

Uklanjanje razmaznog sloja rastvorom limunske kiseline

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Smear layer removal with citric acid solution

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KRATAK SADRZAJ

Cilj ovog istraživanja je bio da se pomoću SEM-a proverí efikasnost 10% rastvora limunske kiseline u uklanjanju razmaznog sloja sa zidova kanala korena zuba. **Materijal i metod:** Istraživanje je obuhvatilo 20 jednokorenih, ekstrahovanih humanih zuba. Svi uzorci su instrumentirani step-back tehnikom i ručnim K turpijama, a tokom instrumentacije ispirani 2,5 % rastvorom NaOCl-a. Uzorci su zatim podeljeni u 2 eksperimentalne grupe. Prva grupa uzoraka je tokom finalnog ispiranja tretirana sa 17 % rastvorom EDTA, tokom 1 minuta, a druga grupa 10 % rastvorom limunske kiseline, po istom protokolu. **Rezultati:** Dobijeni rezultati su pokazali da se primenom 17 % rastvora EDTA i 10 % rastvora limunske kiseline postiže efikasno uklanjanje razmaznog sloja sa zidova kanala korena. Između ispitivanih sredstava nije bilo statistički značajne razlike ($p > 0.05$).

Ključne reči: razmazni sloj, limunska kiselina, EDTA, kanal korena

SUMMARY

The aim of this study was to evaluate efficacy in smear layer removal of 17% EDTA and 10% citric acid, using SEM. **Material and method:** Twenty human, extracted teeth with a single root canal were examined. Whilst instrumentation with step-back technique and manual K files, root canals were irrigated with 2 ml of 2.5% NaOCl, between each file size. After instrumentation, specimens were divided into two groups. The first group was irrigated with a final flush of 17% EDTA, during one minute, and the second group was irrigated with a 10% citric acid. **Results:** Irrigation with 17% EDTA and 10% citric acid removed smear layer from the root canal walls. There was not statistically significant differences ($p > 0.05$) in cleaning ability between EDTA and citric acid groups.

Key words: smear layer, citric acid, EDTA, root canal

Kompletno čišćenje, pravilno oblikovanog kanal-skog sistema, smatra se jednim od osnovnih preduslova za dugoročan uspeh endodontskog tretmana. Čišćenje podrazumeva uklanjanje postojećih ili potencijalnih nadražaja iz kanala korena (bakterije, njihovi produkti, organski debris, vitalno tkivo, nekrotično tkivo, produkti pljuvačke, krv i dr), a postiže se instrumentacijom i irigacijom kanala korena zuba.¹

Poznato je da se kao posledica instrumentacije na zidovima kanala korena stvara razmazni sloj (smear layer), koji se sastoji od neorganskih i organskih čestica sastruganog dentina, vitalnog ili nekrotičnog tkiva pulpe, fragmenata odontoblastnih nastavaka, mikroorganizama i ćelija krvi. Podaci iz literature ukazuju da sve trenutno raspoložive tehnike instrumentacije, naročito mašinske, stvaraju razmazni sloj, različite debljine, koji prekriva

The complete cleaning of the regularly shaped canal system is considered to be one of the main prerequisite for a long-term success of the endodontic treatment. The cleaning means the removal of the existing or the potential irritation from the root canal (bacteria, their products, organic debris, vital tissue, necrotic tissue, saliva products, blood etc.), and it is achieved with instrumentation and irrigation of the tooth root canal.¹

It is known that on the canal walls, as a consequence of the instrumentation, a smear layer is made, which consists of inorganic and organic particles of grinded dentin, vital and necrotic pulp tissue, fragments of odontoblast extensions, microorganisms and blood cells. The literature data point out that all, at the moment available instrumentation techniques, especially mechanical, make smear layer of different thickness that covers the walls of the root canal

zidove kanala korena i blokira otvore dentinskih tubula.² Brojni autori su ispitivali ulogu razmaznog sloja u endodonciji, odnosno njegov uticaj na kvalitet instrumentacije i obturacije kanalskog sistema.³ Iako postoje i drugačija mišljenja, savremena literatura jasno ukazuje na neophodnost njegovog uklanjanja pre svega zbog redukcije mikroorganizama prisutnih u kanalu korena,^{4,5} odnosno zbog poboljšanja adhezije materijala za obturaciju za dentin zidova kanala korena i redukcije apikalnog i koronarnog mikrocurenja.⁶⁻⁸

Za uklanjanje razmaznog sloja koriste se različita hemijska sredstva, ultrazvučni instrumenti a od nedavno i laser.³ Istraživanja su potvrdila da natrijum hipohlorit (NaOCl), bez obzira na snažne antimikrobne osobine i efikasno organolitičko delovanje nije efikasan u uklanjanju razmaznog sloja.^{7,9,10} Kako je razmazni sloj, zbog svog pretežno neorganskog sastava, veoma rastvorljiv u kiselinama, za njegovo uklanjanje se danas predlažu različite, uglavnom organske kiseline kao što su Etilen diamino tetraacetat (EDTA), limunska, taninska i poliakrilna kiselina.³ EDTA, u koncentracijama 15-20% i u različitim oblicima (rastvor, gel), je najčešće korišćeno hemijsko sredstvo za uklanjanje razmaznog sloja sa zidova kanala korena. Mc Comb i Smith su prvi ukazali na sposobnost EDTA da ukloni razmazni sloj,⁹ što su kasnije potvrdili i drugi istraživači.^{10,11} Istovremeno, pojedini autori ukazuju da je sredstvima na bazi EDTA teško postići kompletno čišćenje kanala korena, naročito u apeksnoj trećini.^{7,12} S druge strane, irigacija kanala sredstvima na bazi EDTA, naročito u kombinaciji sa NaOCl-om, može rezultirati preteranom demineralizacijom dentina sa pojavom erozija u koronarnoj i srednjoj trećini kanala korena.^{13,14}

Za irigaciju kanala korena u cilju uklanjanja razmaznog sloja nedavno je preporučena limunska kiselina.¹⁵ Limunska kiselina je slaba organska kiselina koja, kao i EDTA, pripada grupi helatnih agenasa. Koristi se u periodontalnoj terapiji, odnosno kao sredstvo za kondicioniranje dentina u restaurativnoj stomatologiji.¹⁶ Efikasnu dekalifikaciju dentina rastvorima limunske kiseline u različitim koncentracijama demonstrirali su Yamaguchi i sar.¹⁵, a o efikasnom uklanjanju razmaznog sloja rastvorima limunske kiseline pisali su i drugi autori.^{12,16}

Cilj ovog istraživanja je bio da se pomoću SEM-a proverii efikasnost 10% rastvora limunske kiseline, kao finalnog kanalnog irigansa, u uklanjanju razmaznog sloja sa zidova kanala korena zuba.

Materijal i metod

Istraživanje je obavljeno u in vitro uslovima na 20 ekstrahovanih, humanih jednokorenih zuba. Svi uzorci su instrumentirani step-back tehnikom i ručnim K turpijama (Maillefer). Apikalni foramen svih uzoraka proširen je do veličine K \neq 30. Tokom instrumentacije kanali korena

and blocs the openings of the dentin tubules.² Numerous authors investigate the role of the smear layer in endodontics, that is, its influence on the quality of instrumentation and obturation of the canal system. Although there are different opinions, contemporary literature clearly shows the necessity of its removal, above all, because of the reduction of microorganisms present in the root canal^{4,5}, in other words, because of the improvement of the adhesion of the obturative materials for the dentine of the root canals walls and reduction of the apical and coronary micro leakage.^{6,8}

For the removal of the smear layer different kinds of chemical means, is used, ultrasound instruments, and recently a laser.³ The researches confirmed that the sodium hypochloride (NaOCl), regardless its strong antimicrobial characteristics and efficient organolytic effects, is not efficient in the removal of the smear layer^{7,9,10}. The smear layer is, because all of this, mostly of inorganic structure, it is very soluble in acids, so for its removal the different kinds of acid is proposed, mostly organic, like Ethylene bi amino tetra acetate (EDTA), citric, tannin and poly acrylic acid.³ EDTA in 15-20% concentration and in different shapes (solution, gel) is the most used chemical means for the smear layer removal from the root canal walls. Mc Comb and Smith were the first who pointed out on EDTA ability to remove the smear layer, which was lately confirmed by other researchers.^{10,11} At the same time, some of the authors point out that the means based on EDTA are difficult to achieve complete cleaning of the root canal, especially in the third of apex.^{7,12} On the other hand, irrigation of the canal with the means based on EDTA, especially combined with NaCl, could result in exaggerated demineralisation of dentin with erosions in coronary and middle third of the root canal^{13,14}

The citric acid is recommended recently for the root canal irrigation, in the aim of the smear layer removal. The citric acid is weak organic acid, which, the same as EDTA, belongs to the chelate agents. It is used in periodontal therapy, in other words, as means for conditioning dentin and restorative dentistry.¹⁶ Efficient decalcification of dentin with the citric acid solutions in different concentrations was demonstrated by Yamaguchi and associates¹⁵, and it was written, by some other authors, about the efficiency of the smear layer removal.^{12,16}

The Aim of this research was to check the efficiency of 10% solution of the citric acid, with the help of SEM, as a final canal irrigant, in the smear layer removal from the root canal walls.

Material and methods

The research was made in vitro conditions, on 20 extracted, human one-root teeth. All the samples were instrumented by a step-back technique and manual K burs (Maillefer). Apical foramens of all the samples were widened to K \neq 30. During the instrumentation the root canal

su ispirani 2,5 % rastvorom NaOCl-a, u količini od 2 ml između svakog instrumenta. Po završenoj instrumentaciji uzorci su podeljeni u dve grupe na osnovu vrste iriganta korišćenog tokom finalnog ispiranja. U prvoj grupi (8 uzoraka) kanali su ispirani sa 5 ml 17 % rastvora EDTA, a u drugoj (8 uzoraka) sa 5 ml 10 % rastvora limunske kiseline. Finalno ispiranje je realizovano ostavljanjem 1 ml testiranog rastvora u kanalu tokom 1 minuta, nakon čega su kanali ispirani sa još 4 ml istog rastvora. Zatim su svi uzorci ispirani sa još 10 ml destilovane vode. Za ispiranje su korišćeni plastični špricovi, zapremine 2 i 5 ml i lateralno perforirane igle. Tokom irigacije, igle su unošene u kanale što je moguće apikalnije, do osećaja blagog otpora, ali bez zaglavljivanja igle u kanalu korena. Kontrolnu grupu činila su 4 uzorka kod kojih posle instrumentacije nije sprovedeno finalno ispiranje helatnim agensima.

Zubi su potom presećeni longitudinalno, nakon čega su odabrane polovine korenova standardnom procedurom pripremljene za posmatranje na SEM-u. Uzorci su posmatrani na JOEL JSM-840 A SEM-u. Fotomikrografije su napravljene u srednjoj trecini kanala korena, a zidovi kanala korena svakog uzorka su analizirani na uveličanju od 1000x i 4000x.

Za kvantitativnu procenu prisustva razmaznog sloja na zidovima kanala korena korišćeni su kriterijumi Hulsmann-a i sar. (1997)¹⁷

- Ocena 1: Nema razmaznog sloja, dentinski tubuli otvoreni
- Ocena 2: Prisutna mala količina razmaznog sloja, otvoreno nekoliko tubula
- Ocena 3: Homogeni razmazni sloj prekriva zid kanala korena, otvoreno samo par dentinskih tubula
- Ocena 4: Kompletan zid prekriven homogenim razmaznim slojem, dentinski tubuli nisu otvoreni
- Ocena 5: Obilan nehomogeni razmazni sloj prekriva kompletan zid kanala korena.

Dobijeni rezultati statistički su obrađeni primenom Mann-Whitney testa.

Rezultati

Dobijeni rezultati prikazani su u tabeli 1 i na fotografijama 1-4.

Zidovi kanala korena svih kontrolnih uzoraka bili su prekriveni velikom količinom razmaznog sloja koji je u potpunosti maskirao otvorene dentinske tubule. (sl.1)

U uzorcima koji su po završenoj instrumentaciji ispirani 17 % rastvorom EDTA, razmazni sloj je uklonjen, a otvori dentinskih tubula su se jasno uočavali. Uzorci su ocenjeni ocenama 1 i 2. (sl.2 i 3)

U grupi uzoraka koji su ispirani 10 % rastvorom limunske kiseline takođe je uočeno odsustvo razma-

was irrigated with 2.5% solution of NaOCl, in the quantity of 2ml between each instrument. After the finished instrumentation the samples were divided into two groups according to the type of irrigant that had been used during the final flushing. The canals were flushed with 5ml of 17% EDTA solution in the first group (8 samples), and in the second (8 samples) with 5ml 10% solution of the citric acid. The final irrigation was realised by leaving of 1ml of the tested solution in the canal during 1 minute, after which the canals were flushed with 4ml of the same solution. Then, the each sample is irrigated with 10ml of distilled water. The plastic syringe of 2 and 5ml volume and laterally perforated needles were used for the irrigation. During the irrigation, the needles were put into the canals as apical as possible, until the feeling of the mild resistance, and without sticking the needle into a root canal. The control group was made of 4 samples in which there wasn't final irrigation with chelate agents after the instrumentation.

The teeth were then cut longitudinal, and after that the chosen halves of the roots prepared with the standard procedure, for the observation on the SEM. The samples were observed on the JOEL JSM-840 A SEM. Photomicrographs were made in the middle third of the root canal, and the walls of the root canal of each sample were analysed in 1000x and 4000x magnification.

For the quantitative estimation of the smear layer presence on the walls of the root canal the Hulsmann and associates (1997) criteria were used. (17)

- Mark 1. There is no smear layer, dentin tubules are open.
- Mark 2. There is a small quantity of smear layer, a couple of tubules are open
- Mark 3. Homogeneous smear layer covers the wall of the root canal, only two dentine tubules are open
- Mark 4. Complete wall of the root canal is covered with homogeneous smear layer, dentine tubules are not open
- Mark 5. Abundant inhomogeneous smear layer covers the whole wall of the root canal

Achieved results are statistically processed by using the Mann-Whitney test.

Results

The results achieved are presented on the table 1 and on the photos 1-4.

The walls of the root canal in all control samples were covered with large quantity of smear layer, which completely camouflaged the openings of dentine tubules. (figure.1)

At the samples, which were irrigated with 17% solution of EDTA, after the instrumentation had been finished, the smear layer was removed, and the openings of dentine tubules were clearly noticeable. The samples were marked 1 and 2. (figure. 2 and 3)

At the group of samples, which were irrigated, with 10% solution of citric acid, the absence of the smear layer

znog sloja sa jasnom slikom otvora dentinskih tubula. Najveći broj uzoraka ove grupe ocenjen je ocenom 1. (sl.4 i 5)

Izmedju ispitivanih grupa uzoraka nije uočena statistički značajna razlika u količini preostalog razmaznog sloja, iako su kanalni zidovi bili nešto čistiji nakon irigacije sa 10 % rastvorom limunske kiseline. ($p > 0.05$)

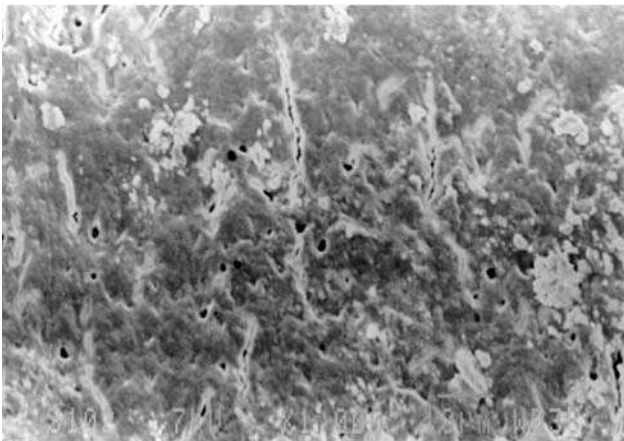
is noticed, too, with the clear picture of dentine tubules openings. The largest number of this group samples were marked 1. (figure.4 and 5)

Among the tested groups of samples, statistically important difference, in the quantity of the smear layer left, is not noticed, although the walls of the root canal were a little bit cleaner after the irrigation with 10% solution of citric acid. ($p > 0.05$)

Tabela 1. Kvantitativna procena razmaznog sloja

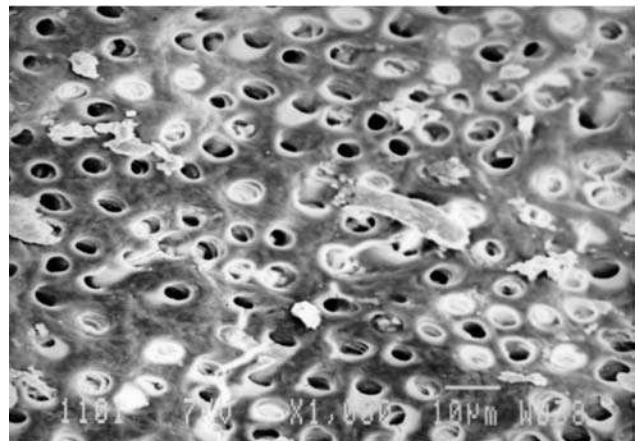
Table 1. Quantitative evaluation of smear layer

Testirani rastvor	n	X	SD	χ_u %	Mann Withney U test
17% EDTA	8	1.50	0.76	50.67	U=30.5
10% LIMUNSKA KISELINA	8	1.38	0.52	37.68	$p > 0.05$



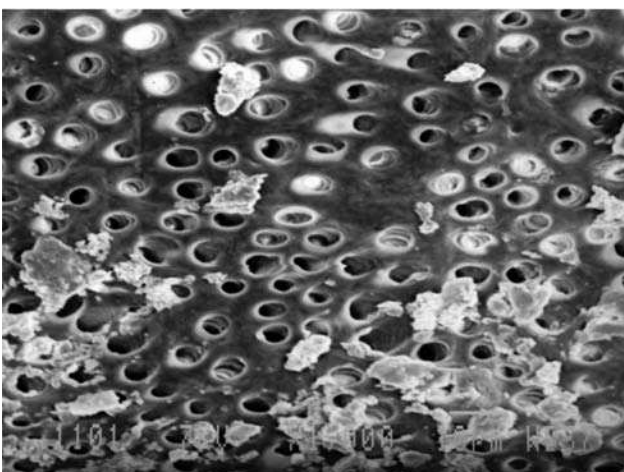
Slika 1. Površina zida kanala uzorka ispiranog 2,5% NaOCl-om (SEM x1000)

Figure 1. Canal wall surface of a sample irrigated with 2,5% NaOCl (SEM x 1000)



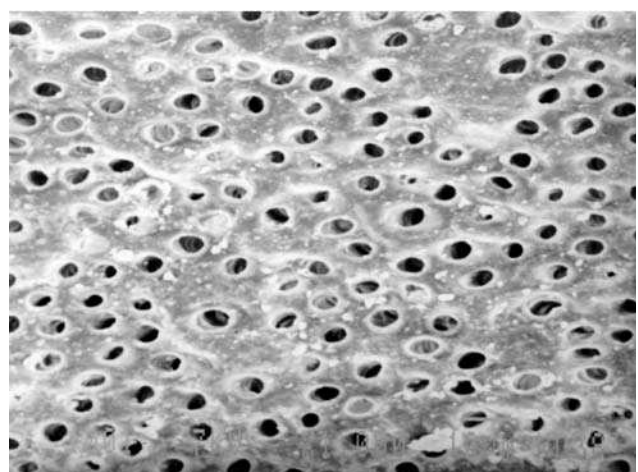
Slika 2. Površina dentina uzorka tretiranog 17% EDTA (SEM x 1000)

Figure 2. Dentinal surface of a sample treated with 17% EDTA (SEM x 1000)



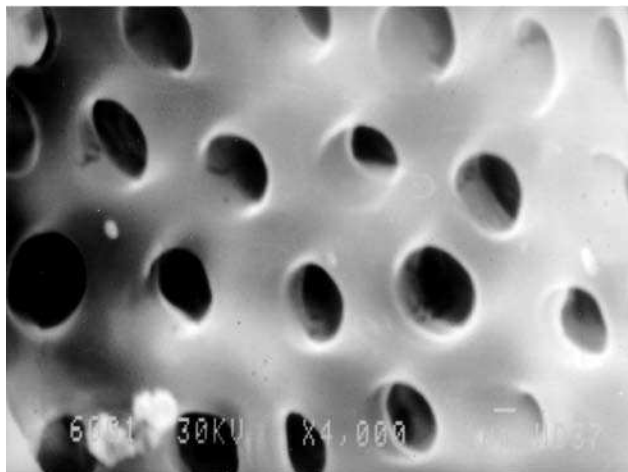
Slika 3. Površina dentina uzorka tretiranog 17% EDTA (SEM x 1000)

Figure 3. Dentinal surface of a sample treated with 17% EDTA (SEM x 1000)



Slika 4. Površina dentina uzorka tretiranog 10% limunskom kiselinom (SEM x 1000)

Figure 4. Dentinal surface of a sample treated with 10% citric acid (SEM x 1000)



Slika 5. Površina dentina uzorka tretiranog 10% limunskom kiselinom (SEM x 4000)

Figure 5. Dentinal surface of a sample treated with 10% citric acid (SEM x 4000)

Diskusija

Tehnika instrumentacije i irigacije u ovom istraživanju su realizovane na način prihvatljiv u kliničkim uslovima. Za irigaciju kanala korena tokom instrumentacije korišćen je 2.5 % rastvor NaOCl-a, s obzirom da u ovoj koncentraciji NaOCl pokazuje zadovoljavajuću organolitičku aktivnost i efikasno antimikrobno delovanje uz redukovanu toksičnost.^{1,18}

Po završenoj instrumentaciji, u cilju uklanjanja razmaznog sloja, uzorci su ispirani različitim helatnim agensima. Za ispiranje su korišćene lateralno perforirane igle. Ove igle efikasno raspršuju i distribuiraju irigantse čitavom dužinom kanala korena i time postižu bolje čišćenje kanalskog sistema u poređenju sa konvencionalnim iglama za ispiranje, bez obzira na vrstu korišćenog irigansa.¹⁹ Testirana helatna sredstva su u kanale korena aplikovana tokom 1 minuta, kako su preporučili Calt i Serper 2002 god, kada su utvrdili da irigacija kanala 17% rastvorom EDTA u ovom vremenskom intervalu ne dovodi do erozivnih promena na dentinu kanala korena.¹⁴

Iako su za endodontsku primenu najpre preporučeni rastvori limunske kiseline u većim koncentracijama (25% i 50%),²⁰ novija istraživanja donose više podataka o efikasnom delovanju slabijih rastvora limunske kiseline (6-19%),^{12,15,16} zbog čega je u ovom istraživanju korišćen 10% rastvor.

Rezultati ovog istraživanja ukazuju da je primenom testiranih helatnih agenasa postignuto efikasno uklanjanje razmaznog sloja sa zidova kanala korena. U uzorcima koji su ispirani 10% rastvorom limunske kiseline zapaženo je nešto bolje čišćenje u poređenju sa uzorcima koji su ispirani 17 % rastvorom EDTA. Međutim, razlika u količini preostalog razmaznog sloja u ispitivanim grupama nije bila statistički značajna.

Dobijeni rezultati su u skladu sa nalazima Calt i Serper-a koji su ukazali da irigacija 17% rastvorom EDTA tokom 1 minuta efikasno uklanja razmazni sloj sa zidova kanala korena.

Discussion

The technique of the instrumentation and irrigation in this research are realised in a way, which is accepted in clinical conditions. For the canal irrigation during the instrumentation, the 2.5% solution of NaOCl is used, regarding to, that, in this concentration NaOCl shows satisfactory organolitic activity and efficient Antimicrobial effect with reduced toxicity.^{1,18}

After the finished instrumentation, in objective to remove the smear layer, the samples were irrigated with different chelate agents. For the irrigation there were used the laterally perforated needles. Those needles are efficient in dispersion and distribution of the irrigants along the whole length of the canal and successful in better cleaning of the canal system comparing to conventional needles for irrigation, no matter what kind of irrigants is used. (19) The tested chelate substances were applied into the root canals during 1 minute, which was recommended by Calt and Serper in 2002, when they established that, the irrigation of the canals with 17% solution of EDTA in this time interval didn't lead to erosive changes on the dentin of the root canal.¹⁴

Although the solutions of citric acid are, in the first place, recommended for endodontic use, in larger concentration (25% and 50%)²⁰, the latest researches bring more data about the efficient performance of the weaker solutions of citric acid (6-19%)^{12,15,16}, and that is why in this research 10% solution was used.

The results of this research show that with the application of tested chelate agents, efficient removal of the smear layer from the walls of the root canal is achieved. In the samples, which were irrigated with 10%, solution of citric acid a little bit better cleaning was noticed comparing to the samples irrigated with 17% solution of EDTA. However, the difference in the quantity of the smear layer left, in tested group, wasn't statistically important.

The results achieved are in accordance with the results of Cat & Serper who pointed out that the irrigation with 17% solution of EDTA during 1 minute efficiently removed the smear layer from the walls of the root canal.

Rezultati ovog istraživanja ukazuju da je dekalcifikujućí kapacitet 10% rastvora limunske kiseline sličan, ili čak izraženiji od 17 % EDTA. Yamaguchi i sar. su, ispitujućí dekalcifikujućí kapacitet 0.1 M rastvora (pH 2.6), 0.5 M rastvora (pH 1.6), 1M rastvora (pH 1.3) i 2M rastvora (pH 1.1) rastvora limunske kiseline, našli da je vezivanje Ca^{2+} jona sa 0.5 M, 1 M i 2 M rastvorima limunske kiseline izraženije nego sa 0.5 M rastvorom EDTA. Na osnovu dobijenih rezultata autori su zaključili da je dekalcifikujućí kapacitet limunske kiseline posledica helatacije kalcijumovih jona ali i izražene kiselosti rastvora.¹⁵

Di Lenarda i sar. su takođe poredili efikasnost EDTA i limunske kiseline u uklanjanju razmaznog sloja sa zidova kanala korena ali u funkciji različitih tehnika instrumentacije. Njihovi rezultati su ukazali na sličnu efikasnost 19 % rastvora limunske kiseline (1 mol L^{-1}) i 15% rastvora EDTA. Autori su još istakli da je u grupi mašinski instrumentiranih uzoraka, obrađenih u kraćem vremenskom intervalu, limunska kiselina bila efikasnija. Na osnovu dobijenih rezultata autori su zaključili da efikasnost testiranih sredstava zavisi od trajanja aplikacije i da se čišćenje kanala korena može brže realizovati primenom limunske kiseline.¹⁶

Rezultati Takeda i sar. su takođe ukazali na superiornije čišćenje kanala korena finalnim ispiranjem 6 % rastvorom limunske kiseline u poređenju sa 17% rastvorom EDTA. Autori su još ukazali da, iako veoma efikasna u srednjoj trećini, limunska kiselina nije u potpunosti uklonila razmazni sloj u apeksnoj trećini kanala korena.¹²

U ovom istraživanju efikasnost helatnih agenasa u uklanjanju razmaznog sloja je procenjivana samo u srednjoj trećini kanala korena. Prema rezultatima istraživanja u kojima je efikasnost različitih iriganasa analizirana po trećinama korenskih kanala^{7,12}, moglo bi se pretpostaviti da bi čišćenje u apeksnoj trećini, sa oba testirana helatna agensa, bilo nešto slabije, pre svega zbog ograničene količine rastvora koju je moguće uneti u apeksnu trećinu kanala korena.

Zaključak

Na osnovu dobijenih rezultata može se zaključiti da je 10% limunska kiselina efikasna u uklanjanju razmaznog sloja sa zidova kanala korena i kompletnom čišćenju kanalskog sistema i da se može koristiti kao finalni irigans tokom endodontskog tretmana.

The results of this research show that the decalcified capacity of 10% solution of citric acid is similar, or even more obvious than 17% solution of EDTA. Yamaguchi and associates found, investigating the decalcified capacity of 0.1 M solution (pH 2.6), 0.5M solution (pH 1.6), 1M solution (pH 1.3) and 2M solution (pH 1.1) solution of citric acid, that the bond with Ca^{2+} ions with 0.5M, 1M and 2M solutions of citric acid is more distinct than with 0.5 M solution of EDTA. Based on the results that had been achieved the authors concluded that the decalcified capacity of citric acid was the consequence of chelation of Ca ions, but it was also the consequence of the outstanding acidity of the solution.¹⁵

Di Lenarda and associates were also comparing the efficiency of EDTA and 10% citric acid in the removal of the smear layer from the walls of the root canal, but in the function of different techniques of instrumentation. Their results showed the similar efficiency of the 19% solution of citric acid (1 mol L^{-1}) and 15% solution of EDTA. The authors also emphasized that in the group of mechanically instrumented samples, which had been done in a shorter time interval, citric acid was more efficient. On the basis of results achieved the authors concluded the efficiency of the tested means depended of application durability and that the canal cleaning could be realised quicker by citric acid implementation.¹⁶

The results of Takeda and associates showed also the superior cleaning of the root canal with final irrigation using 6% of the citric acid solution comparing to 17% EDTA solution. The authors also pointed out that, although, it was very efficient in the middle third, citric acid didn't remove the smear layer in the apex third of the root canal.

In this research, the efficiency of chelate agents in the smear layer removal was estimated only in middle third of the root canal. According to the results of the researches in which the efficiency of the different irrigates were analysed according to the thirds of the root canals (7,12), it could be assumed that the cleaning in the apex third, with both tested chelate agents, would be a little bit weaker, because of limited quantity of the solution which is possible to put into the apex third of the root canal.

Conclusion

On the basis of the achieved results, it could be concluded that the 10% solution of citric acid is efficient in the smear layer removal from the root canal walls and in the complete cleaning of the canal system, and that it can be used as a final irrigant during the endodontic treatment

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