Razmazni sloj u endodonciji

Smear Layer in Endodontics

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KRATAK SADRŽAJ

Savremene metode čišćenja i oblikovanja kanala dovode do formiranja razmaznog sloja na preparisanim površinama kanala korena zuba. ***Cilj*** *ovog rada je bio da ukaže na klinički značaj razmaznog sloja u endodonciji. Razmazni sloj nastaje kao posledica instrumentacije zidova kanala i sadrži organske i neorganske čestice sečenog dentina, nekrotično i/ili vitalno tkivo pulpe, mikroorganizme i njihove raspadne produkte. Prisustvo razmaznog sloja utiče na propustljivost dentina korena, umanjuje efekat intrakanalnih medikamenata i smanjuje atheziju materijala za opturaciju za zidove kanala.Uklanjanje razmaznog sloja sa zidova kanala podrazumeva upotrebu različitih hemijskih sredstava, kao i ultrazvučnu i lasersku tehniku. Bez obzira na oprečne stavove i mišljenja, uklanjanje razmaznog sloja je neophodno zbog moguće kontaminacije bakterijama, umanjenog efekta intrakanalne medikacije i stvaranja uslova za bolju opturaciju kanalskog sistema zuba.*

Ključne reči: razmazni sloj, mikroorganizmi, intrakanalni medikamenti, opturacija.

SUMMARY

Modern methods of root canal cleaning and filing are causing formation of the smear layer on treated surfaces.

The aim *of this paper was to review clinical aspect of smear layer in endodontics. Smear layer is the consequence of instrumentation of root canal walls and is consisted of organic and inorganic particles of cut dentine, necrotic and/or vital pulp fragments, microorganisms and their products. Existence of smear layer is affecting permeability of the radicular dentine, thus decreasing effects of canal medicaments and impairing adhesion of obturation materials in root canal. Removal of the smear layer from canal walls is possible with use of various chemical agents, ultrasonic or laser techniques.*

Regardless to contradictory attitudes and opinions, removing the smear layer is required for possible bacterial contamination, compromised effects of root canal medication and in order to obtain better obturation of canals' system.

Key words: smear layer, microorganisms, root canal medicaments, obturation.

Uspeh endodontskog lečenja obolelog zuba zavisi od brojnih faktora, a pre svega od kvalitetnog čišćenja i oblikovanja kanala, odnosno adekvatne opturacije kanalskog sistema zuba. Međutim, pravilna preparacija kanala (čišćenje i oblikovanje) odgovarajućim endodontskim instrumentima, dovodi do formiranja mikrosloja na zidovima kanala koji je u literaturi poznat kao razmazni sloj (smear layer) i čija je uloga predmet brojnih rasprava među endodontistima. (Sl.1)

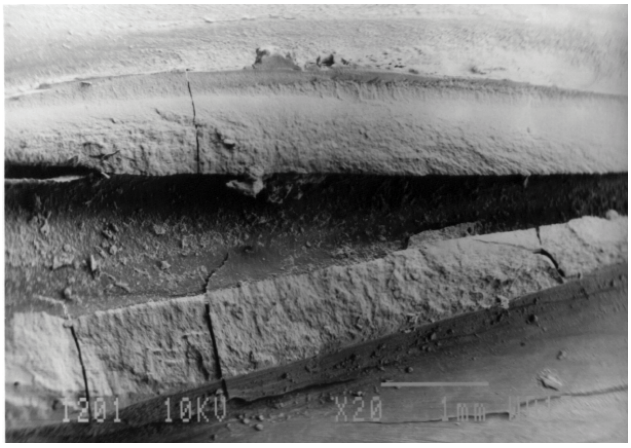
Razmazni sloj je proizvod instrumentacije zidova kanala korena, odnosno posledica sečenja i abrazije dentina i ne postoji na neinstrumentisanim površinama kanala.[1] Od momenta kada je prvi put opisan[1], razmazni sloj je postao predmet brojnih kontaverzi i rasprava,

Success rate of endodontic treatment of a pulp diseased tooth is depending on numerous factors, but predominantly on good cleaning and root canal filing, and subsequently on adequate obturation of canals' system. However, an accurate canal preparation (cleaning and filing) with proper endodontic instruments is causing formation of a microlayer on root canal walls, known as smear layer which properties have been widely discussed among endodontists. (Fig. 1)

Smear layer is the consequence of root canal walls instrumentation; i.e. it is the result of dentine cutting and abrasion and it cannot be found on untreated canal surfaces[1]. Since was described initially[1], smear layer has become the subject of many controversies and discussions,

prvenstveno zbog nepoznavanja njegove morfologije, sastava, fizičkih i bioloških osobina.[2-5] Drugi, ne manje značajan predmet sporenja među istraživačima, bilo je pitanje da li razmazni sloj treba ukloniti sa zidova kanala ili ostaviti.

primarily for the reason that its morphology, composition and biological characteristics still remain unknown[2-5]. Other, but not less important and disputable issue among researchers is the question whether smear layer should be removed of not from root canal walls.



Slika.1: Skening elektronska mikrografija (SEM) uzdužnog preseka preparisanog kanala korena zuba sa razmaznim slojem na površini zida dentina.

Figure 1: Scanning electrone micrograph (SEM) of a treated root canal cross section, with smear layer on dentine surface.

Osnovni argument većine istraživača koji smatraju da razmazni sloj treba ukloniti je činjenica da ovaj sloj zatvara dentinske tubule kanala korena i time sprečava efekat intrakanalnih medikamenata, odnosno efikasnost dezinfekcije kanala tokom endodontske intervencije.[3,6] Osim toga razmazni sloj sadrži i značajnu količinu organskih materija (sa bakterijama i njihovim produktima) koje mogu biti značajan rezervoar iritanasa iz kanalnog sistema, a koji mogu dovesti do oštećenja periapeksnih struktura zuba.[1,4,5,7,8] Uklanjanje razmaznog sloja sa zidova kanala pre definitivne opturacije kanalskog sistema značajno povećava atheziju paste za zidove i time povećava kvalitet zaptivanja, a smanjuje pojavu mikrocurenja duž zidova kanala i komunikaciju između usne duplje i periapeksnih struktura.[9-14]

Jedna grupa istraživača, međutim, smatra da prisustvo razmaznog sloja na zidovima kanala korena može predstavljati barijeru za prodor bakterija u dentinske tubule, odnosno, barijeru bakterijama koje su već prodrle u dentinske kanaliće pre instrumentacije da izađu u neadekvatno opturisan kanal i ispolje svoju patološku aktivnost.[15-17]

Međutim, iako je uspeh endodontske intervencije zasnovan na pravilnoj dijagnozi, kvalitetno realizovanoj instrumentaciji i opturaciji kanala, opšte prihvaćen stav u endodonciji je da pravilan debridman predstavlja najvažniji aspekt uspešnog endodontskog lečenja.

The main argument of the greater number of scientists recommending removal of the smear layer, is the fact that this layer obturates dentinal tubules in root canal and effects of canal medication are blocked, as well as the efficacy of disinfecting during endodontic treatment[3,6]. In addition, smear layer is containing significant amount of organic material (including bacteria and their products), which can act as a reservoir to irritation factors in canals' system and influence further disorders in periapical structures of the tooth[1,4,5,7,8]. When smear layer is removed from root canal walls prior to canal obturation, adhesion of the sealing material to the walls is increased and adaptation improved, thus preventing microleakage and communication path between oral cavity and periapical structures[9-14].

Not many authors claim that existence of the smear layer on root canal walls may present a barrier against bacterial penetration into dentinal tubules and vice versa, a barrier against microorganisms that already have penetrated dentine before endodontic instrumentation, to flow back into inadequately obturated canal and express their pathogenicity[15-17].

Even though success of endodontic treatment is based on adequate diagnosis, successfully completed instrumentation and canal obturation, it is generally accepted in endodontics that a thorough debridement is the most important aspect of endodontic treatment.

Sastav i struktura razmaznog sloja

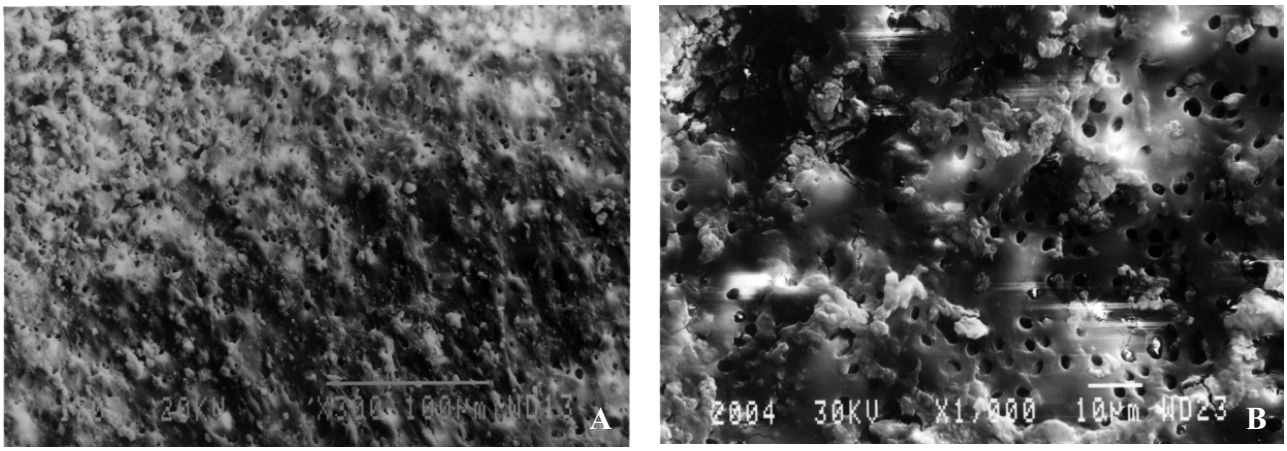
Pri preparaciji kanala korena zuba ručnim ili mašinski pokretanim instrumentima, na površini dentina se formira specifična površinska struktura koja pokriva i naj-

Composition and structure of smear layer

When root canal is prepared, manually or mechanically, a specific structure is formed on dentine surface, which is covering dentine texture and is often closing

manju strukturu dentina i, često pokriva otvore dentinskih kanalića.[5,7,18] Ovaj sloj koji nastaje kao posledica instrumentacije sadrži organske i neorganske čestice sečenog dentina, nekrotičnog ili vitalnog tkiva pulpe odontoblastne nastavke, bakterije i ćelije krvi. (Sl. 2a i b)[4,5]

openings of the tubules[5,7,18]. This layer that is consequenting from instrumentation, contains organic and inorganic particles of cut dentine, necrotic or vital pulp fragments, odontoblasts endings, microorganisms and blood cells[4,5] (Fig. 2a & b).



Slika 2: Skening elektronska mikrografija (SEM) razmaznog sloja na površini dentina preparisanog kanala korena: A) pod manjim uveličanjem i B) pod većim uveličanjem (uočavaju se otvori dentinskih tubula).

Figure 2: Scanning electron micrograph (SEM) of smear layer on dentine surface in a treated root canal: A) lower magnification and B) higher magnification (note the openings of dentine tubules).

Razmazni sloj na zidovima kanala, posmatran SEM-om, izgleda kao iregularna, amorfna masa sa granuliranom površinom.[7,19,20] Ovaj sloj je najčešće sastavljen iz dva odvojena sloja: jedan površni koji je tanak i slabo atherira za dentin i drugi koji je čvrsto vezan sa dentinom i u vidu čepova zatvara ulaze dentinskih kanalića.[19,20,21,22]

Sa hemijske tačke gledišta, razmazni sloj se sastoji iz dva dela, organskog i neorganskog. Organski deo razmaznog sloja se, većim delom, sastoji od dentinskih kolagenih vlakana i glikozaminoglikana iz organskog ekstraćelijskog matriksa[1,4,5] i služi kao matriks za drugi dominantni neorganski deo[8,23]. Ovaj sloj može, ponekad, da sadrži i bakterije (usled kontaminacije kanala nesterilnim instrumentima, odnosno, neadekvatnog privremenog zatvaranja).[3,5]

Varijacije u debljini i sastavu razmaznog sloja na zidovima kanala korena posledica su anatomije kanala, prirode dentinskog tkiva (uzrast pacijenta, nekrotičan ili vitalan dentin), primenjenih tehnika preparacije (ručne, mehaničke), količine i vrste irigacinog rastvora, odnosno tehnike irigacije (klasična igla i igla sa tupim vrhom i perforacijama sa strane)[7,19,20,24]

Postoji saglasnost među istraživačima da intenzivnija instrumentacija kanala korena formira deblji sloj, odnosno, da je debljina razmaznog sloja u zavisnosti, pre svega, mehaničke instrumentacije.[7,20] Debljina površnog sloja je, najčešće, 1-2μm dok dubina sloja utisnutog u dentinske kanale može biti i do 40 μm.[8,22]

Različite vrste bakterija (uglavnom anaerobni sojevi) se mogu naći u razmaznom sloju na zidu kanala korena.[25,26] Kako je morfologija korenskih kanala vrlo kom-

When analysed by SEM, smear layer on root canal walls appears as an irregular amorphous mass with grained surface[7,19,20]. It is commonly built from two separate sublayers: (a) superficial, which is thin and adhering to dentine walls delicately and (b) underlying, which is firmly attached to dentine capping openings of the tubules [19-22].

From the chemical point, smear layer has two components, organic and inorganic. Organic part of the smear layer contains dentine collagen fibres and glycosamineglycane, originating from extracellular matrix[1,4,5]. This part presents the base for the other, dominant inorganic[8,23]. It, sometimes, contains bacteria (canals contaminated with non-sterile instruments, and more by inadequate temporary filling)[3,5].

Variations in thickness and composition of the smear layer on root canal walls are caused by the anatomy of root canals, dentine tissue properties (patient's age, necrotic or vital dentine), preparation techniques applied (manual, mechanical), quantity and type of irrigating agents, i.e. irrigation techniques (standard needle, blunt perforated needle)[7,19,20,24].

Most researchers agree that exstensive instrumentation of root canal subsequently is leading to formation of smear layer, which means that thickness of the layer depends on instrumentation[7,20]. Common depth of superficial sublayer is 1-2 μm, while the depth of the sublayer impressed into dentinal tubules may be up to 40 μm[8,22].

Different bacterial species (anaerobs) can be detected in smear layer existing on root canal walls[25,26]. Considering the complexity of root canals morphology and sur-

pleksna i sve površine kanala nisu u potpunosti dostupne savremenim endodontskim instrumentima, značajan broj bakterija može zaostati na tim nepristupačnim delovima kanalskog zida.[27] Dakle, bakterije se mogu naći na svim površinama sistema korenskog kanala, odnosno, dentinskim tubulima inficiranih kanala.[28,29] Dentinski kanalići u korenskom delu dentina se pružaju relativno pravolinijski od pulpe prema periferiji (nasuprot S-obliku kanalića u kruničnom dentinu) što omogućava bakterijama da prodru duboko u tubule, skoro do polovine rastojana između zida kanala i cementno-dentinske granice.[18] Faktori, kao što su vrsta zuba, uzrast, broj i vrsta bakterija, odnosno, dužina ekspozicije korenskih kanala značajno utiču na dubinu prodora bakterija u dentinske kanaliće.[6]

Piters i sar. su izučavali prisustvo, dubinu prodora, morfogenetske tipove i broj bakterijskih kolonija u dentinu korenova zuba sa periapeksnim lezijama i utvrdili, kod više od polovine uzoraka, prodor bakterija u blizini cementne granice.[30] SEM ispitivanja humanih zuba sa nekrotičnom pulpom Sena[29] i saradnika su ukazala na bakterijski prodor u dentinske tubule do 150 μm u apeksne dve trećine korena, a Perez[31] i saradnici nalaze srednju vrednost prodora od 479 μm, odnosno, maksimalan prodor bakterija u dentinske kanaliće od 737 μm.

Faktori koji utiču na formiranje razmaznog sloja

Nesumnjivo je potvrđeno jatrogeno poreklo razmaznog sloja, jer na površinama kanalskog zida koje nisu bile izložene delovanju endodontskih instrumenata ovog sloja nema.[8,19]

Na formiranje razmaznog sloja utiču faktori na koje se tokom endodontske intervencije ne može uticati (komplikovana morfološka struktura kanalskog sistema zuba, povijenost kanala) i faktori koji se mogu kontrolisati tokom endodontske procedure. Ova druga grupa obuhvata izbor endodontskih instrumenata (ručni, mašinski, ultrazvučni), tehniku preparacije (standardna, step-back, crown-down), izbor i količinu irigansa (NaOCl, EDTA), tehniku irigacije (obična igla, igla sa perforacijama sa strane) i naravno vestina terapeuta.[7,8,19,24,32,33]

Složenost kanalskog sistema značajno umanjuje efikasnost čišćenja i oblikovanja kanala. Različiti oblici kanala (nepravilan, elipsast, sužen, povijen) otežavaju pravilnu manipulaciju endodontskim instrumentima, pa se na zidovima kanala mogu uočiti područja koja su zahvaćena instrumentacijom i neinstrumentisane zone. Ove nepravilnosti, odnosno, divertikuli u kanalskom sistemu obično predstavljaju "depoe" za određenu količinu debrisa i razmaznog sloja, koje je teško ukloniti klasičnom irigacijom.[32-34]

Instrumentacijom dentinskog zida kanala omogućava se sečenje sloja dentina rotacionim pokretima ili pokretima turpijanja. Mehanizam sečenja je, ustvari, kompresivni

faces unreachable for endodontic instruments, significant number of microorganisms is left on hidden sites of root canal walls[27]. That means that bacteria can be detected in all surfaces of canals system, and more exactly in dentine tubules of infected canals[28,29]. Dentine tubules in radicular part are linear, directed from the pulp toward peripheral parts (opposite to S-shaped tubules in crown's dentine), which is enabling microorganins to penetrate deep into the tubules, almost the half-distance between canal wall and cement-dentine junction[18]. Factors, like type of the tooth, age, number and bacterial types, and root canals exposure, significantly influence the depth of bacterial leakage into dentinal tubules[6].

Peters and co-workers have studies presence, penetration depth, morphogenetic types and counts of bacterial colonies in radicular dentine with periapical lesions and have reported that in more than half of the samples examined, bacterial penetration has reached cement border[30]. SEM analysis of human teeth with necrotic pulp, undertaken by Sen and co-workers[29], has shown that depth of bacterial penetration into dentinal tubules was up to 150 μm in apical two-thirds of the root. Perez et al.[31] has found that mean value of penetration was 479 μm to 737 μm max.

Factors of influence in formation of smear layer

It was undoubtedly confirmed that smear layer is resulting from iatrogenic reasons since surfaces that were not treated endodontically do not have this layer attached[8,19].

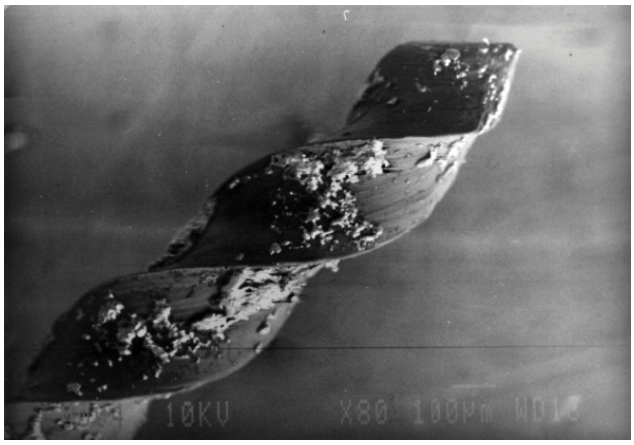
Formation of smear layer is affected by the factors, which cannot be modified (complex morphology of dental canals' system, curved root canals) and factors, which can be controlled over the endodontic procedures. The latest are choice of endodontic instruments (manual, mechanical, ultrasonic), preparation technique (common, step-back, crown-down), selection and quantity of irrigating agents (NaOCl, EDTA), irrigation technique (standard needle, blunt perforated needle) and working skill[7,8,19,24,32,33].

Complexity of the canals' system is significantly limiting the efficacy of cleaning and filing root canals. Various shapes of root canals (irregular, elliptic, narrow, curved) contribute to difficulties in adequate manipulation with endodontic instruments, which is consequenting in unevenly treated zones on canal walls. These irregularities are known as diverticles in canals' system and are usually acting as "depots" for detritus and smear layer that are very difficult to remove with simple irrigation[32-34].

During instrumentation of root canal, dentine is cut by rotational and filing movements. Cutting mechanism is a compressive stress on cutting edges of the endo-

stres na sečivne ivice endodontskog instrumenta što omogućava sečenje (odlamanje) sloja dentina. Efikasnost sečenja zavisi pre svega od dinamike rada instrumenta, primenjene sile, odnosno od oblika i obima sečiva, konfiguracije osovine instrumenta, dizajna vrha, otpornosti na trošenje i mogućnosti eliminisanja piljaka tokom manipulacije.[2,35,36] Kada dođe do akumulacije dentinskog detritusa između sečiva radnog dela instrumenta, smanjuje se radni efekat i povećava trenje između instrumenta i zidova kanala. Time se smanjuje sečivni ugao i sečivna efikasnost, a više dolazi do izražaja abrazivni efekat instrumenta što ima za posledicu formiranje veće količine razmaznog sloja na zidu kanala korena. Formiranje ovog sloja je još izrazitije ukoliko se instrumentacija realizuje bez pravilne irigacije kanalskog sistema.[34,36] (Sl.3) Treba napomenuti da se na početku instrumentacije, na zidovima nalazi mnogo više organskih materija, koje bolje atheriraju za metalne delove instrumenta, formirajući jedan sloj koji omogućava lepljenje dodatnih opiljaka sa dominantnom mineralnom komponentom dentina kanala korena zuba.[34]

dontic instrument and subsequent result is breakage of dentine parts. Efficacy of cutting is primarily dependent on working dynamics, applied force, shape and size of the blades, instrument's axis configuration, tip of instrument, resistance and elimination of excess particles during manipulation[2,35,36]. When dentinal detritus is accumulated in blades of the instrument, working effect is impaired and friction between the instrument and canal walls is increased. In that way, both cutting angle and cutting effect are decreased with the consequence in formation of larger amount of smear layer on root canal walls. It becomes more extensive when proper irrigation is skipped[34,36] (Fig.3). It should be noted that there is a lot more organic material on canal walls in the beginning of instrumentation, which is stuck to metal parts of endodontic instrument and is causing subsequent adhesion of dentine particles with predominant mineral component attached[34].



Slika 3: Skening elektronska mikrografija (SEM) opiljaka sečenog dentina kanala korena zuba na vrhu ručnog endodontskog instrumenta.

Figure 3: Scanning electron micrograph (SEM) of root canal dentine particles on top of the endodontic file.

Ispitivanja su, takođe, potvrdila da ručna instrumentacija rezultuje manjim količinama i tanjim razmaznim slojem u poređenju sa mašinskim rotirajućim instrumentima. Mašinska obrada kanala obezbeđuje intenzivniju instrumentaciju a veće brzine pri rotaciji i formiranje kompaktnijeg razmaznog sloja na površini zida kanala, ali i u dentinskim tubulima.[7,22]

Postoji saglasnost među istraživačima da sonična i ultrasonična preparacija obezbeđuju najefikasnije čišćenje i debridman kanala korena zuba, a samim tim i najmanje zaostajanje razmaznog sloja na zidovima kanala tokom instrumentacije. Naime, ovde je obezbeđen sinergičan efekat mehaničkog delovanja instrumenta u kanalu i hemijskog efekta odabranog irigansa. Velike količine irigansa usmerene su na radni deo instrumenta čime obezbeđuju efikasnije uklanjanje dentina (bez zaostajanja opiljaka između sečiva) i, naravno, sprečavaju zadržavanje opiljaka na zidovima kanala korena.[23,24,37-40]

Ispitivanja Kaningama i saradnika[40] pokazala su da ultrazvučna instrumentacija obezbeđuje zadovoljavajući, ali neujednačen debridman kanala korena. Zbog problema da

There are some studies, which have shown that manual instrumentation is causing less smear layer comparing to use of rotational instruments. Mechanical treatment of root canal is giving more effective instrumentation but, also, higher speed of rotation influences compact smear layer on the surface and in dentinal tubules[7,22].

Researchers agree that sonic and ultrasonic preparation of root canal are the most efficient in cleaning and debriding that is leading to only minor formation of smear layer. In other words, mechanical instrumentation and chemical properties of irrigation solution here are acting synergistically. Massive irrigation is directed toward working part on the instrument and removal of dentine becomes more efficient (particles are washed out from cutting edges) and prevents debris binding on root canal walls[23,24,37-40].

Studies of Cunnigham et al.[40] have indicated that by ultrasonic instrumentation, a satisfactory but uneven debridement of root canal is obtained. Irrigating solution is not penetrating apical part of the canal and cleaning of

irigacioni rastvor prodre u apeksni deo kanala, čišćenje ovog segmenta zuba je manje efikasno pa u ovom delu dolazi do zaostajanja značajnih količina razmaznog sloja.[39,40]

Osnovni cilj preparacije kanala korena je adekvatno čišćenje i oblikovanje kanalskog prostora endodontskim instrumentima uz obilnu irigaciju antiseptičkim rastvorima kako bi se obezbedila dobra opturacija. Naravno, kvalitet preparacije najviše zavisi od anatomije kanala, odnosno, tehnika instrumentacije i irigacije.

Kvalitetniji debridman kanala se ostvaruje primenom tehnika preparacija sa koronarnim pristupom, jer se na ovaj način omogućava i bolji mehanički efekat endodontskih instrumenata i bolji hemijski efekat irigacionih rastvora. Sve ovo rezultuje stvaranjem manjih količina razmaznog sloja.[2,35,41-43]

Potvrđeno je da preparacija kanala bez irigacije dovodi do zaostajanja 70% više razmaznog sloja na zidovima kanala.[38,39] Efikasnost irigacije u uklanjanju razmaznog sloja zavisi od širine kanala, vrste i količine irigacionog rastvora (NaOCl, H_2O_2, hlorheksidin diglukonat, EDTA) i tehnike irigacije. Veće zaostajanje razmaznog sloja je uočeno posle korišćenja klasične igle i šprica za ispiranje kanala, a efikasnije uklanjanje ovog sloja primenom igle sa zatupastim vrhom i perforacijama sa strane. Igla za ispiranje sa perforacijama sa strane pod pritiskom dovodi do odlubljivanja razmaznog sloja sa zidova kanala i time do efikasnijeg debridmana kanalskog prostora. Sam irigacioni rastvor ima fizički efekat na razmazni sloj (uklanja ga ili smanjuje debljinu) i hemijski (razlaže, demineralizuje) i time obezbeđuje bolju propustljivost dentina kanala korena zuba.[19,23,44]

this segment is less efficient with consequent smear layer stagnation[39,40].

The main task in root canal preparation is adequate cleaning and shaping of the canal with endodontic instruments and irrigating antiseptic solutions that will provide good obturation. It is certain that the quality of preparation depends mostly on the anatomy of root canal, instrumentation and irrigation technique.

An adequate debridement of root canal is obtained by preparation techniques with coronal approach since that is enhancing mechanical effect of endodontic instruments and chemical effect of irrigation solutions. All these procedures are resulting with small amounts of smear layer[2, 35, 41-43].

It was confirmed that preparation of root canal without irrigation causes up to 70% more stagnation of smear layer[38,39]. Efficacy of irrigation in removal of the layer depends on canal width, type and quantity of the solution (NaOCl, H_2O_2, chlor-hexidine-digluconate, EDTA) and on irrigating technique. More significant stagnation of smear layer was observed following irrigation with standard needle and syringe, while more efficient when blunt perforated needle was used. Blunt needle for irrigation is enabling detaching of smear layer from root canal walls under pressure, thus making debridement of canal more efficient. Irrigation solution has physical (removal of smear layer) and chemical (dilute, demineralise) properties in enhancing permeability of radicular dentine[19,23,44].

Klinički značaj razmaznog sloja u endodonciji

Klinički značaj razmaznog sloja i oprečni stavovi o tome da li ga uklanjati ili ne, još uvek je predmet mnogobrojnih rasprava u endodonciji. Ovaj problem bi se mogao analizirati kroz prizmu savremenih metoda preparacije kanala, odnosno, kroz činjenicu da svaka instrumentacija dovodi do formiranja razmaznog sloja. Ovaj sloj može da sadrži bakterije, da zbog pokrivanja i blokiranja dentinskih tubula smanjuje propustljivost dentina i sprečava efekat intrakanalnih medikamenata, i na kraju, da sprečava atheziju između materijala za opturaciju i kanalskih zidova.

Infekcija kanalskog prostora omogućava da bakterije prodru do ramifikacija, istmusa, apeksne delte i u dentinske tubule. Stalno prisutna infekcija periapeksnih tkiva je često uzrokovana mikroorganizmima iz dentinskih tubula. Invazija u dentinske tubule je olakšana dimenzijom bakterija (manja je od prečnika tubula) i njihovom ishranom u dentinskim kanalićima. Bakterije, koje se nalaze bliže zidu kanala korena najčešće se uklanjaju mehaničkom preparacijom ili razaraju hemijskim efektom irigacionih rastvora, dok bakterije u dubljim slojevima dentinskih tubula, mogu da zaostanu i posle čišćenja i oblikovanja kanala korena zuba.

Clinical aspects of smear layer in endodontics

Clinical aspects and opposite opinions on whether smear layer should be removed or not still present issues of numerous discussions in endodontics. This problem could be analysed from the point of contemporary methods in root canal preparation, that is through the fact that every instrumentation is resulting in smear layer formation. This layer may contain microorganisms; decrease dentine permeability because it covers dentinal tubules, limit the effect of root canal medicaments and, eventually may prevent adhesion of obturation material to canal walls.

Infection of the canal is further complicated by bacterial leakage to ramification, isthmus, apical delta and into dentine tubules. Persisting infection in periapical tissue is often caused by bacterial interactions in dentinal tubules. The size of bacterial cell is making easier invasion into the tubules (smaller diameter of bacterial cell comparing to tubule's). Microorganisms that are closer to canal wall are removed by mechanical preparation or affected by chemical irrigation, while strains in deeper parts of dentine tubules are remaining after canal was cleansed and shaped. If obturation is not hermetic percolation of tissue

Ukoliko opturacija ne obezbeđuje hermetičko zaptivanje, moguća je perkolacija tkivne tečnosti ili pljuvačke čime se omogućava njihovo dodatno razmnožavanje.[25-27,29-31,45]

Intaktan razmazni sloj, koji se formira na površini dentina posle instrumentacije kanala, može imati dvostruku ulogu. Naime, on može da blokira penetraciju bakterija i/ili fluida u dentinske kanaliće posle obrade kanala, ali u isto vreme, i da izoluje i spreči već prodrle bakterije da, iz dentinskih tubula ponovo dođu u kanalski sistem (zbog neadekvatne opturacije) i periapeksne strukture.[3,15-17]

Iako eksperimentalni rezultati nekih istraživanja potvrđuju tezu da razmazni sloj inhibira prodor bakterija u dentinske tubule, klinička relevantnost ovih nalaza je prilično nesigurna, jer su eksperimenti vršeni na dentinskim diskovima različite debljine, koji ne odgovaraju kliničkoj situaciji.[15,16]

Klinički važan aspekt u ovom slučaju je da li razmazni sloj sadrži bakterije ili ne. Naime, ovaj sloj može sadržati bakterije iz pljuvačke ukoliko dođe do kontaminacije kanalskog sistema tokom endodontske intervencije ili usled neadekvatnog privremenog zatvaranja između dve posete. Iako postoji rašireno mišljenje da ovaj sloj, najčešće, sadrži bakterije, malo je kliničkih dokaza o tome.[1,4,5] Sigurno je, međutim, da ukoliko bi razmazni sloj sadržao bakterije, osnovni klinički cilj bi bio njegovo potpuno uklanjanje iz kanalskog sistema.[3,27-29]

Činjenica je, takođe, da jedinstvena kanalikularna struktura čini dentin propustljivim za mnoge supstance. Propustljivost dentina kontrolišu difuziona površina, debljina dentina, temperatura, promer kanalića (širi su u blizini pulpe), veličina i rastvorljivost supstanci koje difunduju i dr.[46-48] Potvrđeno je, takođe, da je korenski dentin manje propustljiv od kruničnog. Korenski deo dentina prema pulpi poseduje 20%, a deo dentina prema periodontalnom ligamentu samo 2% od propustljivosti koju ima krunični dentin.[46,49]

Međutim, dva glavna faktora koji direktno utiču na propustljivost korenskog dentina su razmazni sloj i smanjenje debljine dentina posle instrumentacije i obrade kanala korena.[47,48,51]

Osnovni ciljevi endodontskog lečenja su uklanjanje obolelog (nekrotičnog, inficiranog) dentina, eliminacija bakterija iz kanala korena i dentinskih tubula, i prevencija ponovne kontaminacije kanala nakon završenog endodontskog lečenja. Zbog kompleksnosti kanalskog sistema i nemogućnosti instrumentacije svih površina kanala, za uništenje zaostalih bakterija u kanalu preporučuje se primena intrakanalnih medikamenata.[52,53] Potvrđeno je, takođe, da su mnogi medikamenti u laboratorijskim uslovima jaka antibakterijska sredstva, ali je njihova efikasnost u kliničkim uslovima nepredvidiva zbog ograničenog antibakterijskog efekta i antigenog potencijala, ali i zbog ograničene difuzije u dentinske kanaliće.[52,54] Brojna eksperimentalna i klinička istraživanja su potvrdila da prisustvo razmaznog sloja i okluzija dentinskih tubula značajno smanjuje efekte

fluids and saliva occur and bacterial reproduction is continued[25-27,29-31,45].

Intact smear layer that was built after instrumentation can act in two ways. Namely, it can prevent bacteria and/or fluids from penetrating into dentinal tubules following endodontic treatment and, in the same time, stop microorganisms, which have already leaked into the tubules, to return back in canal and periapical tissues if obturation was incorrect[3,15-17].

Although experimental data support the assumption that smear layer is inhibiting bacterial penetration in the tubules, clinical relevance of these findings is uncertain since the experiments were developed on dentine discs of different sizes that are not coinciding with clinical situation[15,16].

One, clinically important thing, here is the question if smear layer contains bacteria or not. Smear layer could harbour salivary strains if canals are contaminated during endodontic treatment or if temporary filling was inadequate. Though is it widely accepted that, most likely, this layer contains microorganisms, only little clinical evidence is available[1,4,5]. However, it is certain that if smear layer was harbouring bacteria, the main clinical goal would be its complete removal from root cana[l3,27-29].

There is another fact that unique canalicular structure is making dentine permeable for various substances. Dentine permeability is controlled by extent of diffusion, thickness of dentine, temperature, tubular diameter (as closer to the pulp it becomes wider), the size and solubility of diffusing particles and so forth[46-48]. It is known, also, that radicular dentine is less permeable than the crown's. Radicular dentine, close to the pulp is 20% and dentine, closer to periodontal ligaments is only 2% permeable, respectively, comparing to level of permeability of dentine in the tooth crown[46,49].

Two important factors affecting permeability of radicular dentine are smear layer and decreased dentine thickness after endodontic treatment[47,48,51].

Aims of endodontic treatment are removal of necrotic and infected dentinal tissue, elimination of microorganisms from root canal and dentinal tubules and prevention of canal contamination following treatment. For complexity of canals' system and impossibility to treat all surfaces in root canal, it is recommended to apply medication in elimination remaining bacteria[52,53]. It is proven that many medicaments in experimental conditions were acting as strong antibacterial agents, but clinically have expressed unpredictable efficacy because antibacterial effect was limited, antigen potential exposed and diffusion into the tubules was only partial[52,54]. Numerous experimental and clinical studies have confirmed that smear layer and occlusion of dentinal tubules are significantly decreasing effects of canal medication over endodontic therapy[52,55-57].

intrakanalnih medikamenata tokom endodontske intervencije.[52,55-57]

Značajna klinička implikacija razmaznog sloja na zidovima kanala korena vezana je za opturaciju kanala korena. Ispitivanja su pokazala značajno bolju atheziju i uvećanje athezivne veze između materijala za opturaciju i zidova kanala korena posle uklanjanja razmaznog sloja.[52,58-60]

Brojni ispitivači su procenjivali dubinu prodora različitih pasti za opturaciju (Tubliseal, AH-26, Sealapex, Rosin, Roth 801, CRCS) u dentinske kanaliće, i pokazali da je, posle uklanjanja razmaznog sloja, pasta prodrla u dentinske kanaliće od 10 do 80μm dok, kod intaktnog razmaznog sloja, prodor paste u tubule nije uspeo.[10,13,14,52,61-63] O ovome, naravno, ima i drugačijih rezultata. Tako je, uočeno da se snaga athezivne veze između materijala za opturaciju i zidova kanala ne razlikuje u uzorcima sa i bez razmaznog sloja.(64) Primenom brojnih rastvora, uočena je manja pukotina na spoju paste i zida kanala kod zuba gde je razmazni sloj uklonjen iz kanala.[12-14,65-68]

Prema nalazima drugih istraživača, uklanjanje razmaznog sloja nema nikakvog uticaja na atheziju i pojavu mikropukotine kod dobro opturisanih kanala.[69-72]

Ovako dijametralno različiti rezultati mogu se, ipak, objasniti razlikama u vrsti i količini primenjene paste, različitim tehnikama opturacije, načinu formiranja razmaznog sloja, odnosno, različitim metodologijama vođenja eksperimenta i različitim metodima provere.

A significant clinical implication of smear layer on root canal walls is related to obturation. Researchers have shown that adhesion and bonding strength of obturation material were highly improved after smear layer has been removed[52,58-60].

Many authors have evaluated penetration depth of various obturation agents (Tubliseal, AH-26, Sealapex, Rosin, Roth 801, CRCS) in dentinal tubules and have obtained following results: obturation material penetrated the tubules up to 10-80 μm when smear layer was removed, while no material penetration was registered when the layer was left on canal walls[10,13,14,52,61-63]. There are, also, other results, on this issue. It was observed that bonding strength of obturation material was not the same in tested samples (with and without smear layer)[64]. When different solutions were applied, minor gap is observed on the material-canal wall interface in teeth with removed smear layer[12-14,65-68].

According to the results of other authors, removal of the smear layer is of no influence on adhesion and occurrence of microgap when canal was obturated adequately[69-71].

Contradictory results could be explained by variations in types and amounts of obturation material used, different techniques of obturation, pattern of smear layer formation and by different experimental and evaluation methods used.

Uklanjanje razmaznog sloja

Uprkos kontraverzama vezanim za uticaj razmaznog sloja na kvalitet instrumentacije, medikacije i opturacije, i činjenice da ovaj sloj može biti inficiran bakterijama, razumnim i opravdanim se čini njegovo uklanjanje.

Razmazni sloj se može ukloniti hemijskim sredstvima (EDTA, NaOCl, limunska kiselina, poliakrilna kiselina, antibiotici), primenom ultrazvuka, odnosno, primenom lasera.

Hemijsko uklanjanje razmaznog sloja

Razmazni sloj se sastoji iz partikula organskog i neorganskog porekla koje su vrlo rastvorljive u kiselinama, pa se zbog toga one i koriste za uklanjanje razmaznog sloja.[5,52]

Prvi istraživači, MekKomb i Smit[1] pokazali su da REDTA (komercijalni naziv za EDTA-etilen diamin tetra acetat) može da ukloni razmazni sloj sa zidova kanala. Kasnije je potvrđeno da ovo sredstvo, ustvari, uklanja samo neorganski deo sloja dok organski sadržaj u dentin kanalićima ostaje intaktan, pa je za to preporučen rastvor natrijum-hipohlorita (NaOCl).[73]

Brojna istraživanja su potvrdila da je naizmenična primena EDTA i NaOCl-a vrlo efikasna metoda za uklanjanje razmaznog sloja preparisanih zidova kanala.[52,74,75] Međutim, pokušaj Alktenera i Bilkaja[76] da se napravi jedan rastvor koji će delovati i na neorganski i na organski

Smear layer removal

Despite controversies on the impact that smear layer may have on quality of instrumentation, medication and obturation and the fact that it may contain microorganisms, it is reasonable and justified to recommend its removal.

Smear layer can be removed by chemical agents (EDTA, NaOCl, citric acid, poliacrylic acid, antibiotics), by ultrasonic and laser techniques.

Chemical removal of the smear layer

Smear layer is consisted of organic and inorganic components that are highly acidsoluble, which is the reason for acid use in smear layer removal[5,52].

Among first researchers, McComb and Smith have reported that REDTA (brand mark of EDTA: ethylendiamine-tetra-acetate) is potent in removing smear layer from root canal walls. Later, it was confirmed that only inorganic part was removed in this way while organic content in dentinal tubules remain untouched. So, the next recommended solution was NaOCl, sodium-hypochlorite[73].

Numerous studies have confirmed that subsequent application of EDTA and NaOCl is a very efficient method for smear layer removal from root canal walls[52,74,75].

deo razmaznog sloja, nije u potpunosti zadovoljio. Oni su napravili kombinaciju EDTA i etilen-diamina, ali nisu bili zadovoljni efikasnošću ove kombinacije. Goldberg i Abramovic[77] su rastvoru EDTA dodavali kvaternerni amonijum bromid (Cetavlon) i potvrdili efikasnost ove kombinacije za uklanjanje razmaznog sloja sa zidova kanala. Kolt i Serper[78] su, u svojim istraživanjima, koristili etilen-glikol-tetra-acetat (EGTA) za uklanjanje razmaznog sloja i dobili zadovoljavajiće rezultate. Oni su zaključili da je ovaj rastvor vrlo efikasan u uklanjanju razmaznog sloja, pri čemu posle njegove primene, ne dolazi do stvaranja erozija na dentinu kao kod primene EDTA.

Brojni istraživači su, takođe, potvrdili efikasnost 50% rastvora limunske kiseline u uklanjanju razmaznog sloja posle instrumentacije kanala.[23,59,61] Vajmen i saradnici[79] su, u svojim istraživanjima, potvrdili da je 50% rastvor limunske kiseline efikasniji za uklanjanje razmaznog sloja od 50% rastvora mlečne kiseline. Oni su, takođe, potvrdili da je naizmenična upotreba 10% rastvora limunske kiseline i 2,5% rastvora NaOCl-a vrlo efikasna za uklanjanje razmaznog sloja.

Rastvor taninske kiseline (2,5%) za uklanjanje razmaznog sloja koristili su Biter[79], Sabak i Hasanin[80], i potvrdili efikasnost ovog sredstva u uklanjanju razmaznog sloja sa zidova kanala.

Beri i saradnici[81] su za uklanjanje razmaznog sloja koristili 40% rastvor poliakrilne kiseline, a Kaufman i saradnici[82-84] - derivate oksina (Bis-dekvalinijum-acetat-BDA). Potvrđena je efikasnost BDA u uklanjanju razmaznog sloja, čak i u apikalnom delu kanala korena, pre svega zbog malog površinskog napona rastvora i mogućnosti prodora u regione nedostupne instrumentima.[82-84]

Antibakterijska efikasnost antibiotika širokog spektra na bazi tetraciklina iskorišćena je u određenim situacijama i za uklanjanje razmaznog sloja sa zidova kanala korena.[85-88] Naime, nizak pH tetraciklina u koncentrovanom rastvoru omogućava površinsku demineralizaciju dentina, sličnu onoj kod limunske kiseline.[87] Rastvor tetraciklina se u kanalu ponaša kao helator (vezuje kalcijum), a može biti apsorbovan u zidu kanala korena i potom se postepeno oslobađati iz zubnih tkiva (dentin, cement).[85,88]

Barkordar i saradnici[89] su pokazali da je doksicilin-HCl (100mg/ml) efikasan rastvor za uklanjanje razmaznog sloja, a Haznedaroglu i sar.[90] su potvrdili sličan efekat 1% rastvora tetraciklin-hlorida i 50% rastvora limunske kiseline u uklanjanju razmaznog sloja sa zidova kanala.

Uklanjanje razmaznog sloja ultrazvukom

Preparacija kanala ultrazvučnim aparatima obezbeđuje dobro čišćenje kanala, jer je ovom tehnikom ostvaren sinergizam mehaničkog i hemijskog efekta instrumentacije. Ultrazvučne vibracije i maksimalan efekat irigansa usmerenog na vrh instrumenta obezbeđuju značajno uklanjanje razmaznog sloja.[33,91]

Tako je, Kameron[92] u svojim istraživanjima, pokazao potpuno uklanjanje razmaznog sloja u kanalu primenom 4% rastvora NaOCl-a u trajanju od dva minuta. Voker i Del Rio[24,93] su, u dva odvojena rada, potvrdili efikasnost

Nevertheless, the attempt made by Alktner and Bilkay[76], to produce one single solution that will affect, both inorganic and organic components of smear layer, did not meet the expectations. They have made the combination of EDTA and ethylen-diamine, but were not satisfied with effects. Goldberg and Abramovich[77] have added quaternery-ammonium-bromide (Cetavlon) to EDTA and have confirmed the effect on the smear layer removal. Calt and Serper[78] have used ethylen-glycol-tetra-acetate (EGTA) to remove smear layer and have got satisfactory results. They came to the conclusion that solution was very efficient in removing the smear layer and no subsequent erosions in dentine have appeared which was the case when EDTA was used alone.

Many researchers have also confirmed the efficacy of 50% citric acid in smear layer removal following endodontic instrumentation[23,59,61]. Waymann et al.[79] in their studies have confirmed that in smear layer removal 50% citric acid is more efficient than 50% lactic acid. They have confirmed the efficacy of subsequent use of 10% citric acid and 2.5% NaOCl, too.

Bitter[79], Sabbak and Hassanin[80] have studied the effect of 2.5% tannic acid in removing the smear layer.

Berry and co-workers[81] have used 40% poliacrylic acid and Kaufman et al.[82-84] applied oxine derivatives (bis-dequalinium-acetate, BDA). BDA effect was confirmed in removal of the smear layer even in the apical part for its low surface potential and penetration ability to reach hidden regions in canals' system.

Antibacterial efficacy of tetracyclines was implemented in certain occasions to remove smear layer form root canal walls[85-88]. Low pH of tetracyclines in a concentrated solution is stimulating superficial demineralisation of dentine in similar way citric acid is acting[87]. Tetracycline solution in root canal is behaving like chelator (bonds calcium ions) and could be absorbed in canal wall and subsequently is released from dental tissues (dentine, cement)[85,88].

Barkhodar et al.[89] have shown that doxycycline-HCl (100mg/ml) is an effective solution in removal of the smear layer, and Haznedaroglu et al.[90] have confirmed similar effects of 1% tetracycline-chloride and 50% citric acid.

Ultrasonic removal of the smear layer

Preparation of root canal with ultrasonic device is providing good canal cleaning because mechanical and chemical effects in removing smear layer are joined by this technique. Ultrasonic vibrations and maximal effect of irrigating agent, which is directed toward instrument's tip, are providing significant removal of the smear layer[33,91].

Cameron[92] has reported complete removal of the smear layer after application of 4% NaOCl over two minutes. Walker and Del Rio[24,93], in two separate studies, have confirmed the efficacy of ultrasound in removal of the

ultrazvuka u uklanjanju razmaznog sloja, ali i ukazali na beznačajne razlike između vode i rastvora NaOCl-a kada se koriste sa ultrazvukom.

Guerisoli i saradnici[94] su efikasno ukanjanje razmaznog sloja ultrazvukom ostvarili primenom 15% rastvora EDTAC u kombinaciji sa destilovanom vodom ili 1% rastvorom NaOCl-a.

U svojim istraživanjima, Baumgartner i Kenin[95] su ukazali da rastvor NaOCl-a u ultrazvučnoj tehnici preparacije nije potpuno uklonio razmazni sloj sa zidova kanala.

Uklanjanje razmaznog sloja laserom

Poslednjih desetak godina, laser dobija značajno mesto u endodontskoj terapiji. Između ostalog, on se može koristiti za uklanjanje razmaznog sloja i eliminaciju zaostalog tkiva u apeksnom delu kanala.[96,97] Osnovni problem, pri uklanjanju razmaznog sloja laserom, je otežan pristup uskom kanalskom prostoru relativno velikim sondama koje usmeravaju laserski snop.

Tefik i sar.[98] su, posle primene lasera, uočili "razaranje" razmaznog sloja, ali i rekristalizaciju dentina ispod.

Takeda i saradnici[96,97,99] su koristili Erbijum-itrijum-aluminijum-garnet (Er: YAG) laser i ukazali na optimalno uklanjanje razmaznog sloja, ali bez razaranja i rekristalizacije dentina ispod.

Kimura i sar.[100] su potvrdili efikasnost Er:YAG lasera u uklanjanju razmaznog sloja, ali je na mikrofotografijama uočena destrukcija peritubularnog dentina.

Zaključak

Savremene metode čišćenja i oblikovanja, odnosno, metode instrumentacije kanala korena, nesporno dovode do formiranja razmaznog sloja na zidovima kanala korena. Ovaj sloj može da sadrži bakterije i njihove produkte, smanjuje propustljivost dentina korena zuba i umanjuje efekat intrakanalnih medikamenata, odnosno, utiče na efikasnu atheziju materijala za opturaciju i zidova kanala.

Dosadašnja literarna saznanja i klinička iskustva su potvrdila da uklanjanje razmaznog sloja obezbeđuje kvalitetnu dezinfekciju sistema kanala i osigurava bolju adteziju materijala za opturaciju za zidove kanala, odnosno, kvalitetniju opturaciju kanala.

Razmazni sloj sa zidova kanala, posle instrumentacije se može ukloniti primenom različitih hemijskih sredstava, odnosno, primenom ultrazvučne i laserske tehnike.

Nijedna od savremenih tehnika uklanjanja razmaznog sloja nije univerzalno prihvaćena, jer ne obezbeđuje potpuno i efikasno uklanjanje ovog sloja.

Najviše oprečnih stavova je vezano za uklanjanje razmaznog sloja pre opturacije kanala korena. Ipak, zbog moguće kontaminacije, uklanjanje razmaznog sloja kod zuba sa inficiranim kanalima je neophodno, jer se time pojačava efekat intrakanalne medikacije i stvaraju uslovi za bolju adaptaciju materijala za opturaciju.

smear layer, but also have shown insignificant differences regarding effects of water and NaOCl solutions when are used in ultrasonic treatment.

Guerisoli and co-workers[94] have successfully removed smear layer by combining 15% EDTAC and distilled water or 1% NaOCl with ultrasonic technique.

Baumgartner and Cuenin[95] have shown in their studies that NaOCl in ultrasonic technique was not completely efficient in removing smear layer from root canal walls.

Laser technique in removal of the smear layer

During the last decade, laser technique has won important place in endodontic therapy. Among other, it can be used for smear layer removal and elimination of tissue fragments in the apical part of root canal[96,97]. The main problem in removal of the smear layer by laser is a complicated approach to narrow space with considerably large tips when laser beam is directed.

Tewfik et al.[98] have recorded "destruction" of the smear layer but also recrystalisation of the dentine tissue lying beneath.

Takeda et al.[96,97,99] were using Erbium-yttrium-aluminium-garnet (Er: YAG) laser and have shown an optimal removal of smear layer but without consequent dentine recrystalisation.

Kimura et al.[100] have confirmed the efficacy of Er: YAG laser in removing the smear layer but on microphotographs they discovered destruction of the peritubular dentine.

Conclusion

Contemporary methods of cleaning and filing, i.e. instrumentation of root canal, are causing formation of the smear layer on root canal walls. This layer may contain microorganisms and their products, furthermore it is decreasing permeability of radicular dentine and impairing effects of canal medicaments, which consequently is compromising adhesion of obturaion material to root canal walls.

Up-to-date data from the literature and clinical experience have confirmed that removing the smear layer will ensure both a good disinfecting of canals' system and a better adhesion of obturation material, that is, better root canal obturation.

Smear layer can be removed from root canal walls following instrumentation by use of various chemical agents, ultrasonic or laser techniques. Non of the techniques for smear layer removal was not universally accepted, because this layer cannot be removed entirely.

Majority of contradictory statements is related to removal of the smear layer prior to root canal obturation. Nevertheless, for possible contamination, removal of the smear layer in teeth with infected root canals is mandatory, because in that way canal medication is enhanced and conditions for a better adaptation of obturation material are created.

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