Serbian Dental Journal, vol. 65, N° 3, 2018

ORIGINAL ARTICLE
ORIGINALNI RAD

DOI: 10.2478/sdj-2018-0015
UDC: 616.314.18-085

Efficacy of different irrigation techniques on calcium hydroxide removal from the root canal

Vanja Opačić Galić, Jovana N. Stašić

University of Belgrade, School of Dental Medicine, Department for Restorative Dentistry and Endodontics, Belgrade, Serbia

SUMMARY

Introduction Calcium hydroxide (CH) is a medicament widely used in endodontic treatment due to its antibacterial, regenerative and biocompatible properties. Studies have shown that remaining CH on root canal walls and dentinal tubules can compromise sealer penetration, leading to its weak adhesion, volume change and, consequently, apical leakage.

The aim of this study was to compare the efficacy of four different techniques in removing calcium hydroxide from the root canal.

Material and Methods 32 extracted single-rooted teeth with one canal were used in this study. The canals were prepared using BioRaCe system (FKG Dentaire, Swiss) BR5 40/.04 with sodium hypochlorite irrigation after each instrument. Longitudinal grooves were formed on the proximal root surfaces. All canals (except negative control) were filled with aqueous CH suspension. After seven days of incubation, the teeth were allocated into the four groups (n=7), plus positive and negative control. Four techniques (systems) for CH removal were tested: conventional syringe irrigation (CSI), passive ultrasonic irrigation (PUI), XP-endo Finisher (FKG Dentaire, Swiss) and Canal Brush (Roeko, Coltene) with irrigation of 5 ml 2% NaOCl and 5 ml 10% citric acid. All the roots were then split into the two halves with chisel and observed under the stereomicroscope (Boeco, Germany) at magnification of 20x. The area with remaining CH on the root canal wall surface was then divided with the total root canal surface area (%). The obtained results were statistically processed using One-way ANOVA and Tukey post-hoc test ($p<0.05$).

Results The most efficient system was XP-endo Finisher with 91.33% of clean surface, followed by PUI 88.36%, Canal Brush 87.83%, and CSI with 66.92%.

Conclusion None of the systems completely removed the traces of the medicament from the root canal. For optimal clinical success, it is necessary to combine various systems with copious irrigation.

Keywords: calcium hydroxide; irrigation; ultrasound; XP-endo finisher; canal brush

INTRODUCTION

Canal instrumentation and irrigation is not sufficient to complete full cleaning of root canals. Despite technological advancements in the instrumentation technique and irrigation systems, canal medication is still necessary phase in some cases.

Calcium hydroxide (CH) is the most often used intracanal medicament due to its antibacterial, biocompatible and regenerative properties. Before obturation, it has to be completely removed from the root canal walls in order to allow sealer adhesion and prevent intracanal microleakage as a consequence. Numerous studies have dealt with the problem of CH removal from the root canals and the role of different irrigation substances [1] or different irrigant activation techniques: laser activated irrigation (PIPS) [2, 3], sonic and ultrasonic irrigant activation [4, 5], RinsEndo system [6], EndoVac system [7], SAF (Self adjusting files) [8], Gentle Wave system [9] and others.

The most described method for CH removal from the root canal walls is instrumentation of the canals with a master instrument along with excessive irrigation [3]. Research indicates that with this technique only the main part of the canal can be cleaned and that the depth of needle plays a crucial role [10]. Passive ultrasonic irrigation (PUI) increases the efficacy of canal disinfectants by agitation of the solution, which was beforehand placed in the canal [8]. XP Endo Finisher (FKG Dentaire, La-Chaux-de Fonds, Switzerland) is a NiTi canal instrument with the size of ISO #25, and without taper (25/.00). This instrument increases the penetration of the solution for irrigation in irregular root canals [11, 12]. CanalBrush (CB) (Roeko Canal Brush TM Coltene/Whaledent, Langenau, Germany) is flexible endodontic micro brush, made of polypropylene and used with endodontic motor providing efficient canal cleaning just before the obturation [8, 11].

The aim of this study was to compare the efficacy of conventional irrigation technique, passive ultrasonic irrigation, Canal Brush and XP Endo Finisher in CH removal from the root canal walls.

MATERIAL AND METHODS

Thirty-two extracted single-rooted teeth were used in this study. Water-cooled round diamond bur was used

Address for correspondence: Vanja OPAČIĆ GALIĆ, School of Dental Medicine, Department for Restorative Dentistry and Endodontics, Rankeova 4, 11000 Belgrade, Serbia; *vanja.opacic.galic@gmail.com*

for access cavity preparation on the palatal surface of the crown. Canal instrument K-15 (Dentsply Maillefer) was used to check patency. Working length was determined 1 mm shorter of the apical foramen. The canals were prepared using BioRaCe system (FKG Dentaire, Swiss) BR5 40/.04 with 2% NaOCl irrigation after each instrument. On the buccal and lingual surfaces of the root, 1 mm deep longitudinal grooves were created using a diamond disk, taking care not to endanger the integrity of the root canal. After instrumentation and irrigation, canals were dried with paper points and filled with aqueous suspension of CH (Ca powder and distilled water), and closed with temporary filling Citodur hard (DoriDent-Dr.Hirschberg, Austria). All samples were wrapped in wet gauze soaked with distilled water and kept in an incubator at 37° C. After seven days of storage, the teeth were randomly divided into the four groups (n=7). Two teeth were used as positive and negative control. Positive control consisted of teeth filled with CH that was not removed from the root canal. Negative control consisted of prepared teeth with empty canals (without CH paste).

I group: **Conventional syringe irrigation** (CSI) – Medicament was removed using manual instruments (files) from K-15 to K-40 (master apical file-MAF) and irrigation.

II group: **Passive ultrasonic irrigation (PUI**) (PB-323,W&H Dentalwerk Bürmoos, Austria) – Ultrasonic needle was placed into the canal 1 mm shorter than the working length without contact with canal walls and activated 3 times for 20 sec (the frequency of 25-30 kHz). For each cycle fresh irrigant was inserted.

III group: **XP–Endo finisher (XP)** – The instrument was used with an X-smart endodontic motor (Dentsply Sirona, Ballaigues, Switzerland) at a speed of 800 rpm and torque of 1 N/cm. The instrument was placed in the canal 1 mm shorter than the working length, and used with gentle movements up and down in three cycles of 1 minute with constant irrigation.

IV group: **CanalBrush (CB)** – The canal brush size M was placed into the canal 1 mm shorter than the working length, and activated with an endo-motor at a speed of 600 rpm during 1 min for each irrigant. Gentle brushing movements with constant irrigation were used. A new brush was used for each canal.

All groups were irrigated under the same conditions, continuously irrigated with 5 ml of 2% NaOCl for 1 min, and 5 ml of 10% citric acid for 1 min. Finally, all samples were irrigated with 5 ml of distilled water.

All teeth were cut into the two halves with a chisel and observed under the stereomicroscope (Boeco BSZ-405, Germany) with an integrated digital camera at 20X magnification. Images were processed and measured in Scope Image 9.0 program (Teleskop, Austria). The total surface area of the canal (P_s) was measured, from the enamel-dentin junction to the apical foramen (expressed at 100%). Surfaces with residual medicament (P_{ch}) were measured in the same program. The percentage of clean surface of the root canal (P_c) was calculated by subtracting the obtained values (P_s-P_{ch}=P_c). The obtained results were statistically analysed using One-way ANOVA and Tukey post-hoc tests. P value <0.05 was considered significant.

RESULTS

The results are shown in Figures 1-5.

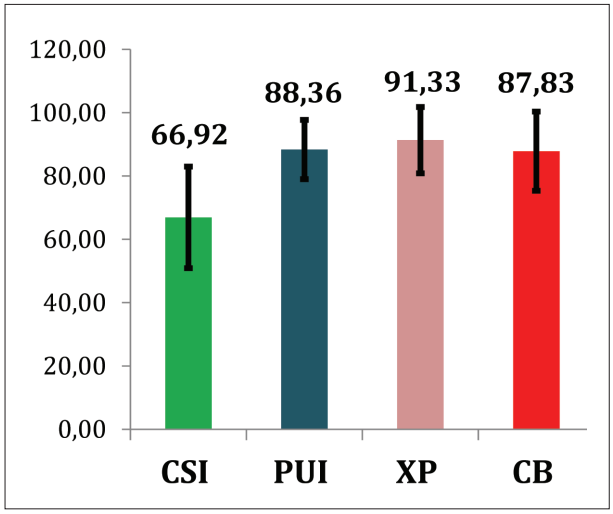

Figure 1. Mean values of clean surface of the root canals by groups
Slika 1. Srednje vrednosti očišćenih površina kanala po grupama

CSI – conventional syringe irrigation; PUI – passive ultrasonic irrigation; XP-XP Endofinisher; CB – Canal Brush
CSI – konvencionalna irigacija špricem; PUI – pasivna irigacija ultrazvukom; XP-XP Endofinisher; CB – kanalna četkica

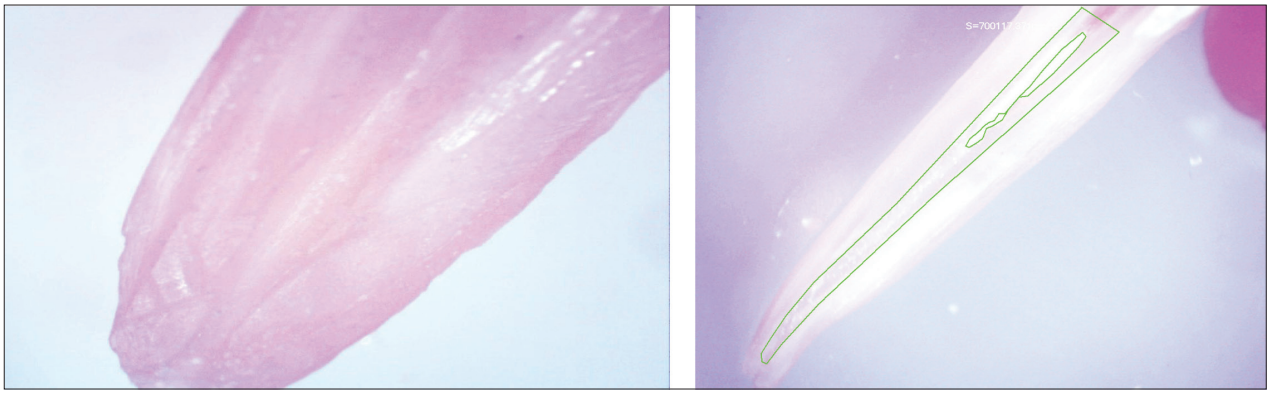

Figure 2. Completely clean root canal surface in the apical third after irrigation with XP-endo Finisher
Slika 2. Potpuno čista površina kanala korena u apikalnoj trećini posle irigacije XP-endo Finisherom

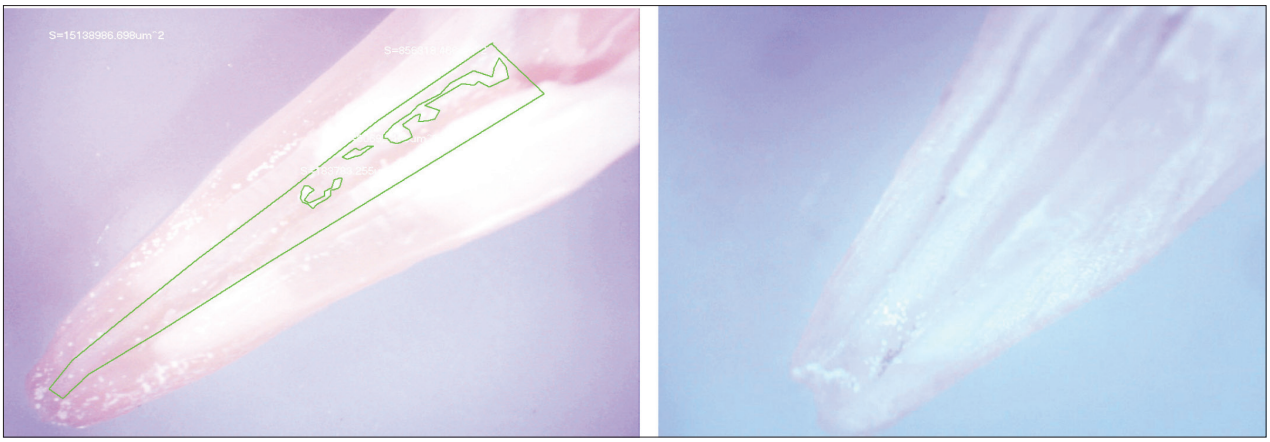

Figure 3. Well-cleaned root canal surface, especially in the apical third, after passive ultrasonic irrigation
Slika 3. Dobro očišćeni zidovi kanala korena, posebno apikalna trećina, posle pasivne ultrazvučne irigacije

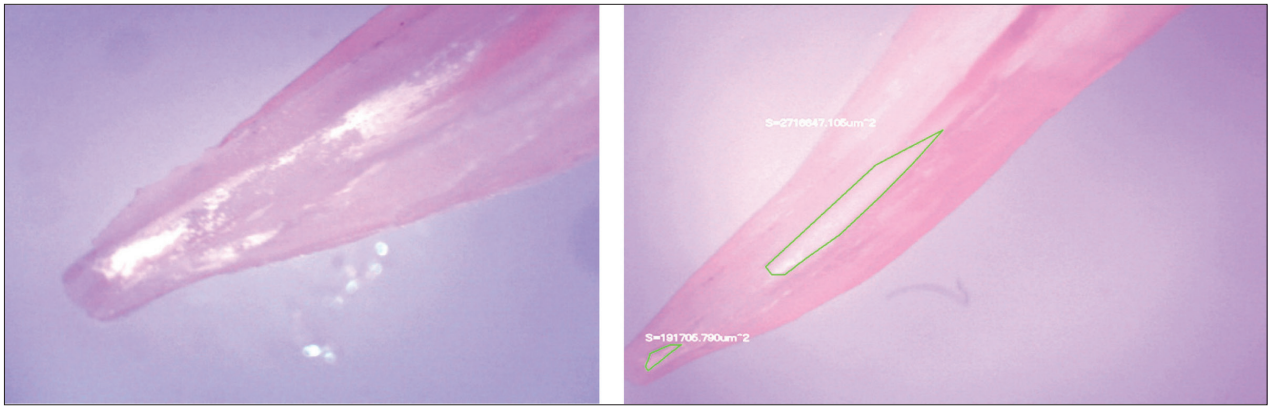

Figure 4. Residual medicament intruded into the apical third, after the use of Canal Brush
Slika 4. Zaostali medikament intrudiran u apikalnu trećinu, posle upotrebe Canal Brusha

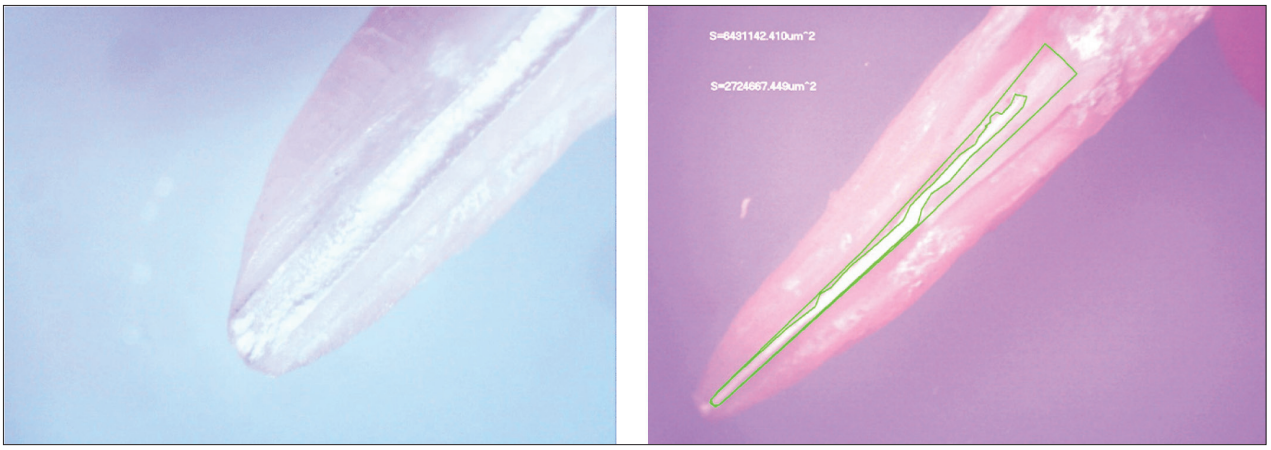

Figure 5. Excessive quantity of residual medicament along the root canal walls, after the conventional syringe irrigation
Slika 5. Velika količina zaostalog medikamenta duž celog kanala, posle konvencionalne irigacije špricem

The mean value of clean surface of the root canals was 91.33% for XP EndoFinisher, 88.36% for passive ultrasonic irrigation, 87.83% for Canal Brush and 66.92% for conventional syringe irrigation (CSI). The third group with XP showed the highest efficacy in removing CH from the canal walls with maximum of 99.40% clean surface. For the samples from the fourth group, CB, the intrusion of CH in the apical third was observed. The lowest efficacy in the removal of CH from the canal walls was shown by conventional technique, CSI, where only 47.58% of the surface was cleaned in some samples. CSI was significantly less effective than XP and PUI ($p<0.05$), while there was no significant difference between XP and PUI. No irrigation technique was able to completely remove medication from the canal walls.

DISCUSSION

Irrigation and medication play an important role in the root canal infection control. The most often-used intra-

canal medicament is CH. Considering necessity of removing CH from the canal there are contradictory research results [13, 14, 15]. However, the necessity of removing CH was accepted, due to its influence on dentin adhesion, and adhesion of endodontic sealers [1]. Previous studies indicated difficulties in complete removal of CH paste from the root canal system, especially from the apical third [1, 13, 16].

The current study was designed to compare the ability of different methods in removing CH from the root canal. To obtain precise results, the area of CH remnants on the canal walls was calculated in relation to the entire surface of the canal. Numerous studies used different scoring systems of 0-3 [1, 8, 11] or 1-5 [5] to calculate residual medicament, where lower values indicated clean canal, and higher values indicated canal filled with CH. These methods actually represent subjective assessment of the amount of residual medicament or clean surface of the canal. Ma and al. agreed with this and highlighted that this scoring method was not sensitive enough for comparing samples and interpretation of the results [9]. The other described method is measuring the volume of CH before and after removal from the root canal, which often requires expensive and sophisticated equipment or usage of radioactive isotopes [3, 9, 17]. In our study, quite exact method of calculating the surface of cleaned canal walls was used. The main advantage of this method is repeatability [2, 16].

No technique of irrigation and cleaning the root canal, tested in our study, completely eliminated CH from the canal, and that is in compliance with findings of other studies that found at least 2-4% residual medicament on the canal walls [3, 7, 9].

The results of our study showed that conventional technique of removing medicament with MAF and constant irrigation was the least effective. The most efficient system was the XP Endo finisher. Silva et al. found that the amount of residual CH could be between 3 to 20% [18]. In our study, with conventional technique, the canal was cleaned only about 24%, while larger parts of canal walls remained unclean, which could have a negative effect on the outcome of endodontic therapy. In this paper, XP showed the best results with over 99% clean surface of the canal. The reason for such good result could be the design of the instrument that is placed into the canal after instrumentation and with gentle extrusion and intrusion movements extended the cleaning effect up to 6 mm in diameter. An additional reason for effective canal cleaning with XP was the corresponding dimension of the apex preparation 40 /.04. CH and smear layer were removed efficiently due to the physical contact of rotating instruments and canal walls. Findings of Haman et al. indicate that XP was superior, especially in the apical third, just because of the contact with walls, and more efficient than ultrasonic irrigation [16]. At PUI sonic energy and frequency up to 30 kHz transmitted through ultrasonic extension formed cavitation bubbles. This agitation of irrigant increased its penetration, although passively without touching the walls of canal. Ultrasonic tip was placed 1 mm from the working length, and in authors' opinion, the apical segment remained without direct effect of ultrasonic activation. This might be the reason of lagging medicament in the apical segment of the root canal [18]. Also, the efficiency of PUI does not depend only on the duration of irrigant activation, but also on the constant addition of fresh solution [5].

There was statistically significant difference between the conventional technique for CH removal and other irrigation systems in this study. Between CU, PUI and XP there was no statistically significant difference, although the Canal Brush did not prove to be effective enough, especially in the apical third. This was also pointed out by other authors [8, 17]. Canal Brush failed to effectively remove medicament from all canal walls which was even supressed toward apex, especially those widely prepared. This could be a special problem in narrow and curved canals. The findings of our study are in accordance with other studies reporting XP and PUI as the most efficient methods for cleaning canal, without a significant difference between them [4, 8, 19, 20]. It is known that canal irrigation with NaOCl alone is not sufficient to remove CH from the root canal [21]. In addition, chelating agent (citric acid or EDTA) alone is not efficient either [22]. Topçuoğlu et al. pointed out that combination of these irrigants (NaOCl, EDTA) improved their effectiveness in removal of CH [8]. Effective removal of medicament did not depend only on irrigation technique and volume of irrigant, but also on chemical activity of irrigation agents and the size of apical preparation. The amount of used irrigant was inversely proportional to the residual medicament [17]. On the other hand, Ma et al. pointed out the importance of duration time of irrigation (up to 7 min per canal) [9].

In our paper, simple root canals were used in order to assess the efficacy of the techniques themselves, without the influence of the complexity of the root canal. The efficacy of CH removal from complicated and irregular canals is subject to further testing.

CONCLUSION

None of the irrigation techniques completely removed CH from the root canal. XP Endo finisher showed the highest efficacy in cleaning medicament from the canal walls. For optimal clinical success, it is necessary to combine various systems and copious irrigation.

REFERENCES

1. Capar ID, Ozcan E, Arslan H, Ertas H, Aydinbelge HA. Effect of different final irrigation metods on the removal of calcium hydroxide from an artificial standardized groove in apical third of root canals. J Endod. 2014; 40(3):451–4. [DOI: 10.1016/j.joen.2013.10.019] [PMID: 24565670]
2. Arslan H, Akcay M, Capar ID, Saygili G, Gok T, Ertas H. An ***in vitro*** comparison of irrigation using photon-initiated photoacoustic streaming, ultrasonic, sonic and needle technique in removing calcium hydroxide. Int Endod J. 2015; 48:246–51. [DOI: 10.1111/iej.12306] [PMID: 24786363]

3. Lloyd A, Navarrete G, Marchesan MA, Clement D. Removal of calcium hydroxide from Weine Type II systems using photon-induced photoacoustic streaming, passive ultrasonic, and needle irrigation: a microcomputed tomography study. J Appl Oral Sci. 2016; 24(6):543–8. [DOI: 10.1590/1678-775720160234] [PMID: 28076457]
4. Yaylali IE, Kececi AD, Kaya BU. Ultrasonically activated irrigation to remove calcium hydroxide from apical third of human root canal system: a systematic review of ***in vitro*** studies. J Endod. 2015; 41(10):1589–99. [DOI: 10.1016/j.joen.2015.06.006] [PMID: 26238527]
5. Alturaiki S, Lamphon H, Edrees H, Ahlquist M. Efficacy of 3 different irrigation systems on removal of calcium hydroxide from the root canal: a scanning electron microscopic study. J Endod. 2015; 41(1):97–101. [DOI: 10.1016/j.joen.2014.07.033] [PMID: 25442071]
6. Rödig T, Hirschleb M, Zapf A, Hülsmann M. Comparison of ultrasonic irrigation and RinsEndo for the removal of calcium hydroxide and Ledermix paste from root canals. Int Endod J. 2011; 44:1155–61. [DOI: 10.1111/j.1365-2591.2011.01937.x] [PMID: 21910743]
7. Faria G, Viola KS, Kuga MC, Garcia AJ, Daher VB, De Pasquali Leonardo MF, et al. Effect of rotary instrument associated with different irrigation techniques on removing calcium hydroxide dressing microscopy research and technique. 2014; 77:642–6. [DOI: 10.1002/jemt.22382] [PMID: 24844676]
8. Topçuoğlu HS, Düzgün S, Ceyhanli KT, Akti A, Pala K, Kesim B. Efficacy of different irrigation techniques in the removal of calcium hydroxide from a simulated internal root resorption cavity. Int Endod J. 2015; 48:309–16. [DOI: 10.1111/iej.12316] [PMID: 24860966]
9. Ma J, Shen Y, Yang Y, Gao Y, Wan P, Gan Y, et al. ***In vitro*** study of calcium hydroxide removal from mandibular molar root canals. J Endod. 2015; 41(4):553–8. [DOI: 10.1016/j.joen.2014.11.023] [PMID: 25596727]
10. Chou K, George R, Walsh LJ. Effectiveness of different intracanal irrigation techniques in removing intracanal paste medicaments. Aust Endod J. 2014; 40:21–5. [DOI: 10.1111/aej 12055] [PMID: 24330380]
11. Gokturk H, Ozkocak I, Buyukgebiz F, Demir O. Effectiveness of various irrigation protocols for the removal of calcium hydroxide from artificial standardized grooves. J Appl Oral Sci. 2017; 25:290–8. [DOI: 10.1590/1678-7757-2016-0414] [PMID: 28678948]
12. Alves FR, Marceliano-Alves MF, Sousa JC, Silveira SB, Provenzano JC, Siqueira JF Jr. Removal of root canal fillings in curved canals using either reciprocating single-or-rotary multi-instrument systems and a supplementary step with the XP-Endo Finisher. J Endod. 2016; 42(7):1114–9. [DOI: 10.1016/j.joen.2016.04.007] [PMID: 27215810]
13. Kim SK, Kim YO. Influence of calcium hydroxide intracanal medication on apical seal. Int Endod J. 2002; 35:623–8. [DOI: 10.1046/j.1365-2591.2002.00539.x] [PMID: 12190902]
14. Amin SA, Seyam RS, El-Samman MA. The effect of prior calcium hydroxide intracanal placement on the bond strength of two calcium silicate-based and an epoxy resin-based endodontic sealer. J Endod. 2012; 38:696–9. [DOI: 10.1016/j.joen.2012.02.007] [PMID: 2251590]
15. Barbizam JV, Trope M, Teixeira EC, Tanomaru-Filho M, Teixeira FB. Effect of calcium hydroxide intracanal dressing on the bond strength of a resin-based endodontic sealer. Braz Dent J. 2008; 19:224–7. [DOI: 10.1590/S0103-64402008000300009] [PMID: 18949295]
16. Hamdan R, Michetti J, Pinchon D, Diemer F, Georgelin-Gurgel M. The XP-Endo Finisher for the removal of calcium hydroxide paste from root canals and from the apical third. J Clin Exp Dent. 2017; 9(7):e855–60. [DOI: 10.4317/jced.53962] [PMID: 28828150]
17. Zorzin J, Wießner J, Wießner T, Lohbauer U, Petschelt A, Ebert J. Removal of radioactively marked calcium hydroxide from the root canal: influence of volume of irrigation and activation. J Endod. 2016; 42(4):637–40. [DOI: 10.1016/j.joen.2016.01.005] [PMID: 26906243]
18. Silva LJM, Pessoa OF, Teixeira MBG, Gouveia CH, Braga RR. Micro-CT evaluation of calcium hydroxide removal through passive ultrasonic irrigation associated with or without an additional instrument. Int Endod J. 2015; 48:768–73. [DOI: 10.1111/iej.12374] [PMID: 25156123]
19. Uygun AD, Gundoglu EG, Arslan H, Ersoy I. Efficacy of XP-endo finisher and TRUShape 3D conforming file compared to conventional and ultrasonic irrigation in removing calcium hydroxide. Aust Endod J. 2017; 43:89–93. [DOI: 10.1111/aej.12176] [PMID: 27862702]
20. Leoni GB, Versiani MA, Silva-Souza YT, Bruniera JF, Pecora JD, Sousa-Neto MD. ***Ex vivo*** evaluation of four final irrigation protocols on the removal of hard-tissue debris from the mesial root canal system of mandibular first molars. Int Endod J. 2017; 50(4):398–406. [DOI: 10.1111/iej.12630] [PMID: 26992452]
21. Calt S, Serper A. Dentinal tubule penetration of root canal sealers after root canal dressing with calcium hydroxide. J Endod. 1999; 25:431–3. [DOI: 10.1016/S0099-2399(99)80273-8] [PMID: 10530245]
22. Margelos J, Eliades G, Verdelis C, Palaghias G. Interaction of calcium hydroxide with zinc oxide-eugenol type sealers: a potential clinical problem. J Endod. 1997; 23:43–8. [DOI: 10.1016/S0099-2399(97)80206-3] [PMID: 9594745]

Received: 18.04.2018 • Accepted: Prihvaćen 20.08.2018

Efikasnost različitih tehnika irigacije u uklanjanju kalcijum-hidroksida iz kanala korena

Vanja Opačić Galić, Jovana N. Stašić

Univerzitet u Beogradu, Stomatološki fakultet, Klinika za bolesti zuba, Beograd, Srbija

KRATAK SADRŽAJ

Uvod Kalcijum-hidroksid (CH) predstavlja medikament koji se u velikoj meri koristi u endodontskoj terapiji zbog svojih antibakterijskih, regenerativnih i biokompatibilnih svojstava. Istraživanja pokazuju da ostaci CH na dentinskim zidovima i u tubulima mogu kompromitovati prodor silera, što doprinosi njegovoj lošijoj adheziji, promeni volumena, a samim tim i apeksnom curenju.
Cilj rada je bio da se uporedi efikasnost četiri različite tehnike uklanjanja kalcijum-hidroksida iz kanala korena zuba.

Materijal i metode Korišćena su 32 ekstrahovana jednokorena zuba sa jednim kanalom. Kanali su mašinski obrađeni BioRaCe sistemom (FKG Dentaire, Swiss) BR5 40/.04 uz irigaciju natrijum-hipohloritom posle svakog instrumenta. Na aproksimalnim površinama korenova napravljeni su uzdužni žlebovi. Svi kanali (osim negativne kontrole) napunjeni su vodenom suspenzijom CH. Posle sedam dana u inkubatoru, zubi su podeljeni u četiri grupe (n = 7), uz pozitivnu i negativnu kontrolu. Testirane su četiri tehnike (sistema) za ukljanjanje CH iz kanala korena: konvencionalna irigacija špricem (CSI), pasivna ultrazvučna irigacija (PUI), XP-endo Finisher (FKG Dentaire, Swiss) i Canal Brush (Roeko, Coltene), uz irigaciju 5 ml 2% NaOCl i 5 ml 10% limunskom kiselinom. Svi korenovi su dletom podeljeni na dve polovine i posmatrani pod stereomikroskopom (Boeco, Germany) na uveličanju od 20×. Od vrednosti ukupne površine kanala korena oduzimane su vrednosti neočišćene površine (%). Dobijene vrednosti su statistički obrađene one-way ANOVA i Tukey post hoc testom ($p < 0,05$).

Rezultati Najefikasniji sistem bio je XP-endo Finisher sa 91,33%, zatim PUI sa 88,36%, Canal Brush sa 87,83%, i konvencionalna irigacija špricem sa 66,92% očišćene površine kanala korena.

Zaključak Nijedan sistem nije u potpunosti uklonio tragove medikamenta iz kanala korena. Za potpuni klinički uspeh neophodno je kombinovati više sistema uz obilnu irigaciju.

Ključne reči: kalcijum-hidroksid; irigacija; ultrazvuk; XP-endo Finisher; Canal Brush

UVOD

Kanalna instrumentacija i irigacija najčešće nisu dovoljne za kompletno čišćenje kanala korena. Uprkos tehnološkom napretku u tehnikama instrumentacije i sistemima irigacije kanala korena, kliničari i dalje smatraju da je medikacija kanala u mnogim indikacijama neophodna faza u terapiji inficiranog korena.

Kalcijum-hidroksid (CH) najčešće je korišćen interseansni medikament, zbog svojih antibakterijskih, biokompatibilnih i regenerativnih svojstava. Medikament, pre opturacije, mora biti potpuno uklonjen sa zidova kanala korena kako se ne bi kompromitovala adhezija silera za zidove kanala, što za posledicu ima kanalno mikrocurenje. Brojne studije su se bavile problemom uklanjanja CH iz kanala korena i proveravana je uloga različitih sredstava za irigaciju [1] ili različitih tehnika aktivacije irigansa: laserom aktivirana irigacija (PIPS) [2, 3], sonična i ultrasonična aktivacija irigansa [4, 5], RinsEndo sistem [6], EndoVac sistem [7], SAF (Self adjusting files) [8], Gentle Wave sistem [9] i drugi.

Najčešće opisan metod za uklanjanje CH sa zidova kanala korena je instrumentacija kanala sa master instrumentom uz obilnu irigaciju [3]. Istraživanja ukazuju da se ovom tehnikom može očistiti samo glavni kanal i da dubina plasirane igle igra važnu ulogu [10]. Pasivna ultrazvučna irigacija (**PUI)** povećava efikasnost kanalnog dezinficijensa, agitacijom rastvora za irigaciju koji je prethodno plasiran u kanal [8]. **XP-endo Finisher** (FKG Dentaire. La-Chaux-de Fonds, Switzerland) jeste NiTi kanalni instrument veličine ISO #25 bez koničnosti koji nakon instrumentacije povećava penetraciju rastvora za irigaciju u iregularne prostore kanala [11, 12]. CanalBrush **(CB)** (Roeko Canal Brush TM Coltene/Whaledent, Langenau, Germany) jeste endodontska mikročetkica, veoma fleksibilna, od polipropilena, a koristi se sa endokolenjakom i obezbeđuje efikasno čišćenje kanala neposredno pre opturacije [8, 11].

Cilj ovog rada je bio da se uporedi efikasnost konvencionalne tehnike irigacije (CSI) sa pasivnom ultrazvučnom irigacijom (PUI), CanalBrusha (CB) i XP-endo Finishera (XP) u uklanjanju CH sa zidova kanala korena zuba.

MATERIJAL I METODOLOGIJA

U istraživanju su korišćena 32 jednokorena, jednokanalna ekstrahovana zuba. Okruglim dijamantskim svrdlom uz vodeno hlađenje su ispreparisani pristupni kaviteti na oralnim površinama krunica, a kanalnim instrumentom # K-15 (Dentsply Maillefer) proverena je prohodnost kanala. Radna dužina je utvrđena 1 mm kraće od apikalnog foramena na vrhu korena. Svi kanali su mašinski obrađeni BioRaCe sistemom sa apikalnom preparacijom do 40/.04. uz irigaciju 2% rastvorom NaOCl posle svakog instrumenta. Na bukalnim i lingvalnim površinama korenova dijamantskim diskom napravljeni su uzdužni žlebovi dubine 1 mm vodeći računa da se ne ugrozi integritet kanala korena. Posle obrade i irigacije kanali su posušeni papirnim poenima i napunjeni vodenom suspenzijom CH (prah CaO i destilovana voda) i zatvoreni privremenim ispunom Citodur hard (DoriDent-Dr. Hirschberg, Austria). Uzorci su tokom sedam dana bili umotani u vlažnu gazu natopljenu destilovanom vodom u inkubatoru na 37°C. Posle sedam dana zubi su nasumično podeljeni u četiri grupe (n = 7). Po dva zuba su bila korišćena kao pozitivna i negativna kontrola. Pozitivnu kontrolu su činili zubi ispunjeni pastom CH, koja nije uklanjana iz kanala korena, a negativnu ispreparisani zubi sa praznim kanalima (bez paste CH).

I grupa: **Konvencionalna irigacija špricem (CSI)** – medikament je uklanjan ručnim instrumentima (turpijama) od #K15 do #K40 (master apical file-MAF) uz irigaciju.

II grupa: **Pasivna irigacija ultrazvukom (PUI)** (PB-323,W&H Dentalwerk Bürmoos, Austria) – ultrazvučna igla je postavljena u kanal na 1 mm kraće od radne dužine bez kontakta sa zidovima kanala i aktivirana tri puta po 20 sek. (frekvencija 25–30 kHz). Za svaki ciklus je ubacivan svež irigans.

III grupa: **XP-endo Finisher (XP) –** instrument je korišćen sa endodontskim motorom X-Smart (Dentsply Sirona, Ballaigues, Switzerland), sa brzinom od 800 rpm i obrtnim momentom 1 Ncm. Instrument je postavljan u kanal 1 mm kraće od radne dužine, nežnim pokretima gore-dole u tri ciklusa od 1 min. sa stalnom irigacijom.

IV grupa: **CanalBrush (CB)** – kanalna četkica veličine M je plasirana 1 mm kraće od radne dužine, sa endomotorom brzine 600 rpm po 1 min. za svaki irigans. Korišćeni su pokreti laganog četkanja uz konstantnu irigaciju. Korišćena je nova četkica za svaki kanal.

Sve grupe su irigirane na isti način, kontinuirana irigacija 5 ml 2% NaOCl u trajanju od 1 min., pa irigacija sa 10% limunskom kiselinom 5 ml, tokom 1 minuta. Na kraju, svi uzorci su irigirani sa 5 ml destilovane vode.

Zubi su dletom sečeni na dve polovine koje su posmatrane na stereomikroskopu (Boeco BSZ-405, Germany) sa intergrisanom digitalnom kamerom, na uveličanju ×20. Slike su obrađene i izmerene u softverskom programu Scopelmage 9.0 (Teleskop, Austria). Uz pomoć navedenog softverskog programa merene su ukupne površine kanala (P_k) od gleđno-dentinske granice do foramena apikale (izraženo kao 100%), kao i površine polja sa zaostalim medikamentom (P_{ch}). Oduzimanjem dobijenih vrednosti ($P_k - P_{ch} = P_č$) izračunat je procenat očišćenih površina kanala korena ($P_č$). Dobijeni rezultati su statistički obrađeni One way ANOVA i Tukey post hoc testovima. P-vrednost <0,05 je smatrana značajnom.

REZULTATI

Rezultati istraživanja su prikazani na slikama 1–5. Srednja vrednost očišćenih površina kanala korena iznosila je 91,33% za XP-endo Finisher, 88,36% za pasivnu ultrazvučnu irigaciju, 87,83% za Canal Brush i 66,92% za konvencionalnu irigaciju špricem. Treća grupa sa XP je pokazala najveću efikasnost u uklanjanju CH sa zidova kanala korena sa maks. 99,40% čiste površine. Kod uzoraka iz četvrte grupe, CB, uočena je intruzija CH u apikalnu trećinu. Najmanju efikasnost u uklanjanju CH sa zidova kanala je pokazala konvencionalna tehnika, CSI, gde je tek 47,58% površine bilo očišćeno u nekim uzorcima. CSI je bila statistički značajno manje efikasna od XP i PUI ($p < 0,05$), dok između XP i PUI nije bilo statističke razlike. Nijedna tehnika irigacije nije uspela u potpunosti da ukloni medikament sa zidova kanala.

DISKUSIJA

Irigacija i medikacija imaju značajnu ulogu u kontroli endodontske infekcije u kanalu. O neophodnosti uklanjanja CH iz kanala postoje kontradiktorni rezultati istraživanja [13, 14, 15]. Ipak, prihvaćen je stav o neophodnosti uklanjanja CH, zbog njegovog uticaja na vezu sa dentinom, kao i na vezivanje samog endodontskog silera [1]. Prethodno objavljene studije ukazuju na teškoće prilikom kompletnog uklanjanja paste CH iz sistema kanala korena, a posebno apikalne trećine [1, 13, 16].

Ovo istraživanje je dizajnirano tako da se uporede sposobnosti različitih metoda čišćenja i uklanjanja CH iz kanala korena. Za dobijanje preciznih rezultata izračunavana je neočišćena površina kanala u odnosu na površinu celog kanala. Brojni radovi su za izračunavanje zaostalog medikamenta koristili različite sisteme skorovanja od 0 do 3 [1, 8, 11] ili od 1 do 5 [5], pri čemu su najmanje vrednosti označavale čist kanal, a najveće potpunu ispunjenost CH. Problem ovih metoda je dosta subjektivna procena o količini zaostalog medikamenta ili očišćene površine kanala. S ovim se slažu i Ma i sar. i ističu da ova metoda ocenjivanja nije dovoljno prihvatljiva za upoređivanje uzoraka i tumačenje dobijenih rezultata [9]. Druga opisana metoda je merenje volumena CH pre i posle uklanjanja iz kanala korena, što često zahteva skupu i sofisticiranu opremu ili upotrebu radioaktivnog izotopa [3, 9, 17]. U ovom radu korišćena je dosta egzaktna metoda izračunavanja površine očišćenih zidova kanala, što omogućava istraživačima lako ponavljanje i proveru korišćene metode. Sličnu metodologiju su koristili i drugi istraživači, smatrajući je preciznijom [2, 16].

Nijedna tehnika irigacije i čišćenja kanala testirana u ovom radu nije kompletno eliminisala kalcijum-hidroksid iz kanala, što je u saglasnosti sa nalazima i drugih istraživača, gde zaostaje bar 2–4% medikamenata na zidovima [3, 7, 9].

Rezultati ovog istraživanja pokazuju da se kao najmanje efikasna tehnika pokazala konvencionalna tehnika uklanjanja medikamenta turpijama do MAF sa stalnom irigacijom, a najefikasniji sistem je bio XP-endo Finisher. Silva i sar. ističu da količina zaostalog kalcijuma iznosi od 3 do 20% [18]. U ovom radu, kod konvencionalne tehnike kanal je očišćen samo oko 24%, dok su veći delovi zidova ostali neočišćeni, što sigurno ima i negativan uticaj na ishod endodontske terapije. Najbolji rezultat u ovom radu pokazao je XP sa preko 99% očišćene površine kanala. Razlog za ovako dobar rezultat leži u dizajnu instrumenta koji se postavlja u kanal nakon instrumentacije i sa blagim pokretima uvlačenja i izvlačenja može da proširi efekat čišćenja i do 6 mm u prečniku. Dodatni razlog za efikasno čišćenje kanala XP-om je i odgovarajuća dimenzija apeksne preparacije – 40/.04. Kalcijum-hidroksid, ali i razmazni sloj, uklanja se efikasno zbog fizičkog kontakta rotirajućeg instrumenta i zidova kanala. Nalazi Hamdana i sar. ukazuju da je XP bio superioran, posebno u apeksnoj trećini, baš zbog ostvarenog kontakta sa zidovima, i efikasniji i od ultrazvučne irigacije [16]. Kod PUI zvučna energija i frekvencija do 30 kHz preneta kroz ultrazvučni nastavak stvaraju kavitacione mehuriće. Ova agitacija irigansa povećava njegovu penetraciju, ali pasivno, bez dodirivanja zidova kanala. Vrh ultrazvučnog nastavka se plasira na 1 mm od radne dužine pa, po mišljenju autora, apikalni segment ostaje bez direktnog efekta ultrazvučne aktivacije, što je možda razlog zaostajanja medikamenta u apikalnom segmentu korena [18]. Takođe, efikasnost PUI ne zavisi samo od dužine aktivacije irigansa već i od stalnog dodavanja svežeg rastvora [5].

Postoji statistički značajna razlika između konvencionalne tehnike uklanjanja CH i drugih sistema irigacije u ovom radu. Između CB, PUI i XP nema statistički značajne razlike, iako se CanalBrush nije pokazao dovoljno efikasnim, posebno u api-

kalnoj trećini, što ističu i drugi autori [8, 17]. Mikročetkica nije uspela efikasno da ukloni medikament sa svih zidova kanala, a izraženo je čak i njegovo potiskivanje ka apeksu, koji je bio široko obrađen, tako da to može predstavljati poseban problem u uskim i zakrivljenim kanalima.

Nalazi ove studije su u saglasnosti sa drugim istraživanjima koji nalaze da su najefikasnije metode za čišćenje kanala XP i PUI, bez značajne razlike između njih [4, 8, 19, 20]. Poznato je da irigacija kanala samo sa NaOCl nije dovoljno efikasna u uklanjanju CH iz kanala [21]. Takođe, ni samo helatno sredstvo (limunska kiselina ili EDTA) nije dovoljno efikasno [22]. Topçuoğlu i sar. ističu da kombinovanje ovih iriganasa (NaOCl, EDTA) poboljšava njihovu efikasnost u uklanjanju CH [8]. Efikasno uklanjanje medikamenta ne zavisi samo od tehnike irigacije, volumena irigansa već i od hemijske aktivnosti sredstava za irigaciju i od dimenzije apeksne preparacije. Količina upotrebljenog irigansa je obrnuto proporcionalana zaostalom medikamentu [17]. S druge strane, Haapasalo ističe i značaj vremena, odnosno trajanje irigacije (čak i do 7 min. po kanalu) [9].

U ovom radu korišćeni su jednostavni kanali sa namerom da se ispita efikasnost samih tehnika, bez uticaja kompleksnosti kanalnog sistema. Efikasnost uklanjanja CH iz komplikovanih i iregularnih kanalnih prostora je tema daljih ispitivanja.

ZAKLJUČAK

Nijedna tehnika irigacije nije uspela u potpunosti da ukloni kalcijum-hidroksid iz kanala korena. XP-endo Finisher je pokazao najveću efikasnost u čišćenju medikamenta sa zidova kanal. Za potpuni klinički uspeh potrebno je kombinovati više sistema čišćenja kanala uz obilnu irigaciju.