrically warmed spreader. Silver et al. (6) have tested Touch'n Heat and System B techniques and found no root canal fillings to exceed apical constriction.

The purpose of this study was to test root canal obturation using dye penetration technique in canals filled using cold lateral condensation, Thermafil and Touch'n Heat techniques.

Materials and methods

The study sample consisted of 70 single-rooted permanent teeth (middle incisives of upper jaw and canines of both jaws.) The teeth were obtained from Department of Oral Surgery, School of Dental Medicine, University of Zagreb and from Health Centre Sinj. Age and sex of patients and the reasons for tooth-extraction were not recorded. Prior to procedure, the teeth were kept in 10% formalin. After mechanical cleaning, the samples were sterilized in au-

ničkog čišćenja sterilizirani su u autoklavu (KaVo Dental, Warthausen, Njemačka) na temperaturi od 120°C i tlaku od 300 kPa te pohranjeni u sterilizatoru u sterilnoj fiziološkoj otopini s dodatkom kristalića timola (Sigma Ltd, Poole, Engleska) na 37°C.

Kruna zuba odrezana je na caklinsko cementnom spojištu fisurnim dijamantnim brusilom, uz stalno vodeno hlađenje. Dužina korijenskog kanala utvrđena je umetanjem proširivača Kerr #15 (ISO #15) (Maillefer, Ballaigues, Švicarska). Kada je vrh instrumenta prošao kroz apikalni otvor, proširivač je uvučen za 1 mm. Dobivena dužina predstavljala je dubinu instrumentacije. Svi kanali obrađeni su u apikalnom dijelu do Kerr proširivača #40 (ISO #40) i tehnikom "step-back" do proširivača Kerr #80 (ISO #80), uz ispiranje 2,5%-tnom vodenom otopinom natrij-hipoklorita (NaOCl) u količini od 5 ml po kanalu. Između svakog instrumenta provedena je rekapitulacija tj. ispiranje otopinom NaOCl, i provjera prohodnosti korijenskog kanala proširivačem Kerr #40. Nakon toga stijenke korijenskog kanala obrađene su korijenskim pilicama (Hedströem file) #40. Ulaz korijenskog kanala proširen je svrdlima Gates Glidden (Maillefer, Ballaigues, Švicarska) br. 3 i 4. Zaostatni sloj stvoren na stijenkama korijenskog kanala (engl. smear layer) uklonjen je etilendiamin-tetraoctenom kiselinom (EDTA), tijekom dvije minute. Zatim su svi uzorci isprani s 2,5% NaOCl te osušeni mlazom zraka i papirnatim štapićima (Johnson & Johnson, Slough, Engleska). Slučajnim odabirom zubi su podijeljeni u tri skupine po dvadeset uzoraka. Deset uzoraka bilo je u kontrolnoj skupini.

Skupina A je punjena tehnikom hladne lateralne kondenzacije

Skupina B je punjena tehnikom tople lateralne kondenzacije (Touch'n Heat)

Skupina C je punjena tehnikom Thermafil.

Skupina A – gutaperkin štapić, koji je odgovarao promjeru zadnjega proširivača Kerr, umočen je u punilo Diaket (ESPE, Seefeld, Njemačka). Pokretima štapića apikalno-koronarno punilo je ravnomjerno raspoređeno po kanalu i istisnut je zračni mjehurić. Zatim je umetnut gutaperkin štapić do prije određene dubine. Nakon toga je u kanal uveden ručni potiskivač #25 (Anataeos, Minhen, Njemačka). Glavna gutaperka potisnuta je apikalno i u stranu, a u mjesto nastalo nakon izvlačenja potiskivača umetnut je dodatni štapić #25. Tehnika se ponavljala sve dok potiskivač nije mogao ući u koronarni dio kanala dublje od dva milimetra. Višak gutaperke je uklonjen ručnim instrumentom koji je prije toga zagrijan

toclave (KaVo Dental, Warthausen, Germany) using temperature of 120°C and pressure of 300 kPa and stored in sterile physiological solution with thymol crystals (Sigma Ltd, Poole, UK) on 37°C controlled by a thermostat.

The tooth crowns were removed on the enamel–cement junction, using fissure diamond drill with permanent water-cooling. The length of root canal was established using Kerr file #15 (ISO #15) (Maillefer, Ballaigues, Switzerland). When the tip of the instrument passed through apical opening the instrument was withdrawn for 1mm and the length obtained was used as instrumentation length. All canals were instrumented to the Kerr file #40 (ISO #40) in the apical part and using step-back technique to the Kerr file #80 (ISO #80), rinsing each canal with 5ml of 2.5% water solution of sodium hypochlorite (NaOCl). Between every two instrumentations, recapitulation was conducted i.e. the canal was rinsed with NaOCl solution and accessibility was assessed using Kerr file #40. Root canal walls were then instrumented using Hedstroem file #40. The canal entrance was widened using Gates Glidden drills (Maillefer, Ballaigues, Switzerland) No. 3 and 4. Smear layer was removed using EDTA, during two minutes. All samples were then rinsed with 2.5% NaOCl, dried with air-stream and paper points (Johnson & Johnson, Slough, England). The teeth were then randomly allocated to three groups of 20 teeth. Ten samples were used as control.

Group A was obturated using cold lateral condensation

Group B was obturated using warm lateral condensation (Touch'n Heat)

Group C was obturated using Thermafil technique

Group A – gutta-percha point of the size according to that of the last Kerr file was dipped in Diaket sealer (ESPE, Seefeld, Germany). The point was moved in the canal to evenly spread the sealer in the canal and the air bubble was expelled. The gutta-percha cone was set at the working length. The hand-spreader #25 (Anataeos, Munich, Germany) was introduced into the canal and the main gutta-percha point was moved apically and sideways, and the space left vacant was filled with additional #25 point. The technique was repeated untill the spreader could not enter more then 2 mm into the coronar part of root the canal. The excess gutta-percha was removed by hand instrument, warmed by flame. A cold flat plugger additionally condensed the filling.

plamenom. Punjenje je dodatno kondenzirano hladnim ravnim nabijačem.

Skupina B je punjena toplom lateralnom kondenzacijom uz uporabu gutaperkina štapića i punila Diaket. Razmekšavanje gutaperke postignuto je uređajem Touch'n Heat, model 5004 (Kerr, Analytic Tehnology, Redmond, USA) prema uputama proizvođača. Postupak kondenziranja gutaperke ponavljao se dok nije bila ispunjena koronarna trećina korijenskog kanala.

Skupina C je punjena obturatorom Thermafil koji je izabran 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 stavljen u korijenski kanal do pune radne dužine. Višak je uklonjen ručnim instrumentom zagrijanim na plamenu.

Kontrolna skupina sadržavala je 10 zuba - 5 je služilo kao pozitivna, a 5 kao negativna kontrola. Uzorci pozitivne kontrole punjeni su štapićima gutaperke bez uporabe punila, a uzorci negativne kontrole punjeni su kao skupina A kod koje je cijela površina zuba, uključujući i apeks, premazana izolacijskim lakom. Svaki je zub stavljen u kušalicu uz dodatak boje (Drawing ink blu – Rotring, GmbH, Hamburg, Njemačka) i tamo je ostao sedam dana. Uzorci su zatim isprani mlazom tekuće vode, a lak je uklonjen skalpelom. Zatim je obavljen postupak "bistrenja" demineralizacijom zuba u 5% dušičnoj kiselini 24 sata, dehidracijom u 80% etilnom alkoholu 24 sata, u 90% etilnom alkoholu tri puta po 1 sat, i u 100% etilnom alkoholu 1 sat. Na kraju su uzorci uronjeni u metil-salicilat. Stereomikroskopom (Zeiss/SV6, Njemačka) očitan je kvantitativni prodor boje i kalibriciranom ljestvicom na okularu su dobiveni su podaci u milimetrima.

Rezultati su statistički obrađeni dvosmjernom analizom varijance s *"post hoc"* LSD testovima. Uzorci koji su pokazali odstupanja veća od krajnje očekivanih vrijednosti, nisu uvršteni u statističku obradu (11 uzoraka).

Rezultati

U Tablici 1. predstavljeni su rezultati prodora boje između punila i stijenke korijenskog kanala prema ispitivanim skupinama. Raspon prodora boje kod svih uzoraka bio je između 0,05 mm i 5,52 mm, a aritmetičke sredine od 1,09 mm do 1,94 mm. Kod svih uzoraka pozitivne kontrole, boja je prodrla cijelom

Group B – was filled using warm lateral condensation using guttapercha cons and Diaket filling material. Heating of gutta-percha was performed with Touch'n Heat device, model 5004 (Kerr, Analytic Tehnology, Redmond, USA), in accordance to the manufacturer's instructions. The procedure was repeated untill the coronar third of the root canal was filled.

Group C was filled with Thermafil obturator, chosen according to the size of the last instrument used in root canal instrumentation and then checked with the verifier. The obturator size was #40. Small amount of filler was introduced using verifier in circular anti-clockwise motion. Thermafil obturator was placed in special heater (Dentsply Tulsa Dental, Tulsa, Oklahoma, USA) (picture 2) and 10 seconds afterwards it was put in the root canal to the working length. The excess was removed with hand instrument previously heated on the flame.

There were 10 teeth used as control group: 5 as a positive and 5 as a negative one. The positive control samples were filled with gutta-percha points without sealer, and negative control samples were filled like A group but the entire surface of the tooth, including its apical part, was covered with insulation varnish.

Every tooth was placed into the taster with the dye addition (Drawing ink blu – Rotring, GmbH, Hamburg, Germany) for seven days. Samples were washed away with running water and the polish was removed with scalpel. Then "clearing" procedure has been performed with the tooth demineralization in 5% nitric acid for 24 hours, dehydration in 80% ethyl alcohol, in 90% ethyl alcohol 3 times for 1 hour and in 100% ethyl alcohol for 1 hour. Finally, samples were dipped in metyl-salicylate. Dye penetration was registered with stereomicroscope (Zeiss/SV 6, Germany) and the data was read with calibrated ocular scale in millimeters.

Results were statistically processed with the two-way analysis of variance with 'post hoc' LSD tests. Samples with high deviation from expected values haven't been considered in the statistical evaluation.

Results

Table 1 shows the results of dye penetration between filling and root canal wall per group tested. Dye penetration range in all samples was between 0.05 mm and 5.52 mm and the arithmetical middle from 1.9 mm to 1.94 mm. In all the positive control samples dye penetrated through the whole length of

dužinom korijenskog kanala, a kod uzoraka negativne kontrole zaštitni lak je spriječio njezin prodor.

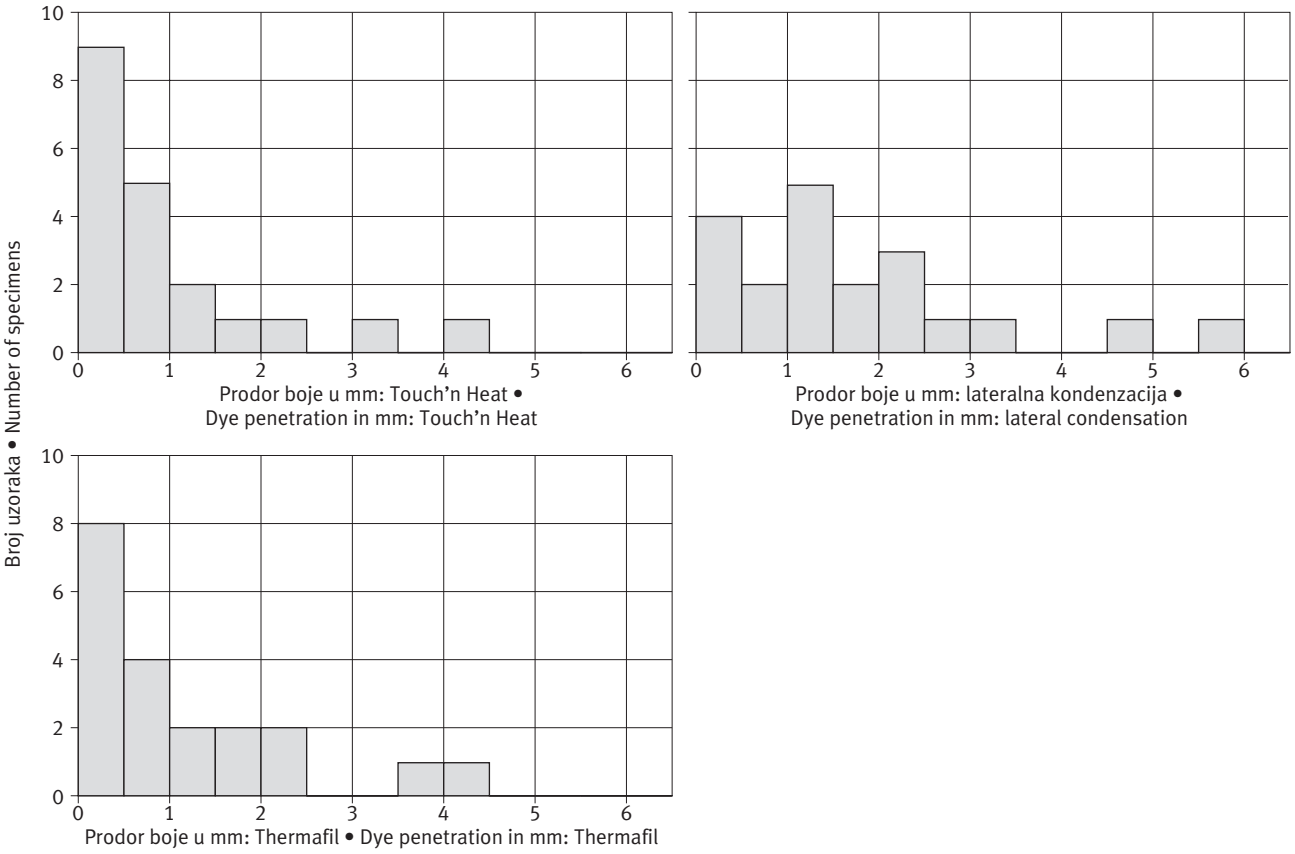
Na Slici 1 vidi se, za tehnike Touch'n Heat i Thermafil, da je najviše uzoraka imao izrazito mali prodor boje (do 0,5 mm), dok je kod tehnike hladne lateralne kondenzacije najveći broj uzoraka propustio boju između 1 mm i 1,5 mm.

the root canal and in the negative control samples protective polish prevented the dye penetration.

The most of the samples treated with Touch'n Heat and Thermafil thickness had very small dye penetration (to 0.5 mm) (Picture 1), while for the cold lateral condensation ethnic dye penetrated between 1 mm and 1.5 mm.

Tablica 1. Rezultati prodora boje kod ispitivanih tehnika punjenja
Table 1. Dye penetration in tested filling techniques

Tehnike punjenja • Filling technique	Broj uzoraka • Number of specimens	Aritmetička sredina • Mean (u mm • in mm)	Standardna devijacija • Standard deviation
Lateralna kondenzacija • Lateral condensation	16	1,31	0,75
Thermafil tehnika • Thermafil	17	0,71	0,57
Touch'n Heat	16	0,63	0,35



Slika 1. Distribucija propusnosti ispuna tehnikom prodora boje - broj uzoraka prema ispitivanim skupinama s obzirom na veličinu prodora boje
Figure1. Leakage distribution - number of specimens in each group regarding dye penetration depth

Rasprava

Uspješnost tehnika punjenja korijenskih kanala može se ispitati *in vitro* različitim postupcima, a najčešći je tehnika prodora boje.

Najveća propusnost punjenja dobivena je tehnikom hladne lateralne kondenzacije. U literaturi su navedeni rezultati prodora boje u korijenski kanal kod uporabe hladne lateralne kondenzacije u rasponu od 0 do 10 mm (7-9). U ovom radu kod tehnike

Discussion

Success level of root canal filling techniques can be tested *in vitro* with various procedures, dye penetration technique being the most common.

The highest degree of dye penetration was registered in cold lateral condensation. In literature, dye penetration into root canal in cold lateral condensation has been stated within range between 0 and 10 mm (7, 8, 9). In this examination of cold lateral

hladne lateralne kondenzacije zabilježen je prodor boje od 1,79, što je više nego u rezultatima Lucyja i suradnika. (7) - u njihovu ispitivanju zabilježen je prodor boje od 0,45 mm. Razlika u rezultatima može se objasniti uporabom različitih boja za procjenu zabrtvljenosti apeksnog otvora. U ovom radu je rabljeno metilensko modrilo, a Lucy i suradnici (7) koristili su se Indija-bojom. Simons i suradnici (8) navode da, ako boja prodre prvih 0,5 mm u korijenski kanal, kroz ostalo punjenje je njezin prodor nesmetan. To znači da je prodor boje moguće spriječiti samo potpunim brtvljenjem samog apeksa, neovisno o brtvljenju punila u ostalom dijelu korijenskog kanala. Beatty i suradnici (10) pokazali su da je Thermafil učinkovitiji nego tehnika hladne lateralne kondenzacije ili tehnika jednog štapića gutaperke. Suprotno tome Lares i El Deeb (11) te Haddix i suradnici (12) dobili su znatno manje propuštanje s lateralnom kondenzacijom negoli Thermafilom. Razlika u rezultatima može se objasniti vještinom terapeuta tijekom punjenja različitim tehnikama, razlikama u očitanju rezultata te različitim vrstama punila i boje rabljene tijekom ispitivanja. Scott i suradnici (13) ispitivali su apikalno brtvljenje tehnike hladne lateralne kondenzacije i tehnike Thermafil uz uporabu Sealapexa. Nisu ustanovili statistički znatnu razliku u prodoru boje kod ispitivanih tehnika punjenja. Zabilježeni prodor boje kod Thermafila bio je 0,24 mm do 1,32 mm, a kod lateralne kondenzacije od 0,47 mm do 1,18 mm. Suprotno tome, u ovom radu koristio se kod svih triju tehnika punjenja Diaket, kao punilo iz skupine materijala temeljenih na umjetnim smolama, ali je Thermafil pokazao najmanji prodor boje od prosječno 1,19 mm, a lateralna kondenzacija od 1,79 mm. Zato se može zaključiti da, osim primijenjene tehnike, na propuštanje utječe i rabljeno punilo.

Kod tehnike tople lateralne kondenzacije (Touch'n Heat) utvrđena je najmanja propusnost. Ti rezultati slažu se s rezultatima Kerstena i suradnika (14) koji su ispitivali koronarno propuštanje i ustanovili najmanju propusnost u uzorcima punjenima toplom lateralnom kondenzacijom u usporedbi s tehnikom hladne lateralne kondenzacije, termomehaničke kompakcije i injekcijskih tehnika.

condensation technique was recorded dye penetration to 1,79 mm, which is higher than in the results of Luccy and al (7). They have recorded dye penetration to 0,45 mm. The difference in the results can be explained by the use of different dyes for the testing of apex opening. In this examination methylene blue was used while Lucy and al (7) used India color. Simons and al. (8) state that if the dye penetrates in the first 0.5 mm of the root canal, dye penetration in the rest of the filling is unopposed. That means that the dye penetration can be prevented only with total closing of apex independently of the closing of filling in the rest of the root canal. Beatty and al. (10) have shown that Thermafil is more efficient than the cold lateral condensation technique or the technique of one gutta-percha point. However, Lares & El Deeb (11) and Haddix and al. (12) had much less penetration with lateral condensation than with Thermafil. Different results can be attributed to the therapeut's skills, different readings, different kind of fillings and colors used. Scott and al. (13) have tested apical closing technique with cold lateral condensation and Thermafil technique with the use of Sealapex. They haven't discovered significant difference of dye penetration. Dye penetration with Thermafil was 0,24 to 1.32 mm, and with lateral condensation 0.47 to1.18 mm.

In this examination, Diaket as a filling material from the group of artificial resin based materials, was used with all the techniques, but the Thermafil showed the lowest colour penetration averaging to 1,19 mm and lateral condensation 1,79 mm. This indicates that the used filling influences the dye penetration too, besides the applied technique.

With the warm lateral condensation technique (Touch'n Heat) the lowest dye penetration has been recorded. These results are similar with those of Kersten and al. (14) who tested coronary penetration and established the lowest penetration in samples filled with the warm lateral condensation compared to the cold lateral condensation, thermomechanical condensation and injection techniques.

Abstract
The aim of this study was to assess leakage of root canals obturated using different techniques: cold lateral condensation, warm lateral condensation (Touch'n Heat) and Thermafil. The experimental sample had 70 single rooted permanent teeth. Root canals were instrumented using step-back technique. The teeth were randomly assigned to three groups of 20 samples and obturated using experimental techniques. Ten samples were used as control samples. After a fifteen-day setting period in sterile saline, the samples were taken out, dried, covered by insulating varnish and placed in test-tube with dye. After seven days, the samples were subjected to demineralisation in nitrogen acid, dehidration in ethanol and submerged in methyl-silicilate, thus rendering them transparent. Dye penetration was then read using stereomicroscope. The results were processed by two-way analysis of variance with LSD post hoc test. The results indicate significantly lower dye-penetration in samples obturated using Touch'n Heat technique (0.63±0.35mm) and Thermafil (0.71±0.57mm), when compared to the sample obturated using cold lateral condensation (1.31 ±0.75mm).

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Key words
Cold lateral condensation technique, Touch'n Heat, Thermafil, leakage, dye-penetration.

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