

Morfologija endodontskoga prostora trajnih zuba

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Sažetak

Uspješnost liječenja zubne pulpe uvjetovana je dobrim poznavanjem endodontskoga prostora i njegovih raznolikosti. Najčešći uzrok neuspjeha jest što se ne nađu korijenski kanali, jedan ili više njih, ili pak njihove anatomske osobitosti. Premda svi zubi imaju više-manje određenu građu endodonta, ipak terapeut mora biti spreman i na moguće varijacije. Najrjeđe varijabilnosti u građi endodontskoga prostora pokazuju gornji sjekutići i očnjak. Oni gotovo u 100% slučajeva imaju jedan korijen i korijenski kanal, a u praksi je zabilježeno tek nekoliko slučajeva gornjih sjekutića sa dva korijena ili korijenska kanala. Donji sjekutići i očnjaci najčešće imaju korijen i korijenski kanal, no moguće ih je naći dva, pa čak i tri. Pretkutnjaci i kutnjaci često variraju u građi endodontskoga prostora. Stomatolog mora biti spreman na postojanje dvaju ili triju korijenskih kanala kod pretkutnjaka, te čak četiriju, pet ili više korijenskih kanala kod kutnjaka. Raspored kanala također može biti vrlo raznolik, pa tako u bilo kojem od korijena tih zuba može postojati više korijenskih kanala. Osobitost u građi gornjih i donjih kutnjaka jest da je moguć i tzv. C-oblik endodonta, a nastaje kao posljedica sraštanja korijena tih zuba. Primjeri iz prakse danomice potvrđuju vrlo složenu morfologiju endodontskoga prostora zuba i zato stomatolog mora biti spreman na te raznolikosti kako bi postigao što bolji uspjeh u endodontskoj terapiji.

Ključne riječi: endodontski prostor, korijen, korijenski kanal

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Uvod

Pulpni prostor smješten je u središnjem dijelu zuba i po svojem je obliku njegova minijaturna verzija (1). Sa svih je strana omeđen dentinskom stijenkom, osim u području apeksnog otvora, a dijele ga na **koronarni** dio (pulpna komorica) i **radikularni** dio (korijenski kanal) (2).

Pulpna komorica prati oblik krune zuba. U njoj razlikujemo krov, lateralne zidove i dno. Na krovu pulpne komorice, ispod vrškova kvržica, jesu prođužetci krova unutar kvržica koje nazivamo pulpnim rogovima (3). Veličina pulpnih rogovina ovisi o dobi osobe, o stupnju abrazije i atricije, te o ja-

kosti i trajanju drugih podražaja (3). Na dnu pulpne komorice ulazi se u korijenske kanale i oni su redovito u obliku lijevka.

Broj, oblik i međusobni odnosi korijenskih kanala izravno ovise o veličini i obliku korijena (3). Iako prigodom instrumentacije nastojimo primarno obraditi glavne korijenske kanale, ipak treba imati na umu da je endodontski prostor vrlo razgranat i da osim glavnoga kanala obiluje i lateralnim ili akcesornim kanalićima. To su postranični ogranci glavnoga kanala koji omogućuju dodatnu povezanost s parodontom. Mogu postojati u bilo kojem dijelu korijena, ali se ipak najviše nalaze u apeksnoj trećini i češći su u lateralnih zuba (2).

Promjer apeksnog otvora kod mladih je zuba širok, ali se poslije zbog odlaganja dentina i cementa sužava. Apeksni se otvor rijetko otvara na samom anatomskom vrhu zuba. Češće je smješten 0,5-2 mm od njega.

Apeksno suženje, ili lat. *foramen internum*, opisano je kao cementno-dentinsko spojište i nalazi se oko 1-2 mm od apeksnog otvora, na mjestu ulaska cementa u korijenski kanal. Teško ga je klinički odrediti, a i sama intrakanalna granica cementa vrlo je varijabilna (2).

Iako su broj, oblik i veličina korijenskih kanala vrlo nestalni u pojedinim zuba, danas je prihvaćena Vertuccieva (4) podijela na osam osnovnih tipova:

- Tip 1 jedan kanal,
- Tip 2 jedan kanal koji se u koronarnoj trećini račva na dva i u apeksnoj trećini opet završava kao jedan,
- Tip 3 jedan kanal koji se u apeksnoj trećini račva u dva i završava kao jedan,
- Tip 4 dva potpuno odvojena kanala,
- Tip 5 jedan kanal koji se u apeksnoj trećini račva na dva i završava kao dva odvojena kanala,
- Tip 6 jedan kanal koji se u koronarnoj trećini račva na dva, u srednjoj trećini se spaja u jedan, te se ponovno račva u apeksnoj trećini i završava kao dva odvojena kanala,
- Tip 7 jedan kanal koji se račva na dva u apeksnoj trećini, zatim se spaja u jedan i opet račva, te završava kao dva odvojena kanala,

- Tip 8 jedan kanal koji se u koronarnoj trećini račva na tri kanala i završava kao tri odvojena kanala.

Gornji sjekutići

Središnji gornji sjekutić zub je relativno jednostavne morfologije endodontskoga prostora. Prema Ingleu i Beveridgeu (5) u 100% slučajeva ima jedan korijen i jedan korijenski kanal Tipa 1. Korijen je voluminozan, ovalnog oblika prosječne dužine od 23 mm (4) s laganim distalnim nagibom u apeksnoj trećini. Korijenski kanal prati njegov oblik i završava apeksnim otvorom koji je rijetko na samom anatomskom vrhu korijena i češće se nalazi postrance (do 2 mm) (6).

Premda vrlo rijetko, u kliničkoj je praksi zabilježeno postojanje središnjega gornjeg sjekutića s dva korijena i korijenska kanala što opovrgava tvrdnju Inglea i Beveridgea. Dva korijena i korijenska kanala prikazao je u jednom od svojih slučajeva Sinai (7).

Sličan je slučaj i s postraničnim gornjim sjekutićem. Prosječna dužina mu je nešto manja od središnjega gornjeg sjekutića i iznosi oko 21-22 mm (6). Iako su Green, Pineda, Kutler (8) i Vertucci (9) potvrdili da se u 100% slučajeva radi o jednokorijenskom zubu s jednim kanalom Tipa 1, ipak postoje prikazi slučajeva koji ne govore u prilog tome, kao npr. Thompson (8) koji je pronašao dva korijenska kanala. Općenito gledano, postranični gornji sjekutić genetski je nestabilniji zub od središnjeg gornjeg sjekutića pa su i razne anatomske anomalije kod njega češće, a samim time može se i morfologija pulpnoga prostora više razlikovati od očekivane.

Gornji očnjak

To je najduži zub u čeljusti i prosječna mu je dužina oko 26,5mm (6). Korijen je znatno širi u labiopalatinalnom nego u meziodistalnom smjeru, uglavnom ravan s možebitnim distalnim nagibom u apeksnoj trećini. U literaturi nije opisan slučaj postojanja dva korijena ili kanala kod ovoga zuba. U 100% slučajeva nailazimo na jedan korijen i jedan korijenski kanal Tipa 1.

Gornji pretkutnjaci

Čestoća jednokorijenog prvoga gornjeg pretkutnjaka varira od 31,5-39,5% (Müller, 1933; Bernaba, Madeira i Hetem, 1965; Carns i Skidmore, 1973). Iste je podatke dobio 1979. godine i Vertucci (10). Prema Waltonu i Torabinejadu (2) jedan korijen sa samo jednim kanalom Tip 1 kod ovoga zuba može se naći u 10% slučajeva, jedan korijen s dva kanala Tip 2 nalazi se u 12% slučajeva, a jedan korijen s dva kanala Tip 4 u 16% slučajeva. Dva korijena s dvama odvojenim kanalima nalazimo u 57% slučajeva i tada je jedan korijen smješten bukalno, a drugi palatinalno (2).

Iako rijetko, u literaturi su opisani slučajevi s tri korijena ili tri kanala. U 5-6% našli su ih Carns i Skidmore (11), te Vertucci (10). U takvim je situacijama najčešći slučaj postojanja tri odvojena korijena s trima odvojenim korijenskim kanalima. Raspored kanala tada nalikuje malomu gornjem prvom kutnjaku: meziobukalni, distobukalni i palatinalni kanal (12). Nešto je rjeđa situacija s tri kanala smještena u jednom ili dva korijena.

Prosječna dužina korijena kod ovoga zuba iznosi oko 21mm (4).

Gornji drugi pretkutnjak u nešto većem postotku ima samo jedan korijen i tada je on znatno širi u bukopalatinalnom nego u meziodistalnom smjeru. Zbog toga je razloga kod ovoga zuba dosta čest nalaz jednoga korijena s dvama korijenskim kanalima. Walton i Torabinejad (2) našli su jedan korijen s jednim kanalom Tip 1 u 53% slučajeva, jedan korijen s dva kanala Tip 2 u 22%, jedan korijen s dva kanala Tip 4 u 13% i dva korijena, jedan bukalni i jedan palatinalni, sa dva kanala u samo 11% slučajeva.

Pojava tri korijena ili kanala kod ovog je zuba iznimno rijetka, rjeđa nego kod prvoga gornjeg pretkutnjaka. U literaturi se spominje pojavnost od 1% (12).

Duljina drugoga gornjeg pretkutnjaka u prosjeku iznosi 21,5mm (4).

Gornji kutnjaci

Prvi gornji kutnjak ima u najvećem broju slučajeva tri korijena od kojih je jedan smješten palatinalno, a druga dva bukalno, i to meziobukalno i distobukalno. Takav raspored korijenova u najvećem broju slučajeva prati četiri korijenska kanala

od kojih su dva najčešće u meziobukalnom korijenu (MB1 i MB2) (4). Kulild i Peters (13) su u svome radu iz godine 1990. naveli postojanje dva kanala u meziobukalnom korijenu u čak 95,2%. Prema Waltonu i Torabinejadu (2) taj je postotak manji i iznosi 60%. Pri tome opisuju da je od toga 80% Tip 2, a samo 20% Tip 4 kanala. Drugačije su podatke u svojoj studiji dobili Pineda i Kuttler (4) koji su pronašli Tip 4 kanala u meziobukalnom korijenu u čak 48,5% slučajeva. Slične podatke kao i Walton (2) dobili su Pomeranz i Fishelberg (14) koji su pronašli dva meziobukalna kanala u 69% slučajeva.

U palatinalnom i u distobukalnom korijenu u najvećem se broju slučajeva nalazi samo jedan kanal, iako to nije pravilo.

Prosječna je dužina prvoga gornjeg kutnjaka oko 22 mm, i zub je nešto dulji u regiji palatinalnoga korijena (4). On je najmasivniji i u oko 50% slučajeva zavija u apeksnoj trećini u bukalnom ili palatinalnom smjeru, što nije vidljivo na rentgenskoj snimci (4).

Dva kanala u distobukalnome korijenu opisao je godine 1983. Martinez-Berna (15) sa suradnicima. Istu pojavu opisao je i Hülsmann (16) u prikazu slučaja 1997. godine. Dva kanala u distobukalnome korijenu, u jednom od svojih radova, spominje i Hession (17). Beatty (18) je čak opisao slučaj gornjega prvog kutnjaka s tri kanala u meziobukalnom korijenu. Iako rijetko, moguće je sraštavanje obaju bukalnih korijena (19). Pojavljuje se u 0,4%, i u svim slučajevima bilateralno (20).

Česte neobičnosti u morfologiji endodontskoga prostora nalaze se u palatinalnom korijenu. Dva odvojena kanala u tom su korijenu opisali Bond i suradnici (21), Cecic i suradnici (22), Jacobsen i Nii (23), Slowey (24), Stone i Stoner (25), Harris (26) te Tews i suradnici (27). Kanali mogu biti potpuno odvojeni i završavati odvojenim apeksnim otvorima (Tip 4) ili se pak spajati u apeksnoj trećini i završavati jednim zajedničkim apeksnim otvorom (Tip 2). Još je neobičniji slučaj postojanja triju odvojenih kanala u palatinalnom korijenu, a opisao ga je Wong (28) 1991. godine. Osim u broju kanala, varijacije se mogu odnositi i na broj korijenova. Dva odvojena palatinalna korijena opisana su u radu Christiea i suradnika (29). Pri tome gornje kutnjake s takvom morfologijom on dijeli u tri skupine:

1. Dva jako odvojena i divergentna palatinalna korijena i bukalni korijeni nešto manje divergentni, u obliku "kravljih rogova". Na rentgenogramu je moguće vidjeti četiri odvojena korijena.
2. Četiri odvojena korijena, ali su svi nešto kraći, manje divergentni, više paralelni i tupih vrhova. Uslijed bukolingvalne superpozicije na rentgenogramu mogu izgledati kao dva korijena - mezijalni i distalni.
3. Distobukalni korijen više divergira od ostalih i donekle strši od ostalih korijena,

Pojava C-oblika kanala kod prvoga gornjeg kutnjaka iznimno je rijetka i opisana je dosad u samo dva slučaja. Opisali su je 1984. Newton i suradnici (30), te 1990. godine Dankner sa suradnicima (31). U posljednjem se slučaju radilo o potpunom stapanju palatinalnog i distobukalnog korijena i pripadajućih kanala.

Drugi je gornji kutnjak u najvećem broju slučajeva samo umanjena kopija svojega prethodnika (4). Korijeni su mu manje divergentni, a njihovo sraštanje znatno je češće nego u prvoga gornjeg kutnjaka (4). Čestoća sraštanja korijena razlikuje se po rasi pa tako u literaturi postoji podatak da u bijelaca taj postotak iznosi oko 45-55%, a u mongola raste na 65-85% (4). Sraštanje korijena i pripadajućeg endodontskoga prostora razlog je češćem nastanku C-oblika kanala kod toga zuba (4). Walton i Torabinejad (2) navode podatak da drugi gornji kutnjak u 60% slučajeva ima tri odvojena korijena. Od toga se u meziobukalnome korijenu dva kanala s odvojenim apeksnim otvorima nalaze u 10%, a dva odvojena kanala s jednim apeksnim otvorom u 15% slučajeva (2). Samo jedan kanal u meziobukalnom korijenu navodi se u čak 70% slučajeva, što je veća čestoća nego kod prvoga gornjeg kutnjaka (2). U 25% slučajeva drugi gornji kutnjak može imati dva korijena, a u 10% samo jedan korijen (2).

I kod toga su zuba moguće razne neobičnosti u morfologiji endodontskoga prostora koje se razlikuju od očekivanog i uobičajenog. Fahid (32) je godine 1988. prikazao slučaj s dvama distobukalnim korijenima i dvama distobukalnim kanalima. Iako je kod drugoga gornjeg kutnjaka izražena sklonost sraštanja korijenova, u literaturi su opisani i slučajevi kod kojih je pronađeno četiri odvojena

korijena, ali je postotak takvih vrlo malen i po Libfeldu i Rotsteinu (33) iznosi samo 0,4%.

Treći gornji kutnjaci podložni su raznim varijabilnostima u morfologiji endodontskoga prostora i njihova je građa vrlo nepredvidiva, a mogu ponekad imati samo jedan ili dva korijenska kanala (4).

Donji sjekutići

Prosječna je dužina tih zuba oko 21mm, no središnji je sjekutić nešto malo kraći (4). Većina autora se slaže da u najvećem broju slučajeva postoji jedan korijen i jedan kanal Tip 1. Prema Waltonu i Torabinejadu (2) takvo se stanje kod središnjega donjeg sjekutića nalazi u 70% slučajeva, a kod lateralnog u 55% slučajeva. Dva korijenska kanala Tip 2 i 3 nalazimo u 25% kod središnjeg sjekutića i u 30% kod lateralnog, a dva kanala Tip 4 mogu se naći kod središnjeg sjekutića u 5%, te kod lateralnog u 15% situacija (2). Ako postoje dva korijenska kanala, jedan je uvijek labijalno a drugi lingvalno.

Koliko je čest taj drugi kanal bavili su se Kartal i Čalićkan (34) i u jednoj od svojih studija dobili su podatak da je ta čestoća 45%, s time da 37% od toga završava jednim zajedničkim apeksnim otvorom i tvori Tip 2 ili 3 korijenskoga kanala. Slične su podatke dobili u svojim studijama Benjamin i Dowson (35) koji su našli drugi korijenski kanal u 41,4%. Madeira i Hetem (36), Vertucci (37) i Green (38) opisuju rjeđu pojavnost drugoga kanala u donjih sjekutića. Ispitivanja slične vrste godine 1997. provodio je Miyashita sa suradnicima (39) i prema tome autoru 87,8% ispitivanih donjih sjekutića imalo je jedan kanal Tip 1; 12,4% ispitivanih zuba imalo je dva korijenska kanala, ali od toga su samo 3,1% pripadali Tipu 3 ili 4.

Postojanje drugoga korijenskoga kanala kod donjih sjekutića često je uzrok neuspjeha u endodontskoj terapiji, jer ga terapeuti previde. Zbog toga treba biti vrlo pažljiv kod instrumentacije tih zuba i ne dopustiti da njihova gracilna građa sakrije moguće postojanje drugoga kanala.

Donji ocnjak

U najvećem broju slučajeva ovaj zub ima jedan korijen i jedan korijenski kanal Tip 1, prema Waltonu (2) u 70% slučajeva. Po podacima iz godine 1985., koje je dao Kaffe (4), u 14% slučajeva do-

nji očajnik može imati dva korijenska kanala, no manje od 6% ima Tip 4. Podatak koji je iznio Walton (2) dosta se razlikuje od prethodnog i po njemu je učestalost dvaju kanala čak 30%, od toga u 20% prevladava Tip 2 ili 3, a u 10% Tip 4. U slučaju postojanja dva kanala, baš kao i kod donjih sjekutića, jedan je smješten labijalno a drugi lingvalno. Prosječna je dužina zuba 22,5mm (4).

Donji pretkutnjaci

Prvi donji pretkutnjak u najvećem broju slučajeva ima jedan korijen i jedan korijenski kanal Tipa 1. Prema Waltonu i Torabinejadu (2) ta je čestota 70%. Jedan korijen s dva korijenska kanala Tipa 2 ili 3 po istim autorima iznosi 4%. Dva korijena koja nastaju najčešće zbog dijeljenja u apeksnoj trećini, nalaze se prema prije navedenim autorima u 25% slučajeva, među kojima prevladava Tip 4 ili 5 korijenskoga kanala (2). U takvim je slučajevima najčešće jedan korijen bukalno a drugi lingvalno.

Iako naizgled ima vrlo jednostavnu morfologiju endodontskog prostora, po mnogim autorima ovaj zub može biti problematičan za endodontsko liječenje (24, 40). Uzrok je varijabilnost u broju i rasporedu korijenskih kanala. Tri korijenska kanala u prvome donjem pretkutnjaku u 0,4-0,9% slučajeva našli su Pineda i sur., Green, Zillich i sur. i Vertucci (41-44). U studiji iz godine 1986. Trope je sa sur. (45) dokazao veći postotak donjih pretkutnjaka s dva ili više korijenskih kanala u crnaca. Taj postotak je za prve donje pretkutnjake u crnaca bio 32,8%, a u ispitivanih bjelaca samo 13,7% (45).

Kod drugih donjih pretkutnjaka ta je razlika nešto manja i za crnu je rasu čestota bila 7,8%, a u bijele rase 2,8% (45).

Prema Waltonu i Torabinejadu (2) postotak drugih donjih pretkutnjaka s jednim korijenom veći je nego kod prvih donjih pretkutnjaka i iznosi čak 97% (2). Od toga na kanal Tip 1 otpada 85%, a na kanal Tip 2 i 3 12%. Dva korijena i dva korijenska kanala prema navedenim se autorima mogu naći u samo 3% slučajeva (2). U takvim situacijama jedan je kanal smješten lingvalno, a drugi bukalno, ali nije pravilo. Goswami je sa sur. (46) pronašao drugi donji pretkutnjak s dva kanala, od kojih je jedan bio smješten mezijalno, a drugi distalno. Isti je slučaj opisan i u radu Sermana i Hassel-

grena (40) iz godine 1992. U literaturi su opisani i slučajevi drugih donjih pretkutnjaka s tri (43,47), pa čak i s četiri korijenska kanala (48).

Ono što donje pretkutnjake čini zubima koje endodontima mogu biti velik problem jest to da je u većini slučajeva vrlo teško ustanoviti veći broj kanala kad oni postoje. Naime, nerijetko se radi o kanalima koji počinju kao jedan i imaju zajednički ulaz, a onda se dijele tek u apeksnoj trećini. Pomoc je rentgenska snimka koja je za ovakve situacije tipična - vidljiv je jedan korijenski kanal koji se naglo gubi u srednjoj trećini korijena. Kod takve snimke uvijek treba posumnjati na račvanje kanala u nekoliko ogranaka u apeksnoj ili srednjoj trećini. Iz toga razloga instrumentaciji ovih zuba treba uvijek prilaziti sa povećanim oprezom i imati na umu moguće varijacije u morfologiji endodontskoga prostora.

Donji kutnjaci

U najvećem broju slučajeva prvi donji kutnjak ima dva korijena, smještena mezijalno i distalno. Distalni korijen obično je nešto manji i ima najčešće okrugli oblik (4). Prosječna je dužina ovoga zuba oko 21mm (4). Najčešće ima tri kanala, od toga dva u mezijalnom korijenu, a jedan u distalnom (4). Distalni je kanal širi i u poprečnom presjeku ovalniji od mezijalnih (4). Prema Waltonu i Torabinejadu (2) dva kanala Tip 4 u mezijalnom se korijenu nalaze u 60% slučajeva, a Tip 2 i 3 u 40%. Jedan korijenski kanal u distalnom korijenu moguće je naći u 70% slučajeva, a dva kanala u 30% (2). Od toga na kanal Tip 2 otpada 20%, a na kanal Tip 4 10% (2).

Kao i većina ostalih zuba tako i ovaj zub može imati određene morfološke osobitosti koje odudaraju od uobičajenog. Postojanje tri kanala u mezijalnom korijenu u svojim su radovima opisali mnogi autori (49-53). Takva se konfiguracija može naći u 2-15% slučajeva (53). Treći kanal u mezijalnom korijenu uvijek je između meziolingvalnog i meziobukalnoga kanala (51). U svom toku može biti potpuno neovisan i završavati odvojenim apeksnim otvorom ili se pak spojiti s jednim od dvaju glavnih mezijalnih kanala (50). U svojoj studiji godine 1985. Fabra-Campos (54) ispitivao je in vivo 145 prvih donjih kutnjaka i među njima pronašao četiri uzorka s tri kanala u mezijalnom korijenu, što odgovara pojavnosti od 2,75%.

Kao i u mezijalnom tako je i u distalnom korijenu prvoga donjeg kutnjaka moguće postojanje triju korijenskih kanala, premda je takvo stanje znatno rjeđe nego u mezijalnom korijenu (51). Takav je slučaj opisao Beatty sa sur. (52).

Drugi donji kutnjak nešto je manji od svojega mezijalnog susjeda (4). Prosječna mu je dužina 20 mm (5). U mezijalnom se korijenu dva korijenska kanala nalaze u 75%, a jedan se kanal nalazi u 25% slučajeva (2). Ako postoje dva kanala, tada na kanal Tip 4 otpada 40%, a na kanal Tip 2 35% (2). U distalnom korijenu jedan korijenski kanal se nalazi u čak 92%, dok se dva korijenska kanala nađu u samo 8% slučajeva (2). Tada je pojavnost kanala Tip 4 oko 3%, a kanala Tip 2 oko 5% (2).

Ono što drugi donji kutnjak na neki način čini posebnim i što ga razlikuje od prvoga donjeg kutnjaka jest sklonost sraštanju korjenova, osobito u pripadnika žute rase (4). U njih ta čestota iznosi od 33 do 52% (4). Zbog sraštanja korjenova može se naći i tzv. C-oblik kanala koji ponekad može biti samo na dnu pulpne komorice, u cervikalnoj trećini zuba, ili se protezati punom dužinom korijena, sve do samog njegova vrha (55).

Treći donji kutnjak često ima razne varijacije u građi endodontskoga prostora, ali ipak ima određene sličnosti s drugim donjim kutnjakom pa nerijetko oponaša njegovu endodontsku morfologiju (4).

Zaključak

Morfologija endodontskoga prostora trajnih zuba vrlo je složena i varijabilna. Iako se danas mnogo zna o anatomiji pulpnoga prostora, ipak su mnogi autori svjedoci svakodnevnih mogućih iznenađenja na tome polju. To potvrđuje koliko oprezni i dobro obaviješteni moramo biti prije nego što se upustimo u bilo kakvu vrstu endodontskog liječenja, jer je to preduvjet za uspjeh endodontske terapije.

Literatura

- BHASKAR S. Orban's Oral Histology, 10-th ed. St. Louis: C.V. Mosby 1986:135.
- WALTON RE, TORABINEJAD M. Principles and Practice of Endodontics, 2nd ed. Philadelphia: WB Saunders 1996:531-554.
- NJEMIROVSKIJ Z i sur. Klinička endodoncija, Zagreb: Globus 1987:38-42.
- HARTY FJ. Endodontics in practice, 3rd ed. Cambridge, Butterworth & Co., 1990:21-54.
- INGLE JI, BEVERIDGE EE. Endodontics, 2nd ed. Philadelphia: Lea & Febiger 1976:117.
- COHEN S, BURNS R. Pathways of the pulp, 3rd ed. St. Louis: C.V. Mosby 1984:127-158.
- SINAI I H, LUSTBADER S. A Dual-rooted maxillary central incisor. J Endodon 1984;10:105-106.
- THOMPSON BH, PORTELL FR, HARTWELL GR. Two root canals in a maxillary lateral incisor. J Endodon 1985;11:353-355.
- VERTUCCI FJ. Root canal anatomy of the human permanent teeth. Oral Surg 1984;58:589-599.
- VERTUCCI FJ, GEGAUFF A. Root canal morphology of the maxillary first premolar. J Am Dent Assoc 1979; 99:194-198.
- CARNS EJ, SKIDMORE AE. Configurations and deviations of root canals of maxillary second premolar. Oral Surg 1973;36:880-886.
- SIERASKI SM, TAYLOR GN, KOHN RA. Identification and endodontic management of three-canal maxillary premolars. J Endodon 1989;15:29-32.
- KULILD JC, PETERS DD. Incidence and configuration of canal systems in the mesiobuccal root of maxillary first and second molars. J Endodon 1990;16:311-317.
- POMERANZ H, FISHELBERG G. The secondary mesiobuccal canal of maxillary molars. J Am Dent Assoc 1974;88:119-124.
- MARTINES-BERNA A, RUIS-BADANELLI P. Maxillary molars with six canals. J Endodon 1983;9:375-381.
- HÜLSMANN M. A maxillary first molar with two distobuccal root canals. J Endodon 1997;23:707-708.
- HESSION RW. Endodontic morphology ÉÉÉ. A radiographic analysis. Oral Surg 1977;44:610-620.
- BEATTY RG. A five-canal maxillary first molar. J Endodon 1984;10:156-157.
- SABALA CL, BENENATI F W, NEAS BR. Bilateral root or root canal aberrations in a dental schoolpatient population. J Endodon 1994;20:38-42.
- MALAGNINO V, GALLOTTINI L, PASSARIELLO P. Some unusual clinical cases on root anatomy of permanent maxillary molars. J Endodon 1997;23:127-128.
- BOND JL, HARTWELL G, PORTELL FR. Maxillary first molar with six canals. J Endodon 1988;14:258-260.
- CECIC P, HARTWELL G, BELLIZZI R. The multiple root canal system in the maxillary first molar: a case report. J Endodon 1982;8:113-115.
- JACOBSEN EL, NII C. Unusual palatal root canal morphology in maxillary molars. Endod Dent Traumatol 1994;10:19-22.
- SLOWEY R R. Root canal anatomy-road map to successful endodontics. Dent Clin North Am 1979;23:561.

25. STONE LH, STONER WF. Maxillary molars demonstrating more than one palatal root canal. *Oral Surg* 1981;51:649-652.
26. HARRIS W. Unusual root canal anatomy in a maxillary molar. *J Endodon* 1980;6:573-577.
27. TEWS ME, KEMP WB, JONES CR. Aberrations in palatal root and root canal morphology of two maxillary first molars. *J Endodon* 1979;5:94-96.
28. WONG M. Maxillary first molar with three palatal canals. *J Endodon* 1991;17:298-299.
29. CHRISTIE WH, PEIKOFF MD, FOGEL HM. Maxillary molars with two palatal roots: a retrospective clinical study. *J Endodon* 1991;17:80-84.
30. NEWTON CW, McDONALD S. C-shaped canal configuration in a maxillary first molar. *J Endodon* 1984;10:397-399.
31. DANKNER E, FRIEDMAN S, STABHOLZ A. Bilateral C-shape configuration in maxillary first molars. *J Endodon* 1990;16:601-603.
32. FAHID A, TAINTOR JF. Maxillary second molar with three buccal roots. *J Endodon* 1988;14:181-183.
33. LIBFELD H, ROTSTEIN I. Incidence of four-rooted maxillary second molars: literature review and radiographic survey of 1,200 teeth. *J Endodon* 1989;15:129-131.
34. KARTAL N, ÇALIÇKAN YANIKOĞLU F. Root canal morphology of mandibular incisors. *J Endodon* 1992;18:562-564.
35. BENJAMIN K, DOWSON J. Incidence of two root canals in human mandibular incisor teeth. *Oral Surg* 1974;38:122-126.
36. MADEIRA M, HETEM S. Incidence of bifurcations in mandibular incisors. *Oral Surg* 1973;36:589-591.
37. VERTUCCI FJ. Root canal anatomy of the mandibular anterior teeth. *J Am Dent Assoc* 1974;89:369-371.
38. GREEN D. A stereomicroscopic study of the root apices of 400 maxillary and mandibular anterior teeth. *Oral Surg* 1956;91:1224-1228.
39. MIYASHITA M, KASAHARA E, YASUDA E, YAMAMOTO A, SEKIZAWA T. Root canal system of the mandibular incisor. *J Endodon* 1997;23:479-484.
40. SERMAN NJ, HASSELGREN G. The radiographic incidence of multiple roots and canals in human mandibular premolars. *Int Endodon J* 1992;25:234-237.
41. PINEDA F, KUTTLER Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. *Oral Surg* 1977;33:101-109.
42. GREEN D. Double canals in single roots. *Oral Surg* 1973;35:690-1.
43. ZILLICH R, DAWSON J. Root canal morphology of mandibular first and second premolars. *Oral Surg* 1973;36:738-744.
44. VERTUCCI FS. Root canal morphology of mandibular premolars. *J Am Dent Assoc* 1978;97:238-239.
45. TROPE M, ELFENBEIN L, TRONSTAD L. Mandibular premolars with more than one root canal in different race groups. *J Endodon* 1986;12:343-345.
46. GOSWAMI M, CHANDRA S, CHANDRA Sh, SINGH S. Mandibular premolar with two roots. *J Endodon* 1997;23:187.
47. ELDEEB ME. Three root canals in mandibular second premolars: literature review and a case report. *J Endodon* 1982;8:376-377.
48. SHAPIRA Y, DELIVANIS P. Multiple-rooted mandibular second premolars. *J Endodon* 1982;8:231-232.
49. BEATTY R, KRELL K. Mandibular molars with five canals: report of two cases. *J Am Dent Assoc* 1987;114:802-804.
50. DEGROOD ME, CUNNINGHAM CJ. Mandibular molar with 5 canals: report of a case. *J Endodon* 1997;23:60-602.
51. HOLTZMANN L. Root canal treatment of a mandibular first molar with three mesial root canals. *Int Endodon J* 1997;30:422-423.
52. BEATTY R, INTERIAN CM. A mandibular first molar with five canals: report of case. *J Am Dent Assoc* 1985;11:769-771.
53. JACOBSEN EL, DICK K, BODELL R. Mandibular first molars with multiple mesial canals. *J Endodon* 1994;20:610-613.
54. FABRA-CAMPOS H. Unusual root anatomy of mandibular first molars. *J Endodon* 1985;11:568-572.
55. MELTON DC, KRELL KV, FULLER MW. Anatomical and histological features of C-shaped canals in mandibular second molars. *J Endodon* 1991;17:384-388.

Endodontic Morphology of Permanent Teeth

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Summary

The prerequisite for successful treatment of dental pulp is a good knowledge of endodontic space and its diversities. The most common reason of not succeeding is failing to notice one or more root canals or their anatomic particularities. Maxillary incisors and canines show least variability in the structure of endodontic morphology. In almost 100% of cases they have one root and one root canal, and in practice only a few cases of maxillary incisors with two roots or root canals have been noted. In mandibular incisors and canine, along with the most often incidence of one, the incidence of two and even three roots and root canals is possible. Premolars and molars often vary in the structure of their endodontic morphology. The stomatologist must be prepared for the existence of two or even three root canals in the premolar and even four, five or more roots canals in the molar. The configuration of canals can also vary a lot and there may exist more roots canals in any of the root of these teeth. The particularity in the structure of maxillary and mandibular molars is the possible occurrence of the so-called C-shaped canals which result as a consequence of the growing into one of the roots in these teeth. Examples from daily practice demonstrate the very complex endodontic morphology of teeth and, therefore, the stomatologist must be prepared for these diversities, in order to achieve the best possible endodontic treatment.

Key words: *endodontic morphology, root, root canal*

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Introduction

The pulp cavity is the central space within a tooth and according to its shape, it is its miniature version (1). It is enclosed by dentin, except at the apical foramen and is divided into a coronal portion (the pulp chamber) and a radicular portion (the root canal) (2).

The pulp chamber follows the shape of the crown, and in it we differentiate the roof, lateral walls and bottom. Pulp horns are extensions of the roof of the pulp chamber. A single pulp horn tends to be associated with each cusp in posterior teeth and mesial and distal horns tend to be found in incisors (3). The size of pulp horns depends on the age of a person, on the level of abrasion and

attrition, as well as on the intensity and duration of other stimuli (3). On the bottom of the pulp chambers there are root canal accesses and they are almost always funnel-shaped.

The number, shape and mutual relations of root canals depend directly on the size and shape of the root (3). Although during instrumentation we primarily try to treat major root canals, one still has to bear in mind that internal anatomy is very ramified and that, besides the major canal, it also abounds in lateral and accessory canals. These are both ramifications of the major canal, which enable an additional connection with the periodontium. They can be found in any part of the root, although, they are most frequently situated in the apical third and are most often found in lateral teeth (2).

The diameter of the apical foramen is wide in young teeth but later it becomes narrower due to the deposition of dentin and cementum. The apical foramen is rarely open at the anatomic apex of the root. Most frequently it is situated 0.5-2mm from it.

The apical constriction or *foramen internum* is described as the cementodentinal junction and is situated approximately 1-2mm from the apical foramen, at the place where the cementum enters the root canal. Clinically it is impossible to determine where one tissue ends and the other begins (2).

Although the number, shape and size of root canals are very variable in different teeth, Vertucci's (4) division into eight basic types is today most commonly accepted:

1. Type 1 one canal
2. Type 2 one canal which bifurcates in coronal third and then terminates like one with one apical foramen
3. Type 3 one canal which bifurcates in apical third and terminates in two apical foramina
4. Type 4 two completely separate canals
5. Type 5 one canal which bifurcates in apical third and terminates with two apical foramina
6. Type 6 one canal which bifurcates in coronal third, joins in the middle of the root and then bifurcates again in apical third, terminating with two separate apical foramina
7. Type 7 one canal which bifurcates in apical third, then merges into one and then bifurcates again terminating in one apical foramen

8. Type 8 one canal which separates in three canals in coronal third and terminates with three separate foramina

Maxillary incisors

A central maxillary incisor is a tooth having a relatively simple morphology of endodontic space. According to Ingle and Beveridge (5) in 100% of cases it has one root and one root canal of type 1. The root is voluminous, in oval shape and of average length of 23mm (4) and it tends toward curvature, usually toward the distal, in its apical portion. The root canal follows its shape and ends in the apical foramen which is rarely situated at the anatomic apex of the root and is more often found laterally (to 2mm) (6).

Although extremely rarely, in clinical practice the occurrence of a central maxillary incisor with two roots and root canals has been noticed, which refutes the assertion of Ingle and Beveridge. Sinai (7) reported two roots and root canals in one of his cases.

The case with the lateral maxillary incisor is similar. Its average length is a little less than that of the central maxillary incisor and amounts to approximately 21-22mm (6). Although Green, Pineda, Kuttler (8) and Vertucci (9) have confirmed that in 100% of cases the lateral maxillary incisor is a single-rooted tooth with one canal of type 1, there are a few case reports which refute this, such as for instance. Thomson (8) who found two root canals. Generally, the lateral maxillary incisor is genetically less stable than the central maxillary incisor, so that different anatomic anomalies are found more often in that tooth, and thus the pulp anatomy can differ more than expected.

Maxillary canine

The maxillary canine is the longest tooth in the dental arch and its average length is approximately 26.5mm (6). The root is considerably wider in the labioalatal than in the mesiodistal direction and the root canal is oval, mostly straight with possible curvature towards the distal in the apical third. In literature there have been no reports of

cases of occurrence of two roots or canals in this tooth. In 100% of cases one root and one root canal type 1 can be found.

Maxillary premolars

The frequency of single-rooted first maxillary premolar varies from 31.5-39.5% (Muller, 1933; Bernaba, Madeira and Hetem, 1965; Carns and Skidmore, 1973). In 1979 Vertucci (10) obtained the same data. According to Walton and Torabinejad (2) one root with only one canal of type 1 can be found in this tooth in 10% of cases, one root with two canals of type 2 is found in 12% of cases and one root with two canals of type 4 in 16% of cases. Two roots with two separate canals occur in 57% of cases and, in those cases, one root is situated buccally and the other palatally (2).

Although extremely rarely, three-rooted teeth and teeth with three canals have been described in the literature. Carns and Skidmore (11) and Vertucci (10) found them in 5-6% of the cases. In such situations the occurrence of three separate roots with three separate root canals is most common. This root canal configuration resembles that of a miniature three-canal maxillary molar; the canals being classified as mesiobuccal, distobuccal and palatal canals (12). The configuration of three canals situated in one or two roots is less frequent.

The usual root length of this tooth on average amounts to approximately 21mm (4).

The maxillary second premolar has only one root in a slightly higher percentage than the maxillary first premolar and is considerably wider in the buccopalatal than in the mesiodistal direction. For that reason, the occurrence of a single-rooted tooth with two root canals is quite frequent. Walton and Torabinejad (2) found a single root with one canal of type 1 in 53% of cases, one root with two canals of type 2 in 22%, one root with two canals of type 4 in 13%, and two roots, one buccal and one palatal, with two canals in only 11% of cases.

The occurrence of three roots or canals in this tooth is extremely rare, more rare than in maxillary first premolar. The incidence of 1% can be found in literature (12).

The length of the maxillary second premolar amounts to 21.5mm on the average (4).

Maxillary molars

In most cases, the first maxillary molar has three roots, of which one is palatal and other two buccal, mesiobuccal and distobuccal. In most cases, such root configuration is followed by four root canals, two of which are in the mesiobuccal root (MB1 and MB2) (4). In their study from 1990, Kulild and Peters (13) mentioned the existence of two canals in the mesiobuccal root in 95.2%. According to Walton and Torabinejad (2) this percentage is less and amounts to 60%. They report that 80% are type 2 and only 20% type 4 canals. Pineda and Kuttler (4) obtained different data in their study. They found type 4 canal in the mesiobuccal root in 48.5% of cases. Pomeranz and Fishelberg (14) obtained similar data to Walton (2) and they found two mesiobuccal canals in 69% of cases.

In the palatal, as in the distobuccal root, there is only one canal in most cases.

The average length of the maxillary first molar is approximately 22 mm, the palatal root being a little longer (4). It is the most massive and in 50% of cases, curves in the apical third toward the buccal or palatal direction, which is not visible on the radiograph (4).

In 1983, Martines-Berna et al. (15) described two canals in the distobuccal root. The same phenomenon was described by Hülsmann (16) in his case report in 1997. In his research Hession (17) also mentions two canals in the distobuccal root. Beatty (18) described a case of a three-canal maxillary first molar, all in the mesiobuccal root. Although rare, the merging of both buccal roots is possible (19). It occurs in 0.4% of cases, always bilaterally (20).

Unusual endodontic morphology is very frequent in the palatal root. Two separate canals in that root have been described by Bond et al. (21), Cecic et al. (22), Jacobsen and Nii (23), Slowey (24), Stone and Stoner (25), Harris (26) and Tews et al. (27). In such cases canals can be completely separate and terminate with separate foramina (type 4) or can merge in the apical third and terminate with

one opening (type 2). More unusual is the case of three separate canals in the palatal root, which was described by Wong (28) in 1991. Apart from the number of canals, variations may relate to the different number of roots. Christie et al. (29) described two separate palatal roots in maxillary molars, which fall into three categories:

1. Type I maxillary molars have two widely divergent palatal roots that are often long and tortuous. The buccal roots of these teeth are often "cow-horn" shaped and less divergent. Four separate root apices are seen on the radiograph.
2. A type II maxillary molar has four separate roots also but the roots are often shorter, run parallel and have blunt root apices. A radiograph with buccolingual superimposition may make this type of maxillary molar appear as having only a mesial and distal root.
3. In a type III maxillary molar the distobuccal root appears to stand alone and may even diverge to the distobuccal.

C-shaped canal in a maxillary first molar is extremely rare and has been described only in two cases. It was described in 1984 by Newton et al. (30) and in 1990 by Danker et al. (31). In the latter case the palatal and distobuccal root and canals were completely merged.

The maxillary second molar is in most cases only a smaller copy of the maxillary first molar (4). Its roots are less divergent and their merging is more frequent (4). Root merging depends on race and in literature, the percentage of 45-55% in the white race has been described, while in Mongols it ranges from 65-85% (4). Root and canal merging is the reason for the more frequent occurrence of C-shaped canals in this tooth (4). Walton and Torabinejad (2) mention three separate roots in this tooth in 60% of cases. Two canals with separate foramina in the mesiobuccal root occur in 10% and two separate canals with a single foramen in 15% of cases (2). The incidence of a single canal in the mesiobuccal root is 70% of the cases, which is a greater incidence than in the maxillary first molar (2). In 25% of cases the maxillary second molar can have two and in 10% only one root (2).

Various peculiarities in endodontic morphology are possible in this tooth. In 1988 Fahid (32) des-

cribed a case with two distobuccal roots and canals. Although root merging is usual in a maxillary second molar, literature describes cases of four separate roots, although in a very small percentage and, according to Libfeld and Rotstein (33) merely 0.4%.

There are many variants in the endodontic morphology of maxillary third molars. They are very unpredictable and can even be single or two root-canal (4).

Mandibular incisors

Numerous authors have studied in different ways the endodontic morphology of these teeth and, therefore the data obtained in literature can vary significantly.

The average length of these teeth is approximately 21mm, the central incisor being somewhat shorter (4). Most authors agree that in most cases there is one root and one canal of type 1. According to Walton and Torabinejad (2) in the central incisor it is 70% and in the lateral incisor it is 55%. Two root canals of type 2 and 3 can be found in 25% of cases in the central and in 30% in the lateral incisor. Two canals of type 4 can be found in the central incisor in 5% and in the lateral in 15% of cases. If two root canals occur one is labial and the other lingual.

Kartal and Çaliçkan (34) studied the incidence of the second canal and in one of their investigations they obtained data of it being 45%, of cases 37% merging in one common foramen, forming a root canal of type 2 or 3. Benjamin and Dowson (35) obtained similar data in their research. They found a second root canal in 41.4%. Madeira and Hetem (36), Vertucci (37) and Green (38) describe a more rare incidence of a second canal in mandibular incisors. In 1997 Miyashita et al. (39) carried out similar research and obtained the following results: 87.8% of the researched mandibular incisors were single-canal of type 1; 12.4% were double-canal, only 3.1% of type 3 or 4.

The incidence of a second root canal in mandibular incisors can usually be the reason for failure in endodontic therapy because it is often not noticed. Therefore, one must be very careful in instrumentation of these teeth.

Mandibular canine

In most cases the mandibular canine is a single-rooted and single-canal tooth of type 1, according to Walton (2) in 70%. In 1985 Kaffe (4) mentions two root canals in the mandibular canine in 14%, but less than 6% of type 4. Walton describes rather different results: the incidence of two canals 30%, of which 20% of type 2 or 3 and 10% of type 4. When there are two canals one is labial and the other lingual. The average length of the tooth is 22.5mm (4).

Mandibular premolars

The mandibular premolar is usually a single-rooted tooth with one root canal of type 1. According to Walton and Torabinejad (2) the incidence is 70%. They also mention one root with two root canals of type 2 or 3 in 4% of cases. Double-rooted tooth, which is formed due to the separation in the apical third, occurs in 25% of the cases, with the prevalence of root canal of type 4 or 5. In such cases one root is most frequently buccal and the other lingual.

According to many authors, this tooth can be one of the biggest problems for endodontic treatment (24,40). The reason is unpleasant variants in the number and configuration of root canals. Pineda et al., Green, Zillich et al. and Vertucci (41-44) found three root canals in the mandibular first premolar in 0.4-0.9% of cases. In a study from 1986 Trope et al. (45) confirmed a higher percentage of these teeth with two or more root canals in black patients. They showed two or more root canals in mandibular first incisors in 32.8%, while in white patients this percentage was 13.7% (45). In mandibular second premolars the difference is somewhat smaller; in black patients the incidence was 7.8% and in white patients 2.8% (45).

According to Walton and Torabinejad (2) the percentage of single-rooted mandibular premolars is higher than in mandibular first premolars and amounts to 97%, 85%, of type 1 and 12% of type 2 or 3. These authors mention double-rooted and double-canal mandibular second premolars in 3% of cases (2). In such situations, one canal is lingual and the other buccal, although this is not

always the case. Goswami et al. (46) found the same tooth with two canals, one located mesially and the other distally. The same case was described by Serman and Hasselgren (40) in 1992. Literature describes cases of mandibular second premolars with three (43, 47) and even four root canals (48).

The difficulty in the endodontic instrumentation of these teeth is the difficulty in detection of possible numerous canals. Usually they are not visible on the radiograph and clinically they are quite difficult to detect. One canal often separates in the apical third into several canals, terminating in separate foramina.

Mandibular molars

In most of cases the mandibular first molar has two roots, mesial and distal. The distal one is usually somewhat smaller with an oval shape (4). The average length of this tooth is 21mm (4). It is usually three-canal; two located in the mesial and one in the distal root (4). The distal canal is wider and more oval than the mesial ones (4). According to Walton and Torabinejad (2) two canals of type 4 in the mesial root can be found in 60% and type 2 and 3 in 40% of the cases. It is possible to find one canal in the distal root in 70% and two canals in 30% of cases. Of that percentage 20% is of type 2 and 10% of type 4.

Like many others this tooth can also have certain peculiarities in endodontic morphology. Many authors describe three canals in the mesial root (49-53) and this configuration can be found in 2-15% of cases (53). A third canal in the mesial root is always located between the mesiolingual and mesiobuccal canal (51). It can have its own apical foramen or it can join one of the mentioned canals (50). In his study of 1985 Fabra-Campos (54) investigated in vivo 145 mandibular first molars and found four examples with three canals in the mesial root, which is an incidence of 2.75%.

In the mandibular first molar the occurrence of three root canals in the distal root is also possible, but less frequent than in the mesial root (51). Such a case was described by Beatty et al. (52).

The mandibular second molar is a smaller version of its mesial neighbour (4). Its average length

s 20mm (4). In the mesial root two root canals can be found in 75% and one canal in 25% of cases (2). If there are two canals then 40% of them are of type 4 and 35% type 2 (2). In the distal root one root canal is found in 92% and two root canals in 8% of the cases (2). 3% are canals of type 4 and 5% canals of type 2 (2).

Root merging in the mandibular second molar is very frequent and especially in Mongols (4). This incidence ranges from 33-52% (4). C-shaped canal may occur due to root merging. It can be found only on the bottom of the pulp cavity in the cervical portion of the tooth or extending through the entire root, reaching the apex (55).

A mandibular third molar shows numerous variants in the endodontic morphology, however it has some similarities with the mandibular second molar (4).

Conclusion

The endodontic morphology of permanent teeth is very complex and varied. Although much is known about this subject today, surprises in this field are not unusual. Thus one must be very careful and well informed before starting any kind of endodontic treatment. This is the prerequisite for a successful endodontic therapy.