ACTA
STOMATOLOGICA
CROATICA
www.ascro.net

Acta Stomatol Croat. 2006; 40: 3-11.

IZVORNI ZNANSTVENI RAD
ORIGINAL SCIENTIFIC PAPER

Lumnije Kqiku[1], Andreas Weiglein[2], Peter Städtler[1]

Usporedno istraživanje pet različitih tehnika punjenja korijenskih kanala

A Comparative Study of Five Different Obturation Techniques

[1] Zavod za opću stomatologiju, Sveučilišna stomatološka klinika, Graz, Austria
Department of Operative Dentistry, University Dental Clinic, Graz, Austria
[2] Institut za anatomiju, Medicinsko sveučilište, Graz, Austria
Institute of Anatomy, Medical University, Graz, Austria

Sažetak
Svrha istraživanja bila je procijeniti prikladnost i kvalitetu ispuna korijenskog kanala postignutih lateralnom kondenzacijom, vertikalnom kondenzacijom te tehnikama Thermafil, Ultrafil i Obtura II. Sedamdeset i pet ravnih i zavinutih korijenskih kanala ekstrahiranih ljudskih zuba instrumentirano je tehnikama "crown-down" / "step-back", uz uporabu 3%-tnog natrij-hipoklorita. Apikalna prohodnost provjerena je K-pilicom veličine 15, a napravljeno je pet skupina po 15 korijenskih kanala te su tretirani različitim tehnikama punjenja. Roekoseal Auotmix rabljen je kao sredstvo punjenja u svim slučajevima. Zubi su rendgenski snimljeni radi procjene opće adaptacije materijala i prepunjenosti. Nije bilo znatnih razlika u sveukupnom punjenju korijenskih kanala, ni u rendgenskoj gustoći ni u adaptaciji uz zidove kanala. Sve termoplastične tehnike punjenja korijenskih kanala pokazale su prihvatljivo punjenje te su dobro brtvile bez statistički znatnih razlika u odnosu prema lateralnoj kondenzaciji. Ispuni korijenskih kanala bili su rendgenski gusti i dobro adaptirani u cijeloj duljini korijenskog kanala.

Zaprimljen: 2. veljače 2006.
Prihvaćen: 25. veljače 2006.

Adresa za dopisivanje
Peter Städtler
Klinički zavod za opću stomatologiju
Auenbruggerplatz 6a
A-8036 Graz
Tel.: ++43-316-385-2213
Fax: ++43-316-385-3375
peter.staedtler@meduni-graz.at

Ključne riječi
Ispun korijenskog kanala, tehnike punjenja, termoplastična gutaperka, rendgenska procjena.

Uvod

Nakon prikladne instrumentacije i dezinfekcije, korijenski je kanal potrebno ispuniti materijalom za ispun kako bi se spriječio ulazak novih bakterija.

Za to se koriste različiti materijali i metode. Štapići gutaperke izrađeni od viskozne, rigidne β-gutaperke rabe se u lateralnoj kondenzaciji. Toplu vertikalnu kondenzaciju gutaperke uveo je Schilder godine 1967. (1).

Razvijeno je mnogo metoda s termoplastičnom gutaperkom, uključujući injekcijsku metodu te onu presvučenog nosača (2, 3). Opturatori Thermafil (Dentsply/Maillefer, Ballaigues, Švicarska) sastoje se od plastičnih nosača presvučenih α-faznom gu-

Introduction

After a suitable instrumental preparation and disinfection, root canals must be obturated with root canal filling material to inhibit the introduction of new bacteria.

Different materials and methods are available for root canal obturation. Gutta-percha points made of viscous, rigid β-gutta-percha are used with cold lateral condensation. The warm vertical condensation of gutta-percha was introduced by Schilder in 1967 (1).

A number of thermoplasticized gutta-percha methods have been developed, including the injection system and the coated carrier system (2, 3).

taperkom, a pripremaju se za uporabu u prijenosnoj pećnici (Thermaprep Plus). Multifazna tehnika opturacije gutaperkom rabi i α-faznu i β-faznu gutaperku (4). Modifikacija te tehnike naziva se Micro-Seal tehnika opturacije.

Iako je hladna lateralna kondenzacijska tehnika jedna od najprihvaćenijih tehnika punjenja kanala, gutaperka se ne adaptira dobro na stijenke kanala, posebice kod nepravilnih. (5). Injicirana termoplastična gutaperka može se učinkovitije adaptirati na nepravilnosti u kanalu, reproducirajući korijenski sustav kanala (6).

Nekoliko istraživanja procjenjivalo je kvalitetu termoplastične gutaperke u usporedbi s hladnom lateralnom kondenzacijom, a zaključci su različiti.

Na rendgenskim snimkama tehnika opturacije Thermatil u pravilu pokazuje bolju adaptaciju nego lateralna kondenzacija, no u apikalnoj trećini korijena rezultati obiju tehnika bili su slični (7).

Scanning - elektronska mikroskopska promatranja tehnika Ultrafil i Thermafil te tehnike lateralne kondenzacije - pokazao je bolju adaptaciju na dentinske zidove u korijenima ispunjenima termoplastičnom gutaperkom, nego kod tehnike lateralne kondenzacije - bez obzira na to ima li ili ne zaostatnog sloja (8). Svrha ovog *in vitro* istraživanja bila je procijeniti kvalitetu adaptacije ispuna korijenskog kanala napravljenog sljedećim tehnikama: Thermafil, Ultrafil, Obtura II, topla vertikalna kondenzacija te hladna lateralna kondenzacija.

Materijal i metode

Za ispitivanje je odabrano sedamdeset i pet ravnih i zakrivljenih kanala ekstrahiranih trajnih ljudskih zuba sa zrelim apeksima. Nakon ekstrakcije fiksirani su u 10%-tnom formalinu. Očišćeni su od mekog tkiva i kamenca te ostavljeni dva tjedna u 3%-tnom natrij-hipokloritu.

Turbinskim fisurnim svrdlom, uz vodeno hlađenje, izrađen je standardni lingvalni ili okluzalni kavitet. Pulpno tkivo uklonjeno je ekstirpatorom. Radna duljina određena je vizualno i rendgenski postavljanjem pilice veličine 15 do apeksa te oduzimanjem 1 milimetra od te mjere.

Ravni kanali obrađeni su instrumentima Flexicut (VDW GmbH, München, Njemačka) i tehnikom "step-back", a zakrivljeni kanali molara obrađeni su instrumentima Profile (Dentsply-Maillefer, Ballaigues, Švicarska) metodom dvostrukoga postupnog proširenja. Koronalna polovica korijenskog kanala instrumentirana je svrdlima Gates Glidden veličine od 1 do 4 (VDW GmbH, München, Njemačka).

Thermafil obturators (Dentsply/Maillefer, Ballaigues, Switzerland) consist of plastic carriers coated with α-phase gutta-percha which are prepared for use with a portable oven (Thermaprep Plus). The multiphase gutta-percha obturation technique uses both α-phase gutta-percha and β-phase gutta-percha to obturate the root canal (4). This technique has been modified as the MicroSeal endodontic obturation technique.

Although cold lateral condensation is one of the most accepted canal obturation techniques, the gutta-percha does not adapt to the canal walls, especially in irregular canals (5). Injected thermoplasticized gutta-percha can adapt more effectively to irregularities in the canal, thus replicating the root canal system (6).

The quality of root fillings of the thermoplasticized gutta-percha in comparison to cold lateral condensation has been evaluated in several studies, with differing conclusions.

On radiographs, the Thermafil obturation technique generally showed better adaptation than lateral condensation, but in the apical third the results for both methods were similar (7).

Scanning electron microscopic observations for Ultrafil, Thermafil and lateral condensation showed better dentinal wall adaptation in roots obturated with thermoplasticized gutta-percha than in laterally condensed root canal fillings, regardless of the presence or absence of a smear layer (8). The aim of this *in vitro* study was to evaluate the quality and adaptation of root canal filling of the Thermafil, Ultrafil, Obtura II, warm vertical condensation and cold lateral condensation techniques.

Materials and methods

Seventy-five straight and curved root canals of extracted human permanent teeth with mature apices were selected. After extraction, all teeth were fixed in 10% formalin. They were cleaned of extraneous tissue and calculus, then stored in 3% sodium hypochlorite for 2 weeks.

Standard lingual or occlusal access cavities were prepared with a high-speed fissure bur and water. Pulp tissue was removed with a barbed broach. The working length was determined visually and radiographically by placing a size 15 file to the apex, then subtracting 1 mm from this measurement.

Straight root canals were prepared with Flexicut files (VDW GmbH, Munich, Germany) using the step-back method while curved root canals of molars were prepared with Profile (Dentsply-Maille-

Svaki put kada se mijenjao instrument, kanal se ispirao 3%-tnom otopinom natrij-hipoklorita pomoću igle br. 27 (BD Microlance 3; BD, Drogheda, Irska). Zaostatni sloj uklonjen je Tubulicidom (Dental therapeutics AB, Saltsjö-Boo, Švedska) tijekom 60 sekundi. Konačna irigacija korijenskih kanala provedena je s 5 ml 3%-tnog natrij-hipoklorita. Svi kanali osušeni su papirnatim štapićima.

Ispun korijenskog kanala

Instrumentirani kanali podijeljeni su u pet ispitnih skupina (n = 15) te su se punili lateralnom kondenzacijom, toplom vertikalnom kondenzacijom, tehnikama Thermafil (Dentsply/Maillefer, Ballaigues, Švicarska), i Ultrafil (Hygienic, Ohio, SAD) te Obtura II (Obtura Spartan, Ontario, Kanada). Kao materijal za brtvljenje uvijek se koristio Roekoseal Automix (Coltène/Roeko, Langenau, Njemačka).

Hladna lateralna kondenzacija

Gutaperka "Master" bila je umočena u materijal za brtvljenje, postavljena u punoj radnoj duljini te lateralno kondenzirana "spreaderom". Dodatni štapići gutaperke također su umočeni u isti materijal za brtvljenje te su postavljani u kanal sve dok nije bio potpuno ispunjen štapićima gutaperke. Suvišak je uklonjen iz kaviteta aparatom Gutta Cut (Dentsply/Maillefer, Ballaigues, Švicarska) te je ispun vertikalno kondenziran "pluggerom" (Hu-Friedy, Berhard Quentin GmbH, Leimen, Njemačka).

Topla vertikalna kondenzacija gutaperke

Kanal je osušen papirnatim štapićima, zatim je u njega materijal za brtvljenje postavljen rotirajućim sredstvom za punjenje. Gutaperka "Master" umočena je u materijal za brtvljenje i nježno potisnuta u radnoj duljini u kanal.

Koronalni dio gutaperke "master" prerezan je aparatom Gutta Cut (Dentsply/Maillefer, Ballaigues, Švicarska) te je kondenziran u apikalnom smjeru "pluggerom" (Hu-Friedy, Berhard Quentin GmbH, Leimen, Njemačka). Nakon što je gutaperka došla na 5 milimetara do apeksa, njezini dijelovi u duljini od 3 do 4 milimetra postavljani su u kanal sve dok nije bio napunjen do koronalnog ulaza.

Tehnika Thermafil

Gutaperka na opturatoru Thermafil omekšana je u električnom aparatu Thermaprep Plus oven (Dentsply/Maillefer, Ballaigues, Švicarska), prema uputama proizvođača. Ispravna veličina plastičnog štapića odabrana je instrumentom za provjeravanje veličine. Mala količina endodontskog materijala za brtvljenje (Roekoseal, Coltène/Roeko, Langenau, fer, Ballaigues, Switzerland) using the double-flare-method. The coronal half of the root canals was prepared with sizes 1-2-3-4 Gates Glidden drills (VDW GmbH, Munich, Germany).

Each time the instrument was changed, the canal was irrigated with a 3% solution of sodium hypochlorite, using a No. 27-guage needle (BD Microlane 3; BD, Drogheda, Ireland). The smear layer was removed with Tubulicid (Dental therapeutics-AB, Saltsjö-Boo, Sweden) for 60 sec. There was a final irrigation of the root canals with 5 ml of 3% sodium hypochlorite. All root canals were dried with paper points.

Obturation

The prepared canals were divided into five experimental groups (n = 15) and filled using lateral condensation, warm vertical condensation, Thermafil (Dentsply/Maillefer, Ballaigues, Switzerland), Ultrafil (Hygienic, Ohio, USA) and Obtura II (Obtura Spartan, Ontario, Canada). Roekoseal Automix (Coltène/Roeko, Langenau, Germany) was always used as sealer.

Cold lateral condensation

A master gutta-percha cone was coated with the sealer, gently seated to the full working length and laterally condensed with a finger spreader. Accessory gutta-percha cones coated with the same sealer were inserted until the canal was completely filled. Excess gutta-percha was removed from the coronal cavity with Gutta Cut (Dentsply/Maillefer, Ballaigues, Switzerland) and the filling vertically condensed with a hand plugger (Hu-Friedy, Berhard Quentin GmbH, Leimen, Germany).

Warm vertical condensation of gutta-percha

The canal was dried with paper points, then sealer was inserted into the canal with a rotary paste filler. The master cone was coated with sealer and gently seated in the working length.

The coronal portion of the master cone was cut with Gutta Cut (Dentsply/Maillefer, Ballaigues, Switzerland) and apically condensed with a hand plugger (Hu-Friedy, Berhard Quentin GmbH, Leimen, Germany). After gutta-percha had been packed to within 5 mm of the apex, 3-4 mm long segments of gutta-percha were backpacked until they reached the coronal orifice of the canal.

Thermafil

An electric Thermaprep Plus oven (Dentsply/Maillefer, Ballaigues, Switzerland) was used to soften the gutta-percha on the Thermafil obturator

Njemačka) stavljena je u kanal pomoću sredstva za unošenje (Dentsply-Maillefer, Ballaigues, Švicarska). Plastični obturator Thermafil zatim je izvađen iz pećnice i u punoj radnoj duljini postavljen u kanal. Nakon hlađenja suvišak je prerezan aparatom Thermacut (Dentsply/Maillefer, Ballaigues, Švicarska), a gutaperka je vertikalno potisnuta "pluggerom".

Tehnika Ultrafil

Injektirajući sistem ugrijan je na nisku temperaturu i korišten prema uputama proizvođača. Svaka je kanila unaprijed ugrijana u pećnici Ultrafil (Hygienic, Ohio, SAD) 15 minuta prije punjenja. Stijenke korijenskog kanala obložene su sredstvom za brtvljenje; igla ugrijane kanile Ultrafil postavljena je u kanal na 6 milimetara od apeksa te je gutaperka ručno injicirana sve dok se suvišak nije pojavio na koronalnom kraju kanala. Zatim je gutaperka vertikalno potisnuta "pluggerom".

Tehnika Obtura II

Koristio se sistem Obtura II (Obtura Spartan, Ontario, Kanada) na 185°C. Kanal je obložen istim sredstvom za brtvljenje, kao i u drugim skupinama. Vrh kanile Obtura veličine 25 (Obtura Spartan, Ontario, Kanada) postavljen je 5 milimetara od kraja radne duljine te je injektirana termoplastična gutaperka. Za kondenzaciju u vertikalnom smjeru koristili su se "pluggeri", u prvom redu u apikalnoj, središnjoj i koronalnoj trećini. Kavitet je ispunjen Cavitom (3M Espe, Seefeld, Njemačka).

Procjena ispuna korijenskog kanala

Rendgenske snimke ispunjenih zuba napravljene su u dvije ravnine (bukolingvalnoj i meziodistalnoj), digitalnim rendgenskim sistemom (Sirona Dental Systems GmbH, Bensheim, Njemačka) te su analizirane prema kriterijima koji se temelje na kompjutorskom ekranu (Tablica 1).

Izlazak sredstva za brtvljenje i gutaperke kroz apikalni otvor bodovan je od 0 do 3 prema kriterijima navedenim u Tablici 2.

Izlazak, ili izostanak izlaska gutaperke ili sredstva za brtvljenje kroz apikalni foramen, procijenio se pod mikroskopom s reflektiranom svjetlosti Axiolab A (Carl Zeiss GmbH, Beč, Austrija). Opturirani korijeni procjenjivani su s obzirom na prazne prostore u apikalnoj, središnjoj i koronalnoj trećini korijena te s obzirom na sveukupnu duljinu ispuna korijenskog kanala. Također su se procjenjivali adaptacija korijenskog kanala, kvaliteta ispuna te izlazak materijala.

as recommended by the manufacturer. The correct size of the plastic core obturator was selected using the size verifier. A small amount of endodontic sealer (Roekoseal, Coltène/Roeko, Langenau, Germany) was inserted in the root canal with a rotary paste filler (Dentsply-Maillefer, Ballaigues, Switzerland). The plasticized Thermafil obturator was then removed from the oven and inserted to the full working length of the canal. After cooling, excess plastic core material was cut with Thermacut (Dentsply/Maillefer, Ballaigues, Switzerland) and the gutta-percha was compacted vertically with a hand plugger.

Ultrafil

A low temperature thermoplasticized injectable system was used according to the manufacturer's instructions. Each cannula was preheated in the Ultrafil oven (Hygienic, Ohio, USA), for 15 min before obturation. The root canal walls were coated with sealer; the needle of the warmed Ultrafil cannula was inserted into the canal to a level 6 mm from the apex and the gutta-percha was injected manually until it extruded at the coronal end of the canal. The gutta-percha was then compacted vertically with a plugger.

Obtura II

The Obtura II (Obtura Spartan, Ontario, Canada) system was used with the temperature set at 185°C. The canal was coated with the same sealer as in all the other groups. The Obtura 25 gauge cannula tip (Obtura Spartan, Ontario, Canada) was inserted 5 mm short of the working length and the thermoplasticized gutta-percha injected. Hand pluggers were used to condense the gutta-percha vertically in the apical, middle and coronal thirds. The access cavity of each tooth was filled with Cavit (3M Espe, Seefeld, Germany).

Assessment of the root canal fillings

Radiographs of each filled tooth were taken in two planes (bucco-lingual and mesio-distal) with a digital radiographic system (Sirona Dental Systems GmbH, Bensheim, Germany) and studied on a computer screen based on the criteria in Table 1.

The extrusion of sealer and gutta-percha through the apical opening was scored 0-3 based on the criteria in Table 2.

Extrusion or absence of gutta-percha or sealer through the apical foramen was assessed under reflected-light microscope Axiolab A (Carl Zeiss GmbH, Vienna, Austria). The obturated root canals

Tablica 1. Kriteriji za rendgensku procjenu materijala za punjenje
Table 1. Criteria for radiographic evaluation of filling material

Ocjena • Ratings	Kriterij • Criteria
0	Konzistentno gusto radiokontrastno punjenje u sva tri segmenta (apikalnom, srednjem i koronalnom); gutaperka ili sredstvo za brtvljenje dobro je adaptirano uz rubove kanala • Consistently dense, radioopaque filling in all three segments (apical, middle and coronal); gutta-percha or sealer is well adapted to the canal outline
1	Prisutnost malih praznih prostora (< 0.5 mm) u apikalnoj, srednjoj i koronalnoj trećini punjenja • Presence of small voids (< 0.5 mm) in the apical, middle and coronal thirds throughout the filling
2	Prisutnost praznih prostora (> 0.5 mm < 1 mm) u apikalnoj, srednjoj i koronalnoj trećini punjenja • Presence of voids (> 0.5 mm < 1 mm) in the apical, middle and coronal thirds throughout the filling
3	Prisutnost praznih prostora (> 1 mm) u apikalnoj, srednjoj i koronalnoj trećini punjenja • Presence of voids (> 1 mm) in the apical, middle and coronal thirds throughout the filling

Tablica 2. Kriteriji za izlazak materijala preko apikalnog foramena
Table 2. Criteria for extrusion of material through the apical foramen

Ocjena • Ratings	Kriterij • Criteria
0	Materijal ne prelazi radnu duljinu • No filling material beyond the working length
1	Materijal prelazi radnu duljinu, ali ne doseže rendgenski apeks • Filling material beyond the working length but not at radiographic apex
2	Materijal doseže rendgenski apeks • Filling material at the radiographic apex
3	Materijal prelazi rendgenski apeks • Filling material beyond the radiographic apex

Statistička analiza

U statističkoj analizi koristili su se testovi Kruskal-Wallis i Mann-Whitney U - za dva neovisna uzorka. Rezultati su prikazani grafički. Također se koristio test hi-kvadrat.

Rezultati

Rendgenska procjena adaptacije materijala

Kvaliteta opturacije postignuta s pet tehnika uspoređivala se testovima Kruskal-Wallis i Mann-Whitney-U. Sveukupno nije bilo znatne razlike u rendgenskoj kvaliteti (apikalne, središnje i koronalne trećine zajedno, $P > 0.05$)

Usporedba parova opturacijskih metoda (Mann-Whitney U-test za parove) također nije pokazala znatne razlike među tehnikama ($P > 0.05$). Sveukupna rendgenska kvaliteta opturacije pokazala je da sve tehnike postižu dobru adaptaciju u apikalnoj, središnjoj i koronalnoj trećini korijenskog kanala (slike 1-4).

Izlazak sredstva za brtvljenje

Broj kanala s izlaskom sredstva i gutaperke u svakoj tehnici prikazan je u Tablici 3 i na Slici 5. Izlazak materijala za brtvljenje preko rendgenskog apeksa pojavio se kod dva kanala punjena tehnikom Ultrafil, a kod sedam kanala

were assessed for the presence of voids in the apical, middle and coronal thirds and the overall length of the root filling. The adaptation of the canal filling material, the quality of the root filling and material extrusion were also measured.

Statistical analysis

Statistical analysis used the Kruskal-Wallis test and the Mann-Whitney U-test for two independent samples. Results were visualized with box plots. The Chi-square test was also used.

Results

Radiographic evaluation of material adaptation

The quality of obturation obtained with the five techniques was compared with the Kruskal-Wallis test and the Mann-Whitney U-test. Overall, there were no significant differences in the radiographic quality (apical, middle and coronal thirds together, $P > 0.05$)

The two-by-two comparison of obturation methods against each other (Mann-Whitney U-test for paired groups) also showed no significant differences between the techniques ($P > 0.05$). In the overall radiographic obturation quality the techniques showed good adaptation in the apical middle and coronal third of the root canal (Figure 1-4).

Extrusion of root-filling material

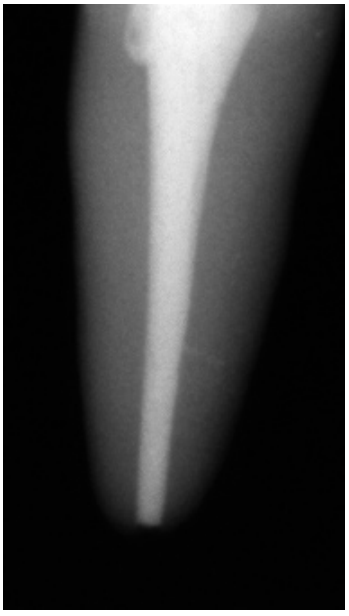
The number of canals with extruded sealer and gutta-percha in each technique are given in Table 3 and Figure 5. Extrusion of filling material beyond the radiographic apex occurred in two canals filled

Tablica 3. Izlazak materijala preko apikalnog foramena
Table 3. Extrusion of material through the apical foramen

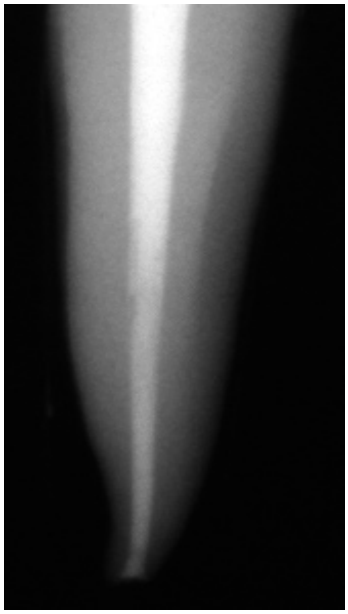
Metoda • Methods	Ekstruzija • Extrusion				Ukupno • Total
	0	1	2	3	
LC	4	4	7	0	15
VC	7	3	5	0	15
TH	0	2	12	1	15
UL	4	2	7	2	15
OB	6	3	6	3	15

LC = lateralna kondenzacija • Lateral Condensation, VC = vertikalna kondenzacija • Vertical Condensation, TH = Thermafil, UL = Ultrafil, OB = Obtura II

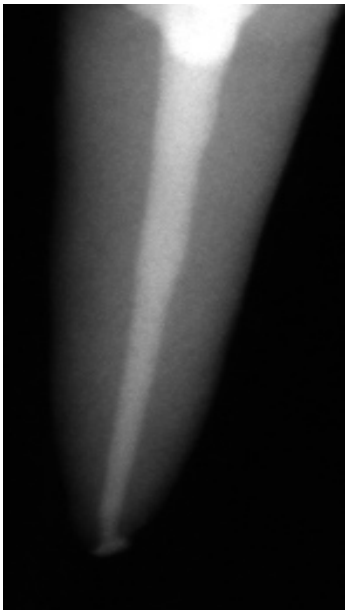
Slika 1. Nema materijala preko radne duljine
Figure 1. No filling material beyond the working length



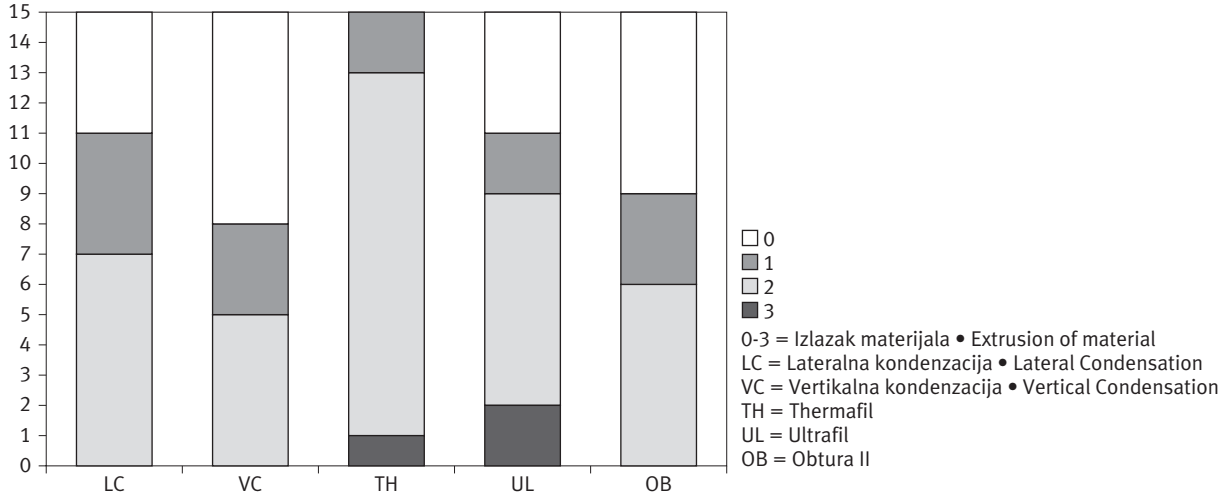
Slika 2. Materijal preko radne duljine, ali ne doseže rendgenski apeks
Figure 2. Filling material beyond the working length but not at radiographic apex



Slika 3. Materijal doseže rendgenski apeks
Figure 3. Filling material at the radiographic apex



Slika 4. Materijal prelazi rendgenski apeks
Figure 4. Filling material beyond the radiographic apex



Slika 5. Izlazak materijala preko apikalnog foramena
Figure 5. Extrusion of material through the apical foramen

sredstvo za brtvljenje dosegnulo je prostor između rendgenskog apeksa i radne duljine. Kanali punjeni tehnikom Thermafil također su pokazali tendenciju punjenja preko radne duljine, no razlike se nisu pokazale znatnijima (hi-kvadrat, $p > 0.05$).

Rasprava

Kliničke rendgenske snimke predstavljaju jedinu metodu procjene liječenja korijenskog kanala (9, 10).

Već je pokazana vrijednost uporabe proksimalnih rendgenskih snimaka za procjenu in-vitro adaptacije materijala za punjenje (11). Sveukupno nije bilo razlike između tehnike Thermafil i tehnika sistema B, budući da su obje pokazale dobru adaptaciju materijala za punjenje uz stijenku kanala (12). Rendgenska analiza ispuna korijenskog kanala tehnikom Thermafil pokazala je dobru adaptaciju na stijenke kanala cijelom duljinom kanala (13).

Rendgenski rezultati ovog istraživanja pokazali su gust i dobro adaptiran ispun korijenskog kanala u svim skupinama te sličnu kvalitetu za sve opturacijske tehnike.

Izlazak sredstva za brtvljenje u periradikularno tkivo, ali i nedostatno punjenje, smatraju se neželjenima. Tehnika Thermafil pokazala je tendenciju potiskivanja materijala preko prohodnog apeksa (7), uz znatno potiskivanje materijala preko apeksa (12).

U ovom istraživanju apikalni foramen bio je prohodan, a tehnika Thermafil također je pokazala veću tendenciju potiskivanju materijala od ostalih metoda punjenja. Druga istraživanja tehnike Thermafil koja nisu osiguravala prohodnost apeksa, nisu imala takve nalaze (14, 15).

with Ultrafil, and in seven canals the filling material reached between working length and radiographic apex. Canals filled with the Thermafil technique also showed a tendency toward filling beyond the working length, but these differences did not prove to be significant (Chi-square test, $p > 0.05$).

Discussion

Clinical radiograph is the only method for the evaluation of root canal treatment (9, 10).

The validity of using proximal radiographs for the in-vitro evaluation of filling material adaptation has already been demonstrated (11). There were no significant differences in the obturation quality between the Thermafil and system B techniques, both techniques demonstrated good adaptation of fillings material to the canal wall (12). Radiographic analysis of the root fillings with Thermafil technique showed good adaptation to the canal walls and all parts of the canal (13).

The radiographic results in this study showed dense and well-adapted root canal fillings in all groups and similar quality for all obturation techniques.

Extrusion of the filling material into the periradicular tissues and underfilling are considered undesirable. The Thermafil technique showed a tendency toward material extrusion beyond a patent apex (7). Significantly filling material extrusion beyond the apex showed Thermafil technique (12).

In the present study, the apical foramen was patent and the Thermafil technique also showed a greater tendency toward material extrusion than all the other obturation methods. Other studies using Thermafil without securing apical patency did not replicate these findings (14, 15).

Nekoliko je istraživanja procjenjivalo postotak gutaperke, sredstva za brtvljenje i prazne prostore na presjecima radi usporedbe različitih tehnika punjenja (16, 17).

Na plastičnim endodontskim modelima pokazalo se da punjenje korijenskog kanala tehnikom Thermafil brtvi bolje nego lateralna kondenzacija (13). Što se sadržaja gutaperke tiče, sve tehnike njezina unošenja te tehnike ugrijane gutaperke, pokazale su se boljima od lateralne kondenzacijske tehnike (18). Najuobičajenija metoda procjene propusnosti još je mjerenje penetracije boje (19). Budući da boja može doprijeti do najmanjih pukotina, rezultati tih testova ne mogu se lako primijeniti na klinička istraživanja (20). Zato su drugi eksperimentalni pristupi ispitivali mogu li bakterije penetrirati od krune uzduž ispuna korijenskog kanala, sve do okoline pogodne za rast u periapikalnom području. Punjenje korijenskog kanala Apexitom ili Ketac Endoom pokazalo je povećanu penetraciju bakterije Enterococcus faecalis u korijenu 30 do 60 dana poslijeoperativno (21). Najnoviji test sposobnosti brtvljenja korijenskog kanala jest model transporta tekućine, koji ispituje mogućnost potiskivanja tekućine kroz ispunjeni korijenski kanal (22, 23). Bakterijska penetracija i penetracija boje dovode do različitih rezultata. Pommel i suradnici otkrili su da punjenje hladnom, toplom ili termoplastičnom gutaperkom drugačije brtvi, ovisno o tome rabi li se metoda penetracije boje, metoda filtracije tekućine ili elektrokemijska metoda (26). Ako mnogobrojna istraživanja istog problema daju različite rezultate, postavlja se pitanje mogućih uzroka tih razlika. Termoplastične tehnike su osjetljive. Injicira li se termoplastični materijal brzo i duboko, sposobnost brtvljenja je dobra, no kanali su često prepunjeni (15, 7, 12). Injicira li se materijal razmjeno sporo i nedovoljno duboko, ispun korijenskog kanala propušta (27). To upozorava na činjenicu da različita brzina i/ili drugačije hlađenje mogu utjecati na različite rezultate sposobnosti brtvljenja termoplastične gutaperke.

Zaključak

Svi testirani termoplastični načini punjenja korijenskih kanala pokazali su prihvatljivo punjenje korijenskih kanala i dobru adaptaciju na stijenke korijenskih kanala bez statistički znatne razlike među njima te u usporedbi s lateralnom kondenzacijom.

Several studies have evaluated the percentage of gutta-percha, sealer and presence of voids in cross sections to compare various obturation techniques (16, 17).

Root canal fillings with Thermafil sealed better than those with lateral condensation in endodontic plastic models (13). In terms of gutta-percha content, all carrier and warm gutta-percha techniques proved to be superior to the lateral condensation technique (18). The most common method used to assess leakage is still the measurement of dye penetration (19). As dye can easily penetrate into minute gaps, the results from dye penetration tests cannot be easily applied to clinical studies (20). For this reason, other experimental approaches have examined whether bacteria are able to penetrate from the crown along a root canal filling and ultimately reach a culture medium beyond the apex. Root canal fillings with Apexit or Ketac Endo showed an increasing penetration of Enterococcus faecalis in the root canal 30-60 days postoperatively (21). A recent testing method for the sealing ability of root canal fillings is the fluid-transportation model, which examines whether it is possible to pump fluid through filled root canals (22, 23). The bacterial penetration tests and the dye stuff penetration tests led to different results (24, 25). Pommel et al. found out, that root canal fillings with cold, warm or thermoplastic gutta-percha seal differently depending on whether dye penetration, the fluid-filtration-method or an electrochemical method was used (26). When numerous investigations of the same question lead to different results, the question of possible causes of the differences arises. Thermoplastic root canal filling methods are technique-sensitive: if thermoplasticized root canal filling materials are injected rapidly and deeply, the sealing ability is good, but the canals are often overfilled (15, 7, 12). When the filling materials are injected relatively slowly and less deeply the root canal filling leaks (27). This suggests that different insertion speeds and / or different cooling rates could be the reason for the differing results on the sealing ability of thermoplasticized gutta-percha.

Conclusions

All the thermoplastic filling systems tested demonstrated acceptable root canal filling and good adaptation to the root canal wall with no statistically significant difference between them and in comparison to lateral condensation.

Abstract
The aim of the study was to evaluate the adaptation and quality of root fillings achieved by the lateral condensation, vertical condensation, Thermafil, Ultrafil and Obtura II techniques. Seventy-five straight and curved root canals of extracted human teeth were prepared according to the crown-down / step-back technique using 3% sodium hypochlorite. Apical patency was verified with a size 15 K-file and five groups of 15 root canals were formed for the different obturation techniques. Roekoseal Automix was used as sealer in all cases. Teeth were radiographed for overall material adaptation and filling material extrusion. There were no significant differences in the overall canal obturation and radiographic density and adaptation to canal walls. All thermoplastic obturation techniques demonstrated acceptable root canal filling and sealed well with no statistically significant difference between them and in comparison to lateral condensation. Root canal fillings were radiographically dense and well adapted throughout the entire root canal system.

Received: February 2, 2006
Accepted: February 25, 2006

Address for correspondence
Univ.-Prof. Dr. P. Städtler
Klinische Abteilung für Zahnerhaltung
Auenbruggerplatz 6a
A-8036 Graz
Tel.: ++43-316-385-2213
Fax: ++43-316-385-3375
peter.staedtler@meduni-graz.at

Key Words
Root canal filling, obturation methods, thermoplasticized gutta-percha, radiographic evaluation.

References

1. Schilder H. Filling root canals in three dimensions. Dent Clin North Am. 1967; 11: 723-44.
2. Yee FS, Marlin J, Krakow AA, Gron P. Three-dimensional obturation of the root canal injection molded, thermoplasticized dental gutta-percha. J Endod. 1977; 3(5): 168-74.
3. Johnson WB. A new gutta-percha technique. J Endod. 1978; 4(6): 184-8.
4. McSpadden J. Multiphase gutta-percha obturation technique. Dent Econ. 1993; 83(9): 95-7.
5. Smith RS, Weller RN, Loushine RJ, Kimbrough WF. Effect of varying the depth of heat application on the adaptability of gutta-percha during warm vertical compaction. J Endod. 2000; 26(11): 668-72.
6. Gutmann JL. Adaptation of injected thermoplasticized gutta-percha in the absence of smear layer. Int Endod J. 1993; 26(2): 87-92.
7. Gutmann JL, Saunders WP, Saunders EM, Nguyen L. An assessment of the plastic Thermafil obturation technique: Part 1. Radiographic evaluation of adaptation and placement. Int Endod J. 1993; 26(3): 173-8.
8. Gencoglu N, Samani S, Gunday M. Dentinal wall adaptation of thermoplasticized gutta-percha in absence or presence of smear layer: a scanning electron microscopic study. J Endod. 1993; 19(11): 558-62.
9. Gutmann JL. Clinical, radiographic and histologic perspectives on success and failure in endodontics. Dent Clin North Am. 1992; 36(2): 379-92.
10. Smith CS, Setchell DJ, Harty FJ. Factors influencing the success of conventional root canal therapy - a five-year retrospective study. Int Endod J. 1993; 26(6): 321-33.
11. Kersten HW, Wesselink PR, Thoden van Velzen SK. The diagnostic reliability of the buccal radiography after root canal filling. Int Endod J. 1987; 20(1): 20-4.
12. Kytridou V, Gutmann JL, Nunn MH. Adaptation and sealability of two contemporary obturation techniques in the absence of the dentinal smear layer. Int Endod J. 1999; 32(6): 464-74.
13. Da Silva D, Endal U, Reynaud A, Portenier I, Orstavik D, Haapasalo M. A comparative study of lateral condensation, heat-softened gutta-percha, and a modified master cone heat-softened backfilling technique. Int Endod J. 2002; 35(12): 1005-11.
14. Lares C, elDeeb ME. The sealing ability of the Thermafil obturation technique. J Endod. 1990; 16(10): 474-9.
15. Scott AC, Vire DE. An evaluation of the ability of a dentin plug to control extrusion of thermoplasticized gutta-percha. J Endod. 1992; 18(2): 52-7.
16. Wu MK, van der Sluis LW, Wesselink PR. A preliminary study of the percentage of gutta-percha-filled area in the apical canal filled with vertically compacted warm gutta-percha. Int Endod J. 2002; 35(6): 527-35.
17. Gencoglu N, Garip Y, Bas M, Samani S. Comparison of different gutta-percha root canal filling techniques: Thermafil, Quick-Fill, System B, and lateral condensation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002; 93(3): 333-6.
18. Gencoglu N. Comparison of 6 different gutta-percha techniques (part II): Thermafil, JS Quick-Fill, Soft Core, Microseal, System B, and lateral condensation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003; 96(1): 91-5.
19. Wu MK, Wesselink PR. Endodontic leakage studies reconsidered: Part I. Methodology, application and relevance. Int Endod J. 1993; 26(1): 37-43.
20. Oliver CM, Abbott PV. Correlation between clinical success and apical dye penetration. Int Endod J. 2001; 34(8): 637-44.
21. Timpawat S, Amornchat C, Trisuwan WR. Bacterial coronal leakage after obturation with three root canal sealers. J Endod. 2001; 27(1): 36-9.
22. Miletić I, Anić I, Pezelj-Ribarić S, Jukić S. Leakage of five root-canal sealers. Int Endod J. 1999; 32(5): 415-8.
23. Pommel L, About I, Pashley D, Camps J. Apical leakage of four endodontic sealers. J Endod. 2003; 29(3): 208-10.
24. Barthel CR, Moshonov J, Shuping G, Orstavik D. Bacterial leakage versus dye leakage in obturated root canals. Int Endod J. 1999; 32(5): 370-5.
25. Gilbert SD, Witherspoon DE, Berry CW. Coronal leakage following three obturation techniques. Int Endod J. 2001; 34(4): 293-9.
26. Pommel L, Jacquot B, Camps J. Lack of correlation among three methods for evaluation of apical leakage. J Endod. 2001; 27(5): 347-50.
27. Levitan ME, Himel VT, Luckey JB. The effect of insertion rates on fill length of a thermoplasticized gutta-percha technique. J Endod. 2003; 29(8): 505-8.