



# STOMATOLOŠKI GLASNIK SRBIJE

## SERBIAN DENTAL JOURNAL

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*Ko se prihvati velikog i pohvalnog poduhvata  
utehu za svoj naporan rad pronaći će najpre u nadi,  
a nakon toga u radosti.*

Samuel Džonson

**P**ravi razlog svakog uspeha su radna etika, marljivost, posvećenost i maksimalna usredsređenost poslu kojim se neko bavi. Tu je, naravno, i snažan motiv za pobedom, tj. iskrena želja da se bude najbolji u sopstvenoj profesiji. Preduslovi za takvu uzlaznu putanju sigurno su dobro obrazovanje, neprestan rad „na sebi“, ali i odlučan stav o važnim pitanjima koja su sastavni deo tog puta ka uspehu.

Može li se ostvariti uspeh u bilo čemu ukoliko nemate sopstveni stav?

Na ovo pitanje naizgled nije teško odgovoriti. Sigurno je da u svemu što radite morate imati plan, viziju, ideje, ali i odlučan stav da dođete do cilja. Svoje stavove treba iskazivati čak i ako oni nisu u saglasju s mišljenjem većine ili onih koji odlučuju. Stav može biti pogrešan, ali o njegovoj vrednosti sigurno ne odlučuju ni trenutna većina, ni odnosi u društvu, ni trenutni strah od pojedinaca koji nas okružuju, već ispravnost i vreme.

U vremenu u kojem živimo najvažnije je imati „fleksibilan stav“. To znači da je „najbolje“ da je stav saglasan sa stavom onih koji se trenutno pitaju i odlučuju o svemu. Jedan prijatelj je u nekom razgovoru ljude bez stava definisao kao ljude koji uvek idu „niz vetar“, jer se na taj način lakše uključuju u „stihiju“. A za život je ipak važnije kretanje „uz vetar“, jer je to siguran znak da ste „možda“ u pravu. Jer svet se može menjati samo idejama uspešnih pojedinaca i većinom koja je vođena upravo idejama ljudi sa stavom.

Da biste imali sopstveni stav, morate, naravno, biti oslobođeni straha. Tamo gde postoji strah i gde je bahatost osnovna vrlina onih koji odlučuju put ka uspehu je uvek na nizbrdici. A put ka vrhu je vrednost koja se dobija kroz posvećenost, marljivost i naporan rad dok se penjete uzbrdo, ka vrhu. Zato sposobni, ambiciozni i pametni ljudi uglavnom predstavljaju potencijalnu opasnost, a najpogodniji su oni bez stava, čiji strah od eventualnih posledica po njihovo lično bitisanje može ugasiti čak i neke njihove potencijalne kvalitete.

Ljudi bez stava često imaju želju da preuzmu daleko veću odgovornost od one koju stvarno mogu da ostvare i podnesu. U takvim situacijama se događa potpuna kratkovidost. Ona je slična mornaru koji sve vreme izbacuje kofom vodu iz čamca umesto da malo zastane i zapuši rupu. Neko je rekao da nismo na ovom svetu samo da bismo živeli, već da bismo pomogli da se živi bolje, i s većom vizijom i nadom, kao dostignućima koja će svet učiniti boljim.

Ovaj urednički komentar će završiti sjajnim citatom Džordža Bernarda Šoa, jer on samo potvrđuje priču i problem predstavljen u ovom tekstu: „Istinsko zadovoljstvo u životu je raditi svršishodno. To je ono što ispunjava život – da služite cilju koji vi smatrate najvažnijim, da budete snaga prirode, a ne grozničavi, sebični jadničak, ophrvan mukama i patnjama, koji kuka zato što se svet oko njega ne trudi da ga učini srećnim.“

Prof. dr Slavoljub Živković



# Marginal Microléakage of Newly Synthesized Nanostructured Biomaterials Based on Active Calcium Silicate Systems and Hydroxyapatite

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## SUMMARY

**Introduction** Calcium silicate cements can be successfully used for the treatment of root perforations due to their exceptional biological and sealing properties. The aim of this study was to test, using dye penetration method, marginal microléakage of newly synthesized nanostructured biomaterials based on calcium silicate system and hydroxyapatite after their application in interradicular perforation of extracted teeth.

**Material and Methods** The study included 34 extracted human molars. Newly synthesized nanostructured materials: one based on calcium silicate system (CS), and the other one based on hydroxyapatite and active calcium silicate system (HA-CS) were tested. Mineral trioxide aggregate (MTA; Angelus, Londrina, Brazil) was used as control. Marginal microléakage was evaluated using dye penetration test 6 months after the application of materials in experimentally prepared inter-radicular perforations in extracted human molars. Dye penetration was analyzed using light microscope at 30X magnification, a method of quantifying visual information in computer software for image processing (Adobe Photoshop CS5 Extended, version 12.0 x 32). The values were expressed in millimeters, and the results statistically analyzed using one-way ANOVA and Tukey post-hoc test ( $\alpha=0.05$ ).

**Results** The shortest dye penetration was measured for calcium silicate system (0.44 mm), while slightly higher values were found for MTA (0.54 mm). Dye penetration for hydroxyapatite and active calcium silicate system (2.00 mm) was longer than for the other two materials ( $p<0.05$ ).

**Conclusion** The lowest marginal microléakage was observed in CS and was comparable to MTA. Microléakage in HA-CS was significantly higher than CS and MTA.

**Keywords:** marginal microléakage; calcium silicate cements; hydroxyapatite

## INTRODUCTION

Marginal seal or adequate marginal adaptation of material along the cavity walls should be able to prevent leakage of tissue fluid and consequently bacterial microléakage. Therefore, it is considered as significant factor for long-term success of endodontic treatment [1].

Calcium silicate cements were introduced in endodontic practice in the mid 90-ies of the last century in order to be used as materials for closing root perforations and root apical closure after apical surgery. Studies have demonstrated superior marginal seal achieved by calcium silicate cements compared to amalgam and cements based on zinc-oxide-eugenol (ZOE; Super EBA and IRM cement), which have been commonly used in these indications [1]. It has also been demonstrated that calcium silicate cements achieve good marginal seal in cavities contaminated with blood [1, 2], they are biocompatible [1], bioactive [3] and induce regeneration of hard dental [4, 5] and periodontal tissue [6]. Consequently, their indications have expanded significantly [7].

The main issue for clinical use of calcium silicate cements is their long setting time [8]. Initial binding

of several hours increases the risk of material dissolution and leaching from the site of application. Moisture is needed for hydration and setting of these materials, which is why additional external moisture is needed during initial bonding. That inevitably delays completion of endodontic treatment [9]. In previous years, numerous studies have been conducted in order to overcome this problem [10-13].

Modern research has focused on synthesis and evaluation of new nanostructured biomaterials in similar endodontic indications [14]. Nanomaterials are characterized among others, by pronounced activity of particles and consequently, faster setting in comparison with conventional microstructural materials [15]. The Institute of Nuclear Sciences in Vinča, according to the recipe of Jokanović et al. [16], synthesized two new biomaterials: one based on calcium silicate system (CS) and the other one based on hydroxyapatite and active calcium silicate system (HA-CS). These materials showed initial setting of 10 minutes (CS) and 15 minutes (HA-CS), respectively. Previous studies have shown that these materials have less genotoxic and cytotoxic effects, but higher osteogenic potential than commercial calcium silicate cements [17, 18].

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The aim of this study was to test, using dye penetration method, marginal microléakage of newly synthesized nanostructured biomaterials based on calcium silicate system and hydroxyapatite (HA-CS) after their application in interradicular perforation of extracted teeth.

## MATERIAL AND METHODS

Three materials in total were tested in this study: new material based on calcium silicate system (CS), new material based on mixtures of hydroxyapatite and calcium silicate system (HA-CS) and control material MTA (MTA Angelus®, Londrina, Brazil). Experiments were performed on 34 human, extracted, maxillary and mandibular molars with fully developed and non-fused roots. Access cavities were prepared with high speed handpiece, which after hand K-files (K-files, VDW GmbH, Germany) were used to establish working length of root canals up to 1 mm shorter than the anatomy of the foramen. Root canals were instrumented with Crown-down technique using series of rotary files BioRace (FKG Dentaire, Swiss Dental Products, Switzerland). During instrumentation, canals were irrigated with 0.5% NaOCl. For the final rinse 5 mL of 10% citric acid solution (during 1 min) and 5 mL of 0.5% sodium hypochlorite solution were used. After drying the canals were obturated using monocone technique and sealer Acroseal (Septodont, France).

After sealer setting, in the center of the pulp chamber floor, using slow speed handpiece and round bur size # 4 inter-radicular perforations were prepared. The size of perforations was the same as diameter of round bur while the depth depended on the thickness of the pulp chamber floor. After washing perforations with distilled water and air-drying, the teeth were randomly assigned into the three experimental groups according to the materials used: CS, HA-CS and MTA (n=10). Positive controls were teeth with perforations that were not sealed and negative controls were two teeth without perforations.

Prior to the application of the test material, the teeth were placed in a sponge soaked with artificial tissue fluid up to the level of enamel-cement junction (Eng. Hank's balanced salt solution, HBSS). Materials were mixed with distilled water in the ratio of 3: 1 and placed in the prepared cavities using condensers. On the top of the material a moist cotton pellet was placed and the teeth were incubated at 37°C for 24 h. After complete setting of materials access cavities were permanently closed using composite. Teeth were incubated in sponges at 37°C for the next 6 months.

After 6 months marginal microléakage was evaluated using passive dye penetration method. The teeth were coated with two coats of varnish, except in the area of the material in the furcation (about 1 mm around material) and placed in 50% solution of silver nitrate ( $\text{AgNO}_3$ ) for 2 h. After quick rinsing teeth were immersed in photo developer for 6 h. Teeth were cut longitudinally in the region of perforation using diamond disc of 0.7 mm thickness and linear speed saw with water cooling (Isomet testers 4000, Buehler, Lake Bluff, IL, USA). Dye penetration between the material and cavity walls was analyzed using light

microscopy and photographed at 30X magnification. The depth of dye penetration was measured using the method of quantifying of visual information in computer software for image processing (Adobe Photoshop CS5 Extended, version 12.0 x 32). The obtained values were expressed in millimeters. The results were statistically analyzed using one-way ANOVA with Tukey post-hoc test. The level of significance was set at  $\alpha=0.05$

## RESULTS

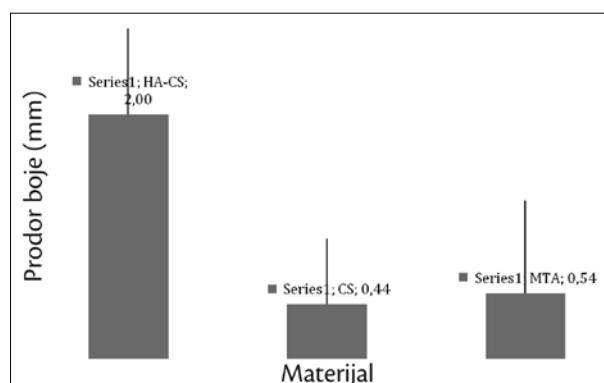
The shortest dye penetration was found for CS ( $0.44 \pm 0.54$  mm) (Figure 1). Similar values were measured for MTA ( $0.54 \pm 0.76$  mm) (Figure 2). The longest dye penetration was recorded for HA-CS ( $2.00 \pm 0.70$  mm) (Graph 1, Figure 3). There was no statistically significant difference in marginal dye penetration between CS and MTA. HA-CS showed dye penetration that was significantly longer than for CS and MTA ( $p<0.05$ ).

In addition to color penetration between restorations and dentin, staining of tested materials was also noticed (Figures 4, 5 and 6).

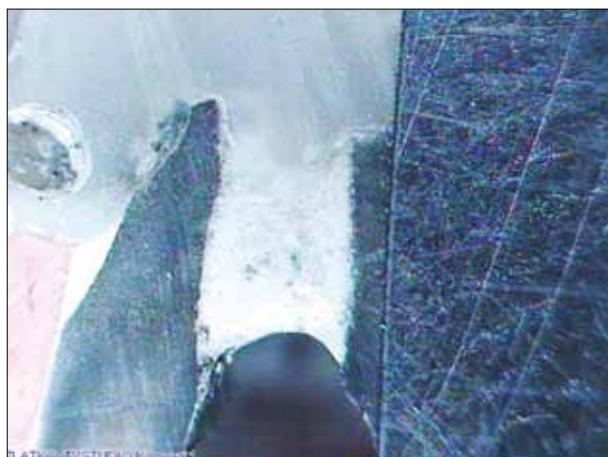
## DISCUSSION

Dye or bacteria penetration or fluid filtration methods are most commonly used for the evaluation of marginal microléakage of different materials *in vitro* [19-22]. In the current study dye penetration method was used due to simplicity as described in numerous studies [19, 20, 23, 24, 25]. One of the main objections to dye penetration method is related to the size of dye molecules that are commonly used which are actually smaller than the size of bacteria [19]. Therefore, for materials that show penetration of small dye molecules, it can be expected that leakage of larger molecules (bacteria and their products) will be absent [1].

When choosing dye for the assessment of marginal leakage chemical nature of the tested material should be taken into account. Wu et al. [26] found that methylene blue is unstable in the presence of alkaline substances resulting in its decolorization. As calcium hydroxide is major ingredient of MTA, the use of methylene blue for



**Graph 1.** Average microléakage of the tested materials  
**Grafikon 1.** Srednje vrednosti prodora boje ispitivanih materijala



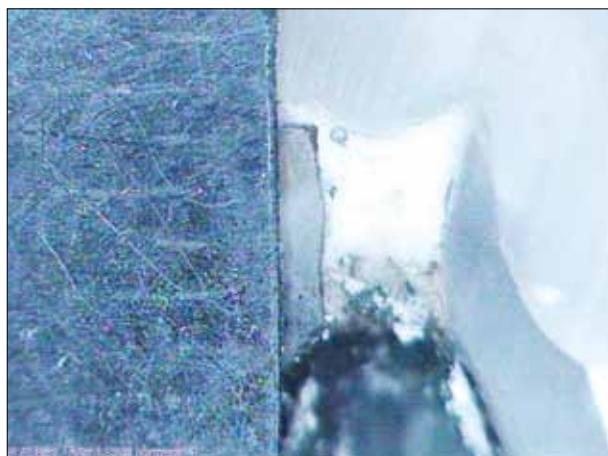
**Figure 1.** Inter-radicular perforation filled with calcium silicate material. There is no dye marginal leakage ( $\times 30$ ).

**Slika 1.** Interradiksna perforacija ispunjena kalcijumsilikatnim materijalom. Ne uočava se marginalni prodor boje ( $\times 30$ ).



**Figure 2.** Inter-radicular perforation filled with MTA. There is no dye marginal leakage ( $\times 30$ ).

**Slika 2.** Interradiksna perforacija ispunjena materijalom MTA. Ne uočava se marginalni prodor boje ( $\times 30$ ).



**Figure 3.** Inter-radicular perforation filled with hydroxyapatite-calcium silicate material. There is dye marginal leakage and absorption with material color change ( $\times 30$ ).

**Slika 3.** Interradiksna perforacija ispunjena materijalom hidroksiapatitom i kalcijumsilikatnim cementom. Uočavaju se prodor i apsorpcija boje sa delimičnim prebojavanjem materijala ( $\times 30$ ).



**Figure 4.** Inter-radicular perforation filled with calcium silicate material. There is dye marginal leakage and absorption with material color change ( $\times 30$ ).

**Slika 4.** Interradiksna perforacija ispunjena kalcijumsilikatnim materijalom. Uočava se prodor i apsorpcija boje sa delimičnim prebojavanjem materijala ( $\times 30$ ).



**Figure 5.** Inter-radicular perforation filled with hydroxyapatite-calcium silicate material. There is dye absorption with most of material having changed color ( $\times 30$ ).

**Slika 5.** Interradiksna perforacija ispunjena materijalom hidroksiapatitom i kalcijumsilikatnim cementom. Uočava se apsorpcija boje sa prebojavanjem većeg dela materijala ( $\times 30$ ).



**Figure 6.** Inter-radicular perforation filled with MTA. There is dye absorption and color change throughout the whole thickness of material ( $\times 30$ ).

**Slika 6.** Interradiksna perforacija ispunjena materijalom MTA. Uočavaju se prodor i apsorpcija boje celom debljinom materijala ( $\times 30$ ).

the evaluation of MTA and other materials of similar composition would cause its discoloration and eventually unreliable results. A solution of silver nitrate was chosen as dye due to its stability in the presence of the high pH and high molecular weight of silver particles [25].

Marginal microléakage was assessed after the application of the test material in experimentally prepared, inter-radicular perforations of extracted teeth. During the experimental period the teeth were stored in an incubator, with a sponge soaked in artificial tissue fluid to simulate clinical conditions [21]. In the current study, the deepest dye penetration was measured after the teeth were longitudinally cut. Therefore, it was not possible to determine precisely in which part of the cavity dye penetrated the most. Dye penetration method done *in vitro* cannot be directly related to the complex *in vivo* microléakage but it can be possible indicator of microléakage in clinical conditions [20].

The lowest dye penetration in the current study was observed for CS material. The values of dye penetration for MTA were slightly higher but with no statistically significant difference compared to CS. Given that CS and MTA have similar composition and physical properties are likely similar. Good marginal seal of calcium silicate cements is associated with mild expansion of cement during setting [27, 28], bio-activity and hydroxyapatite formation on the surface of the material in contact with phosphates from tissue fluids [29].

However, different microléakage evaluating methods have shown that MTA and similar calcium silicate cements do not have the ability of absolute hermetic sealing [21, 22, 25, 30], which is consistent with the results of the current study. In the group of samples with CS, the measured values of dye penetration were lower compared to the MTA samples, however, larger number of samples in the CS group showed microléakage than in the MTA group. The measured values of dye penetration in the MTA group were very different, and the results are consistent with the findings of De Deus et al. [30]. They evaluated the marginal microléakage of different calcium silicate cements (PC, MTA Angelus and MTA Bio) and reported very variable results within groups. They also detected microléakage in all samples but with no statistically significant difference between different calcium silicate cements [30]. In contrast, Hashem et al. [19] observed differences in the permeability of various commercial calcium silicates, considering that different chemical composition and different setting time may play a role in the material attachment to the cavity walls. Also, studies that evaluated permeability of calcium silicate cements using bacteria penetration method have reported different results. Montelano et al. [2] recorded the most pronounced microléakage in the first days of application of materials, while Parirokh et al. [21] detected significantly delayed bacterial penetration (between 39 and 73 days of experiment) highlighting the positive impact of phosphate solution on the adhesion of material.

Literature reviews describe inconsistency in results for the permeability of calcium silicate cements using different testing methods. Many factors influence microléakage of MTA: dye, pH of dye, storage conditions of samples

before experiment, and setting time of material prior to immersion of samples in dye solution [1]. Also, different results may be due to the difference in diameter and depth of perforations, number of samples, or duration of observational period [30].

For adequate understanding of results obtained in the current study, it is important to explain the way of dye penetration. Samples that showed dye penetration did not confirm strictly marginal microléakage. In fact, besides the dye detected at the junction of materials and dentin, staining of materials was noted likely due to dye absorption (Figures 4, 5 and 6). Similar results were reported by Tobón-Arroyave et al. [20]. They found that dye penetration in MTA was different in nature than in conventional cements (IRM and Super EBA). When IRM and Super EBA cements were used as apical plug, dye penetration was noted as a circle around the material, between material and dentin. In contrast, in all MTA samples color change was noted in the entire thickness of the material [20]. The reason for these results could be found in MTA structure made of numerous pores and capillaries that could cause more pronounced permeability. It is important however to note that MTA samples in that study had setting time of just 30 minutes before their immersion in dye, therefore results could reflect incomplete setting of material. In the current study, samples were allowed 24 hours setting time before incubation and then after incubation in humid environment for 6 months. This protocol could allow more complete setting and consequently lower dye penetration and absorption.

HA-CS showed the deepest dye penetration and in the majority of samples material disintegration was observed. Since hydroxyapatite is well known for its porous structure and inadequate mechanical properties, the results were somewhat expected. During synthesis HA-CS, calcium silicate was added to hydroxyapatite in order to improve its mechanical properties. Based on the current results it can be noted that additional quantity of calcium silicate (HA:CS=2:1) under the experimental conditions of this study, did not prevent dissolution and leaching of material from the site of application. Literature findings also suggest that calcium phosphate cements do not provide adequate sealing due to their porosity and solubility and in that sense they are inferior to calcium silicate cements [24, 25].

It is worth noting that in some MTA and CS samples surface disintegration or dissolution of the outer layer material was noted but still less than in HA-CS samples. In contact with water or phosphate solution, cement releases calcium ions with partial decalcification of calcium silicate hydrate, whereas the expansion of cement after contact with liquid may result in microfractures. All these may constitute an obstacle to long-term stability of the material [13]. However, when interpreting results of an *in vitro* study, it must be noted that tissue response was absent. Namely, one of the characteristics of the tested bioactive materials in this study is formation of hydroxyapatite on their surface in contact with tissue fluids [3, 29], as well as the formation of calcified tissue via calcium silicate or calcium phosphate cements. Therefore, one might expect that in clinical setting material disintegration could be

self-limiting and hydroxyapatite formed over time could fill the pores within the material and provide chemical bond to dentin contributing to better marginal seal [31].

## CONCLUSION

The lowest marginal microleakage or the best marginal seal was observed in CS and MTA. Microleakage of HA-CS was significantly higher compared to the other two tested materials.

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# Ispitivanje marginalne mikropustljivosti novosintetisanih nanostruktturnih biomaterijala na bazi aktivnih kalcijumsilikatnih sistema i hidroksiapatita

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## KRATAK SADRŽAJ

**Uvod** Primena cemenata od kalcijum-silikata u lečenju perforacija korena zuba zasniva se na njihovim izuzetnim biološkim svojstvima i odgovarajućem rubnom zaptivanju. Cilj ovog rada bio je da se testom prodora boje ispita marginalna mikropustljivost novosintetisanih nanostruktturnih biomaterijala na bazi kalcijumsilikatnih sistema i hidroksiapatita nakon primene materijala u interradiksne perforacije ekstrahovanih zuba.

**Materijal i metode rada** Ispitivanje je realizovano na 34 ekstrahovana humana molara. Testirani su novosintetisani nanostruktturni materijali: materijal na bazi aktivnih kalcijumsilikatnih sistema (CS) i materijal na bazi hidroksiapatita i aktivnih kalcijumsilikatnih sistema (HA-CS). Kao kontrolni materijal korišćen je komercijalni kalcijumsilikatni cement (MTA Angelus, Londrina, Brazil). Marginalna mikropustljivost je ispitivana testom prodora boje šest meseci nakon primene materijala u eksperimentalno preparisane interradiksne perforacije na ekstrahovanim humanim molarima. Prodor boje je analiziran svetlosnim mikroskopom na uvećanju od 30 puta metodom kvantifikovanja vizuelnih informacija kompjuterskim programom za obradu slike (*Adobe Photoshop CS5 Extended*, verzija 12.0x32). Dobijene vrednosti su izražene u milimetrima, a dobijeni rezultati statistički su obrađeni primenom jednofaktorskog testa ANOVA sa Tukeyevim (*Tukey*) post-hoc testom ( $\alpha=0,05$ ).

**Rezultati** Najmanji prodor boje izmeren je kod materijala CS (0,44 mm), dok su nešto veće vrednosti zabeležene kod MTA (0,54 mm). Prodor boje kod materijala HA-CS (2,00 mm) bio je značajno veći u odnosu na materijale CS i MTA ( $p<0,05$ ).

**Zaključak** Najmanja marginalna mikropustljivost zabeležena je kod materijala CS i bila je komparabilna sa MTA. Mikropustljivost materijala HA-CS bila je značajno veća u odnosu na materijal CS i kontrolni materijal MTA.

**Ključne reči:** marginalna mikropustljivost; kalcijumsilikatni cementi; hidroksiapatit

## UVOD

Kvalitetno rubno zaptivanje, odnosno odgovarajuća marginalna adaptacija materijala uz zidove kavite, treba da onemogući protok tkivnih tečnosti i posledično bakterijsko mikrocurenje, zbog čega se smatra značajnim faktorom za dugoročan uspeh endodontskog lečenja [1].

Cementi od kalcijum-silikata uvedeni su u endodontsku praksu sredinom devedesetih godina prošlog veka, najpre kao materijali namenjeni lečenju korenskih perforacija i zatvaranju vrha korena zuba nakon apeksne hirurgije. Istraživanja su ukazala na znatno bolje rubno zaptivanje kalcijum-silikata u odnosu na amalgam i komercijalne cemente na bazi ZOE (Super EBA i IRM cement), koji su obično korišćeni u navedenim indikacijama [1]. Kasnije je utvrđeno da kalcijumsilikatni cementi ostvaruju kvalitetno rubno zaptivanje i u kavitetima koji su kontaminirani krvlju [1, 2], da su biokompatibilni [1], bioaktivni [3] i da indukuju regeneraciju čvrstih zubnih tkiva [4, 5] i periodoncijuma [6], zbog čega su njihove indikacije danas značajno proširene [7].

Glavni problem koji otežava kliničku primenu kalcijum-silikata je dugo vreme vezivanja [8]. Inicijalno vezivanje od nekoliko sati nosi rizik od rastvaranja i ispiranja materijala s mesta aplikacije. Za hidrataciju i očvršćavanje materijala neophodna je vlaga, pa se preporučuje da se nakon primene (u periodu inicijalnog vezivanja) materijalu obezbedi eksterna vlaga, što neminovalno odlaže završetak endodontskog lečenja [9]. Ranijih godina urađena su brojna istraživanja radi prevazilaženja ovog problema [10-13].

Savremena istraživanja su fokusirana na sintezi i ispitivanja moguće primene nanostruktturnih biomaterijala u sličnim en-

dodontskim indikacijama [14]. Nanomaterijale, između ostalog, odlikuje izraženija aktivnost čestica, te posledično brže vezivanje u odnosu na konvencionalne mikrostrukturne materijale [15]. U Institutu za nuklearne nauke u Vinči, prema recepturi Jokanovića i saradnika [16], sintetisana su dva nova biomaterijala: materijal na bazi aktivnih kalcijumsilikatnih sistema (CS) i materijal na bazi hidroksiapatita i aktivnih kalcijumsilikatnih sistema (HA-CS). Nanotehnologijom dobijeni su materijali s inicijalnim vezivanjem od 10 minuta (CS), odnosno 15 minuta (HA-CS). Dosadašnja istraživanja su pokazala da dobijeni materijali imaju slabija genotoksična i citotoksična dejstva, kao i veći osteogeni potencijal u odnosu na komercijalne kalcijumsilikatne cemente [17, 18].

Cilj ovog istraživanja bio je da se testom prodora boje ispita marginalna mikropustljivost materijala CS i HA-CS nakon primene materijala u interradiksne perforacije ekstahovanih humanih zuba.

## MATERIJAL I METODE RADA

U ovom istraživanju testirani su materijal na bazi kalcijumsilikatnih sistema (CS), materijal na bazi mešavine hidroksiapatita i kalcijumsilikatnih sistema (HA-CS) i kontrolni materijal MTA (MTA Angelus®, Londrina, Brazil). Istraživanje je urađeno na 34 humana ekstrahovana maksilarna i mandibularna molara s potpuno razvijenim i nefuzionisanim korenovima. Pristupni kaviteti su preparisani visokoturažnom bušilicom, nakon čega je ručnim K-turpijama (K-files, VDW GmbH, Nemačka) utvrđena radna dužina kanala korena zuba, na 1 mm kraće od anatomskega foramina. Kanali korena su preparisani tehnikom

crown-down, serijom mašinskih endodontskih instrumenta *Bio Race* (FKG Dentaire, Swiss Dental Products, Švajcarska). Tokom instrumentacije kanali su ispirani sa NaOCl u koncentraciji od 0,5%. Za finalno ispiranje je korišćeno 5 ml desetoprocentne limunske kiseline (tokom jednog minuta) i 5 ml 0,5% NaOCl. Nakon sušenja kanali su opturisani monokonom tehnikom uz siler *Acroseal* (Septodont, Francuska).

Po vezivanju silera, u centru poda pulpne komore, kolenjakom i okruglim borerom veličine #4, preparisane su interradiksne perforacije tako da je širina perforacija odgovarala promeru borera, dok je dubina zavisila od debljine poda pulpne komore. Posle ispiranja preparisanih kaviteta destilovanom vodom i sušenja, zubi su metodom slučajnog izbora podeljeni u tri eksperimentalne grupe, a perforacije zatvorene test materijalima CS, HA-CS i MTA ( $n=10$ ). Pozitivnu kontrolnu grupu činila su dva zuba kod kojih perforacije nisu zatvorene materijalima, a negativnu dva zuba bez perforacija.

Pre primene ispitanih materijala zubi su do nivoa gleđnocementne granice postavljeni u sunđer natopljen veštačkom tkivnom tečnošću – Henkovim uravnoteženim slanim rastvrom (engl. *Hank's balanced salt solution – HBSS*). Materijali su zamešani sa destilovanom vodom u odnosu 3:1 i u kavitete kondenzovani nabijačima. Preko materijala je postavljena vlažna vatica, a zatim su zubi inkubirani na 37°C tokom 24 časa. Po vezivanju materijala pristupni kaviteti su konačno zatvoreni kompozitom, a zubi u natopljenom sunđeru inkubirani na 37°C narednih šest meseci.

Posle šest meseci marginalna mikropustljivost je ispitivana metodom pasivnog prodora boje. Zubi su premazani sa dva sloja laka, osim u predelu materijala i furkaciji (1 mm oko materijala) i potopljeni u pedesetoprocentni rastvor srebro-nitrita ( $\text{AgNO}_3$ ) tokom dva časa. Nakon kratkog ispiranja zubi su ostavljeni u fotografском razvijaču narednih šest sati. Zatim su longitudinalno sećeni u predelu interradiksnih perforacija dijamantskim diskom debljine 0,7 mm, linearnom preciznom testerom sa vodenim hlađenjem (Isomet testera 4000, Buehler, Lake Bluff, IL, SAD). Prodor boje između materijala i zidova kavite je analiziran svetlosnim mikroskopom i fotografisan pri uvećanju od 30 puta. Dubina prodora boje je merena metodom kvantifikovanja vizuelnih informacija kompjuterskim programom za obradu slike (*Adobe Photoshop CS5 Extended*, verzija 12.0x32). Dobijene vrednosti su izražene u milimetrima, a rezultati statistički obrađeni primenom jednofaktorskog testa ANOVA sa Tukeyevim (*Tukey*) *post-hoc* testom. Nivo značajnosti utvrđen je na  $\alpha=0,05$ .

## REZULTATI

Najmanji prodor boje izmeren je kod materijala CS ( $0,44 \pm 0,54$  mm) (Slika 1). Slične vrednosti izmerene su za materijal MTA ( $0,54 \pm 0,76$  mm) (Slika 2). Najveći prodor boje zabeležen je kod materijala HA-CS ( $2,00 \pm 0,70$  mm) (Grafikon 1, Slika 3). Nisu uočene statistički značajne razlike u marginalnom prodoru boje između materijala CS i MTA. Kod materijala HA-CS izmerene vrednosti prodora boje bile su statistički značajno veće u odnosu na prodor boje kod materijala CS i MTA ( $p < 0,05$ ).

Osim prodora boje, na spoju materijala i zubnih struktura uočeno je prebojavanje testiranog materijala primjenjenog u veštački formirane interradiksne perforacije (Slike 4, 5 i 6).

## DISKUSIJA

Za procenu marginalne mikropustljivosti materijala u studijama *in vitro* obično se koriste metode prodora boje [19, 20], prodora bakterija [21] i filtracije tečnosti [22]. U ovom istraživanju za procenu mikropustljivosti je primenjena metoda prodora boje, koja je zbog svoje jednostavnosti korišćena u velikom broju istraživanja [19, 20, 23, 24, 25]. Glavni nedostatak ove metode je, međutim, u tome što je veličina molekula boje koje se obično koriste manja od veličine bakterija [19]. Kod materijala kod kojih se beleži prodor malih molekula boje može se očekivati izostanak mikrocurenja većih molekula, poput bakterija i njihovih proizvoda [1].

Prilikom odabira boje za procenu marginalne propustljivosti uzeta je u obzir hemijska priroda materijala koji se ispituje. Naime, Vu (*Wu*) i saradnici [26] su ustanovili da je metilen plavo nestabilno u prisustvu alkalnih supstanci, što dovodi do njegovog obezbojavanja. Kako je kalcijum-hidroksid glavna hemijska smesa koja se oslobođa iz MTA, upotreba metilen plavog prilikom ispitivanja MTA i drugih materijala sličnog hemijskog sastava bi, usled diskoloracije boje, mogla dovesti do nepouzdanih rezultata. Rastvor srebro-nitrata je stabilan u prisustvu materijala visoke vrednosti pH, a čestice srebra imaju veliku molekularnu masu, što su i bili razlozi za njegovu primenu u ovom istraživanju [25].

Marginalna mikropustljivost je ispitivana nakon primene testiranih materijala u eksperimentalno preparisane interradiksne perforacije na ekstrahovanim zubima. Tokom eksperimentalnog perioda zubi su čuvani u inkubatoru, u sunđeru natopljenom veštačkom tkivnom tečnošću, kako bi se što bliže simulirali klinički uslovi [21]. U ovom istraživanju merena je najdublja tačka prodora boje uz napomenu da longitudinalnim sećenjem zuba, koje se obično primenjuje, nije moguće precizno utvrditi u kojem delu kavite je boja najdublje prodrla. Zbog toga se prodor boje pri određivanju mikropustljivosti u uslovima *in vitro* ne može direktno uporediti s kompleksnim mikrocurenjem u uslovima *in vivo*, ali se može smatrati pokazateljem moguće propustljivosti materijala u kliničkim uslovima [20].

Najmanji prodor boje u ovom istraživanju uočen je kod materijala CS. Vrednosti prodora boje kod MTA bile su nešto veće, ali bez statistički značajne razlike u odnosu na CS. S obzirom na to da su CS i MTA materijali sličnog hemijskog sastava, i njihove fizičke osobine mogu biti slične. Dobro rubno zaptivanje kalcijumsilikatnih cementa se povezuje sa blagom ekspanzijom cementa prilikom vezivanja [27, 28], odnosno bioaktivnom prirodom i stvaranjem hidroksiapatita na površini materijala u kontaktu s fosfatima iz tkivnih tečnosti [29].

Ipak, različitim metodama ispitivanja mikropustljivosti uočeno je da MTA i slični kalcijumsilikatni cementi nemaju sposobnost apsolutnog hermetičkog zaptivanja [21, 22, 25, 30], što je u skladu s rezultatima ovog istraživanja. U grupi uzoraka ispunjenih materijalom CS izmerene su nešto manje vrednosti prodora boje u odnosu na uzorke ispunjene sa MTA, ali je prodor boje uočen u većem broju uzoraka nego u MTA grupi. Izmerene vrednosti prodora boje u MTA grupi bile su vrlo različite, a dobijeni rezultati su u skladu s nalazima De Deusa (*De Deus*) i saradnika [30], koji su, ispitujući marginalnu mikropustljivost različitih kalcijumsilikatnih cemenata (PC, MTA Angelus i MTA Bio), pisali o vrlo varijabilnim rezultatima unutar grupa. Isti autori su mikropustljivost otkrili u svim uzorcima, ali bez

statistički značajnih razlika u pogledu propustljivosti različitih kalcijumsilikatnih cemenata [30]. Suprotno tome, Hašem (*Hashem*) i saradnici [19] su uočili razlike u propustljivosti različitih komercijalnih kalcijum-silikata, smatrujući da različit hemijski sastav i različita brzina vezivanja cemenata može imati ulogu u adaptaciji materijala za zidove kavite. I studije u kojima je propustljivost kalcijum-silikatnih cemenata ispitana metodom prodora bakterija takođe su ukazale na različite rezultate. Tako su Montelano (*Montelano*) i saradnici [2] najizraženije mikročurenje zabeležili u prvim danima primene materijala, dok su Pariroh (*Parirokh*) i saradnici [21] otkrili prodor bakterija značajno kasnije (između 39 i 73 dana eksperimenta), ističući pozitivan uticaj fosfatnog rastvora na prijanjanje materijala.

Uopšteno posmatrajući, pregledom literature uočava se nekonzistentnost rezultata u pogledu dobijenih vrednosti propustljivosti kalcijumsilikatnih cemenata u okviru različitih metoda ispitivanja. Iz dosadašnjih istraživanja može se zaključiti da brojni faktori utiču na mikropustljivost MTA: od vrste boje, pH vrednosti boje, uslova čuvanja uzorka pre eksperimenta, odnosno vremena vezivanja uzorka materijala pre njihovog potapanja u boju [1]. Takođe, različiti rezultati mogu biti posledica i razlika u prečniku i dubini perforacija, broja uzorka, odnosno razlika u trajanju opservacionog perioda [30].

Za razumevanje dobijenih rezultata u ovom istraživanju značajno je napomenuti i način prodora boje. U uzorcima u kojima je uočen prodor boje ne može se govoriti o striktno marginalnoj mikropustljivosti. Naime, osim boje ustanovljene na spoju materijala i zubnih struktura, uočeno je prebojavanje samog materijala koje je verovatno posledica apsorpcije boje (Slike 4, 5 i 6). Do sličnih rezultata došli su i Tobon-Arojave (*Tobón-Aroyave*) i saradnici [20], koji su utvrdili da se način prodora boje kod MTA razlikuje od prodora boje kod konvencionalnih cemenata (IRM i Super EBA). Ispitujući mikropustljivost materijala nakon njihove primene u formi apeksnog čepa, prodor boje kod IRM i Super EBA cementa uočen je kružno oko materijala, odnosno između materijala i dentina kanala korena. Nasuprot tome, u svim uzorcima sa MTA uočena je apsorpcija boje čitavom debljinom materija [20]. Razlog ovakvih rezultata može biti sama struktura cementa, koji su izgrađeni od brojnih pora i kapilara koji su mogli dovesti do izraženije propustljivosti. Važno je, međutim, napomenuti da su se u pomenutom istraživanju uzorci MTA vezivali samo 30 minuta pre njihovog potapanja u boju, te dobijeni rezultati mogu biti i posledica nepotpunog vezivanja materijala. U ovom istraživanju uzorci materijala su se vezivali 24 časa i nakon toga su inkubirani

u vlažnoj sredini još šest meseci. Ovakav protokol je mogao dovesti do potpunijeg vezivanja i posledično manjeg prodora, odnosno manjeg upijanja boje.

Kod materijala HA-CS izmeren je najveći prodor boje, a u većini uzorka je uočena i izražena dezintegracija materijala. S obzirom na to da je hidroksiapatit dobro poznat po poroznoj strukturi i neodgovarajućim mehaničkim svojstvima, dobijeni rezultati su donekle očekivani. Prilikom sinteze materijala HA-CS, kalcijumsilikatni sistem je dodat hidroksiapatitu upravo radi poboljšanja njegovih mehaničkih svojstava. Na osnovu dobijenih rezultata može se zaključiti da dodata količina kalcijumsilikata (HA:CS, 2:1) u eksperimentalnim uslovima ove studije nije sprečila rastvaranje i ispiranje materijala s mesta aplikacije. U literaturi je potvrđeno da su kalcijumfosfatni cementi, zbog svoje poroznosti i posledične rastvorljivosti, materijali sa neodgovarajućim rubnim zaptivanjem, te u tom pogledu značajno manje efikasni od cemenata na bazi kalcijum-silikata [24, 25].

Važno je napomenuti da je i u pojedinim uzorcima sa MTA i materijalom CS uočena površinska dezintegracija, odnosno rastvaranje spoljašnjeg sloja materijala, ali u znatno manjoj meri u odnosu na materijal HA-CS. U kontaktu s vodom ili fosfatnim rastvorom cement otpušta kalcijumove jone sa delimičnom dekalcifikacijom kalcijumsilikatnog hidrata, a ekspanzija cementa posle kontakta s tečnošću može izazvati mikropukotine, što sve zajedno može predstavljati prepreku dugoročnoj stabilnosti materijala [13]. Ipak, prilikom tumačenja rezultata istraživanja u uslovima *in vitro* mora se imati u vidu da tokom ovih ispitivanja izostaje kompleksan odgovor tkiva. Naime, jedna od odlika bioaktivnih materijala ispitanih u ovom istraživanju jeste stvaranje hidroksiapatita na njihovoj površini u kontaktu s tkivnim tečnostima [3, 29], kao i stvaranje kalcifikovanog tkiva preko kalcijumsilikatnih, odnosno kalcijumfosfatnih cemenata. Stoga bi se moglo očekivati da bi u kliničkim uslovima dezintegracija materijala bila samoograničavajuća i da bi hidroksiapatit, formiran u funkciji vremena, mogao ispuniti pore unutar materijala i obezbediti hemijsku vezu sa dentinom i time doprineti kvalitetnijem rubnom zaptivanju [31].

## ZAKLJUČAK

Najmanja marginalna mikropustljivost, odnosno najbolje rubno zaptivanje zabeleženo je kod materijala CS i bilo je slično sa MTA. Mikropustljivost materijala HA-CS bila je značajno veća u odnosu na materijal CS i kontrolni materijal MTA.

# Radiographic Assessment of Peri-implant Bone Level – A Comparative Study of Digital Intraoral and Digital Panoramic Radiography

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## SUMMARY

**Introduction** The objective of this study was to compare two radiographic methods – digital intraoral and digital panoramic radiography in assessing marginal bone level around dental implants. The study also evaluated inter-observer and intra-observer reliability during repeated assessments.

**Material and Methods** Marginal bone around 29 implants in 17 patients was assessed using standardized digital intraoral and digital panoramic radiographs. Two observers evaluated bone level by noting the thread at which marginal bone seemed to be attached at distal and mesial surfaces of the implants. The assessments were repeated after one week. Kappa statistics was used to evaluate agreement between assessments, observers, and radiographical methods.

**Results** The agreement rate between digital intraoral and digital panoramic radiography was fair. Intra-observer agreement was very good, while inter-observer agreement was moderate.

**Conclusion** Digital panoramic radiographs can be used to evaluate marginal bone level in patients with multiple implants and also to supplement intraoral radiographs. However, observer variability should be considered when comparing values from follow up studies for implant maintenance.

**Keywords:** dental implants; intraoral radiographs; marginal bone; panoramic radiographs; peri-implant bone level; observer agreement

## INTRODUCTION

Rehabilitation of partial or complete edentulism using dental implants has become preferred method for replacement of missing teeth. The success of implants greatly depends on the marginal bone around the implant. Marginal bone loss of a maximum 1.5 mm is acceptable in the first year of implant placement followed by an annual bone loss not exceeding 0.2 mm [1, 2]. Thus, measurements of the marginal alveolar bone levels in standardized and serial radiographs are considered to be important parameters to determine implants prognosis.

Intraoral radiography using parallel technique has long been preferred method for measuring marginal bone level [3, 4]. Intraoral radiographs have higher resolution but are more time consuming. Moreover, anatomic considerations like shallow palate or raised floor of mouth make use of intraoral radiography difficult. In such cases, panoramic radiography can be utilized. Panoramic radiography allows wider coverage and also reveals relations between anatomic structures such as sinuses and neurovascular canals.

The aim of the study was to compare the ability of two radiographic methods: digital intraoral and digital panoramic radiographs in the assessment of marginal bone level around dental implants. The study also aimed to evaluate inter-observer and intra-observer reliability during repeated assessments.

## MATERIAL AND METHODS

17 patients referred to the Department of Oral Radiology for follow up examination after treatment with dental implants were included in the study. All patients had implant surgery within last 6 months. Standardized intraoral digital radiographs using paralleling technique were taken with intraoral radiation unit (70 kVp) and cylindrical tubehead, 2.5 mm aluminium filtration and focal spot distance of 21 cm. Digital panoramic radiographs were obtained at the same appointment using Kodak 8000c unit following standard exposure and positioning protocol.

Two dental specialists (oral radiologist and oral surgeon) evaluated all images. The observers were asked to assess marginal bone level by counting the number of threads between the implant–abutment connection and the level of marginal bone on the mesial and distal surfaces of the implant. The first thread completely imaged was designated thread number 1. In cases of double marginal bone contour, assessments were made at the most apical level. 29 implants were evaluated. Assessments were repeated after 1 week by both observers in random order resulting in a total of 232 sites being evaluated.

Data was analysed using SPSS software 19. Kappa statistics was used to compare the agreement between assessments, observers and methods of radiography. Kappa values were evaluated as follows: <0.20 was considered poor, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 good and 0.81–1.00 very good. The total proportion of agreement was calculated as percentage [5].

## RESULTS

A total of 232 observations were done for each method. The agreement rates for digital intraoral and digital panoramic radiography for the two observers varied from 36% to 52% (Table 1). Intra-observer agreement expressed as kappa value ranged from 0.86 to 0.95 for observer 1 and 0.87 to 0.94 for observer 2 (Table 2). The inter-observer

**Table 1.** Comparison of digital intraoral and digital panoramic radiography

**Tabela 1.** Poredenje digitalne intraoralne radiografije i digitalne ortopantomografije

Parameter Parametar	Observer 1 Istraživač 1		Observer 2 Istraživač 2	
	Reading 1 Merenje 1	Reading 2 Merenje 2	Reading 1 Merenje 1	Reading 2 Merenje 2
Agreement (%) Slaganje (%)	51.72	48.28	36.48	37.93
Kappa coefficient Koeficijent kapa	0.3994	0.3527	0.2091	0.2139
Weighted kappa coefficient Težinski koeficijent kapa	0.7201	0.7085	0.6045	0.6086

**Table 2.** Intra-observer agreement for digital intraoral radiography (DIR) and digital panoramic radiography (DPR)

**Tabela 2.** Slaganje ponovljenih merenja istog istraživača za digitalnu intraoralnu radiografiju (DIR) i digitalnu ortopantomografiju (DOP)

Parameter Parametar	Observer 1 Istraživač 1		Observer 2 Istraživač 2	
	DIR	DPR DOP	DIR	DPR DOP
Agreement (%) Slaganje (%)	89.66	96.55	96.43	90.63
Mean difference between repeated measurements Prosečna razlika između ponovljenih merenja	0.10344	0.0344	0.0312	0.1132
Kappa coefficient Koeficijent kapa	0.8676	0.9566	0.9411	0.8786
Weighted kappa coefficient Težinski koeficijent kapa	0.9469	0.9817	0.9790	0.9656

**Table 3.** Inter-observer agreement for digital intraoral radiography (DIR) and digital panoramic radiography (DPR)

**Tabela 3.** Slaganje različitih istraživača za digitalnu intraoralnu radiografiju (DIR) i digitalnu ortopantomografiju (DOP)

Parameter Parametar	Reading 1 Merenje 1		Reading 2 Merenje 2	
	DIR	DPR DOP	DIR	DPR DOP
Agreement (%) Slaganje (%)	62.07	65.52	55.17	62.07
Kappa coefficient Koeficijent kapa	0.5145	0.5586	0.4365	0.5246
Weighted kappa coefficient Težinski koeficijent kapa	0.8054	0.8192	0.7711	0.8022

agreement was moderate for both digital intraoral and panoramic methods (Table 3).

## DISCUSSION

Replacement of missing teeth with implants is the best available prosthetic therapy. Intraoral and panoramic radiographs are commonly used to evaluate the marginal bone level during follow up after implant placement. This study assessed the agreement between digital intraoral and digital panoramic radiographs for evaluating peri-implant bone level. These radiographical methods were chosen to limit radiation dose received by the patient.

Agreement between the two assessed radiographical methods in the present study ranged from 36% to 52%. This agreement rate was fair according to the kappa statistics [5]. Similar agreement rate was reported by Kullman et al. [6]. However, Rohlin et al. [7] found higher agreement rate of 72% between panoramic and intraoral radiography. Other studies [8, 9, 10] have also stated that panoramic radiographs can be used reliably for the assessment of marginal bone. Also, mean difference between repeated measurements was close to zero.

The agreement rate was higher within observers (89.6% to 96.4%) compared with that between observers (55.1% to 65.5%). Based on kappa values, the agreement was very good when the same observer repeated the assessments. However, inter-observer agreement was found to be moderate. Molander et al. [9] demonstrated lower intra-observer agreement rate but similar inter-observer agreement. The inter-observer agreement was higher for panoramic radiography than for intraoral radiographs. This is in accordance with findings of Kullman et al. [6] and De Smet et al. [3], but contrary to the findings of Mörner-Svälling et al. [11], who reported high inter-observer agreement of around 85% for intraoral digital and conventional radiographs.

The current study included assessment by two observers as well as repeated assessments by each observer after a gap of at least 1 week. This was done in accordance to Kullman et al. [6], who recommended using more than one observer to avoid bias of individual observers. Implant thread number was used to evaluate marginal bone instead of measuring distance in mm from implant abutment. Counting number of threads is the most commonly used in everyday practice. Moreover, different magnifica-

tion factors of the two radiographic methods will not affect the evaluation when counting implant threads, therefore that is recommended method for the evaluation of peri-implant bone level [12].

## CONCLUSION

Agreement between digital intraoral and digital panoramic radiograph is fair and panoramic radiographs have acceptable accuracy for the evaluation of marginal bone levels around implants. As panoramic radiography is cost effective, time saving and has low radiation dose, it can be used to evaluate marginal bone level in patients with multiple implants and also to supplement intraoral radiographs when required. However, observer variability should be considered when comparing values from follow up studies for implant maintenance.

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# Radiografska procena kosti oko zubnih implantata – studija poređenja digitalne intraoralne radiografije i digitalne ortopantomografije

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## KRATAK SADRŽAJ

**Uvod** Cilj rada je bio da se uporede dve radiografske metode – digitalna intraoralna radiografija i digitalna ortopantomografija u proceni kosti oko dentalnih implantata. Uporedjivana je i saglasnost istraživača prilikom procene, i to jednog istraživača u ponovljenim merenjima, kao i dva različita istraživača.

**Materijal i metode rada** Primenom standardizovane digitalne intraoralne radiografije i digitalne ortopantomografije procenjena je marginalna kost oko 29 implantata kod 17 pacijenata. Dva istraživača su ocenjivala nivo kosti procenjujući marginalnu kost koja je pripojena na mezikalnoj i distalnoj površini implantata. Merenje je ponovljeno nakon nedelju dana. Za procenu saglasnosti između merenja, istraživača i metode radiografije korišćena je kapa statistika.

**Rezultati** Uočena je dobra saglasnost između digitalne intraoralne radiografije i digitalne ortopantomografije. Takođe, saglasnost između ponovljenih merenja istog istraživača bila je vrlo dobra, dok je saglasnost merenja različitih istraživača bila umerena.

**Zaključak** Digitalna ortopantomografija može se koristiti za procenu marginalne kosti kod više dentalnih implantata i kao dopuna intraoralnoj radiografiji. Međutim, treba uzeti u obzir varijabilnost istraživača kada se upoređuju merenja u različitom periodu.

**Ključne reči:** dentalni implantati; intraoralna radiografija; marginalna kost; ortopantomografija; nivo periimplantantne kosti; slaganje istraživača

## UVOD

Rehabilitacija delimične ili potpune bezubosti pomoću zubnih implantata je postala najbolji način za nadoknadu zuba koji nedostaju. Uspeh implantacije u velikoj meri zavisi od marginalne kosti oko implantata. Gubitak marginalne koštane mase od najviše 1,5 mm je prihvatljiv u prvoj godini nakon ugradnje implantata sa dodatnim godišnjim gubitkom koštane mase ne većim od 0,2 mm [1, 2]. Zato se merenje nivoa marginalne alveolarne kosti u standardizovanim i serijskim radiografijama smatra važnim parametrom za prognozu zubnog implantata.

Intraoralna radiografija, uz primenu paralelne tehnike, koristi se kao najbolji način za merenje nivoa marginalne kosti [3, 4]. Intraoralna radiografija ima veću rezoluciju, ali zahteva više vremena. Osim toga, anatomske varijacije, kao što su plitko nepce ili podignuti pod usta, čine intraoralnu radiografiju teškom ili čak nemogućom. U takvim slučajevima ortopantomografija može biti korisna. Panoramska radiografija omogućuje da se vide veća površina tkiva i odnosi između anatomske struktura, kao što su sinusi i neurovaskularni kanali.

Cilj ove studije bio je da se uporedi sposobnost dve radiografske metode, digitalne intraoralne radiografije i digitalne ortopantomografije, u proceni nivoa marginalne kosti oko dentalnih implantata. Takođe je procenjeno slaganje između ponovljenih merenja istog istraživača, odnosno saglasnost različitih istraživača.

## MATERIJAL I METODE RADA

U studiju je bilo uključeno 17 pacijenata s Klinike za oralnu radiologiju koji su zahtevali kontrolu nakon ugradnje dentalnih implantata. Svi pacijenti su podvrgnuti dentalnoj implantaciju u

poslednjih šest meseci. Standardizovani intraoralni radiogrami su dobiveni koristeći paralelnu tehniku i zračenje od 70 KVP sa cilindričnom RTG cevi, 2,5 mm aluminijumske filtracije i žarišne tačke udaljenosti 21 cm. Digitalni panoramski radiogrami su dobiveni tokom iste posete koristeći rendgenski aparat Kodak 8000C, standardnu ekspoziciju i protokol za pozicioniranje.

Dvoje specijalista stomatologije (oralni radiolog i oralni hirurg) ocenjivali su dobijene snimke. Marginalna kost je ocenjivana brojanjem koštanih niti između veze implantata i suprastrukture i kosti na mezikalnoj i distalnoj površini implantata. Prva nit koja je prikazana u celosti je posmatrana kao broj 1. U slučajevima dvostrukе konture marginalne kosti procena je vršena na najapikalnijem nivou. Ukupno je procenjeno 29 implantata. Merenje je ponovljeno posle nedelju dana, tako da su ukupno izvedena 232 merenja.

Podaci su analizirani pomoću statističkog programa SPSS ver. 19. Kapa (kappa) statistika je korišćena za poređenje saglasnosti između metoda radiografije i istraživača. Vrednosti koeficijenta κ su ocenjeni kao: loše slaganje (<0,20), dovoljno (0,21–0,40), umereno (0,41–0,60), dobro (0,61–0,80) i vrlo dobro slaganje (0,81–1,00). Ukupno slaganje je predstavljeno u procentima [5].

## REZULTATI

Ukupno su izvedena 232 merenja za svaku metodu. Procenat saglasnosti za digitalnu intraoralnu i digitalnu ortopantomografiju za dva istraživača bio je od 36% do 52% (Tabela 1). Saglasnost merenja istih istraživača izražena kao vrednost koeficijenta κ bila je u rasponu 0,86–0,95 za istraživača 1 i 0,87–0,94 za istraživača 2 (Tabela 2). Saglasnost između digitalne intraoralne i panoramske radiografije bila je umerena (Tabela 3).

## DISKUSIJA

Zubni implantati su najbolji način protetičke terapije nakon gubitka zuba. Intraoralna radiografija i ortopantomografija se obično koriste za procenu nivoa marginalne kosti nakon ugradnje implantata. Cilj naše studije je bio da se utvrdi slaganje između digitalne intraoralne radiografije i digitalne ortopantomografije u proceni nivoa kosti oko zubnih implantata. Ove radiološke metode su izabrane da bi se ograničila doza zračenja kojoj je pacijent izložen.

Saglasnost između testiranih radioloških metoda bila je u rasponu od 36% do 52%. Ova stopa saglasnosti je bila dovoljna prema koeficijentu  $\kappa$  [5]. Kulman (*Kullman*) i saradnici [6] su utvrdili sličnu stopu saglasnosti između ovih istih metoda. Međutim, Rolin (*Rohlin*) i saradnici [7] su zabeležili veću stopu saglasnosti (72%) između ortopantomografije u intraoralne radiografije. Druge studije su takođe potvrdile da ortopantomografija može biti korišćena kao pouzdana metoda u proceni marginalne kosti [8, 9, 10]. Takođe, prosečna razlika između ponovljenih merenja je bila blizu nule.

Procenat saglasnosti je bio veći za svakog od dva istraživača (89,6–96,4%) u odnosu na saglasnost između dva različita istraživača (55,1–65,5%). Koeficijent  $\kappa$  je potvrdio dobru saglasnost između ponovljenih merenja istog istraživača. Međutim, saglasnost između različitih istraživača je bila umerena. Molander (*Molander*) i saradnici [9] su uočili niži procenat saglasnosti između ponovljenih merenja istog istraživača, ali sličan procenat između različitih istraživača u poređenju s ovom studijom. Saglasnost između istraživača bila je veća za ortopantomografiju u odnosu na intraoralnu radiografiju. Ovakav rezultat je u skladu s nalazima Kulmana i saradnika [6] i De Smetu (*De Smet*) i saradnika [3], ali u suprotnosti s nalazima Merner-Svalingove (*Mörner-Svälling*) i saradnika [11], koji su ustanovili visok procenat saglasnost između istraživača (oko 85%) za intraoralnu digitalnu i konvencionalnu radiografiju.

Ova studija je obuhvatila procenu saglasnost merenja dva istraživača, kao i ponovljenih merenja svakog istraživača nakon pauze od najmanje nedelju dana. Ovakvo istraživanje je izvedeno u skladu s nalazom Kulmana i saradnika [6], koji su preporučili više od jednog istraživača da bi se izbegla pristransnost. Broj koštanih niti oko implantata je korišćen za procenu marginalne kosti umesto merenja razdaljine (u milimetrima) od spoja implantata sa suprastrukturom do vrha kosti. Brojanje niti se češće koristi u svakodnevnoj praksi. Osim toga, različiti faktori uvećanja ove dve radiografske metode ne utiču na brojanje koštanih niti; stoga je preporučena metoda za procenu nivoa periimplantatne kosti [12].

## ZAKLJUČAK

Saglasnost između digitalne intraoralne i digitalne ortopantomografije je dovoljna i panoramska radiografija ima prihvatljivu preciznost u oceni nivoa marginalne kosti oko zubnih implantata. S obzirom na to da je ortopantomografija isplatljivija, brža i zahteva manju dozu zračenja, ona se može koristiti u proceni nivoa marginalne kosti kod pacijenata s višestrukim implantatima, ali i kao dopuna intraoralnoj radiografiji kada je potrebno. Međutim, treba uzeti u obzir varijabilnost istraživača kada se porede vrednosti dobijene tokom postoperacionog praćenja.

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# XP-endo Finisher: A New Solution for Smear Layer Removal

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## SUMMARY

**Introduction** The aim of this study was to evaluate using SEM analysis the effectiveness of a new instrument XP-endo Finisher in cleaning root canal walls after instrumentation with BioRaCe NiTi rotary instruments.

**Material and Methods** This *in vitro* study was conducted on 30 extracted single rooted teeth divided in two groups. Instrumentation of all canals was done using basic BioRaCe NiTi rotary instruments with copious irrigation of 2% NaOCl. In the first group, after complete instrumentation smear layer was removed using XP-endo Finisher, while the other group served as negative control. The roots were then after longitudinally cut and SEM analysis was performed. The presence of smear layer in the coronal, middle and apical third was assessed. The data were statistically analyzed using Mann–Whitney U-test ( $p<0.05$ ).

**Results** The results showed that average value of smear layer on the canal walls in the XP-endo Finisher group was significantly lower than in the control group ( $p<0.05$ ).

**Conclusion** XP-endo Finisher after canal instrumentation with NiTi rotary instruments effectively cleaned canal walls and removed smear layer.

**Keywords:** XP-endo Finisher; smear layer; NiTi rotary instruments; SEM

## INTRODUCTION

The success of endodontic treatment depends significantly on the quality of cleaning and shaping the root canal system. However, adequate canal preparation, which involves mechanical (instrumentation) and chemical aspects (irrigation) is difficult to achieve due to the complex canal morphology [1].

Both hand and rotary instrumentation create smear layer of different thickness on the canal walls as a consequence of cutting dentin [2]. This layer contains remnants of dentin, pulp tissue, microorganisms and covers canal walls touched by instruments [2, 3]. The presence of smear layer and debris, especially in the apical portion of the canal, is of clinical significance because bacteria in combination with unfavorable local factors may cause endodontic failure [4]. In addition, this layer closes tubules and reduces the effect of irrigating solutions, significantly affects the quality of obturation and outcome of endodontic treatment [3, 4].

Instrumentation using rotary NiTi instruments is relatively new approach in the preparation of root canals, but effective cleaning of a complex canal system still remains a challenge for dental practitioners [2, 5]. It has been confirmed that NiTi rotary instruments provide faster and better canal preparation in the form of elongated cone and with minimal risk of transportation [6-9]. However, due to the limited efficacy of instruments alone in the cleaning root canals, it is necessary to add rinsing of canals using

appropriate irrigants [3]. Endodontic irrigants by their physical and chemical actions allow dissolution of smear layer on the canal walls and its partial removal [1, 3]. It is necessary to use a combination of different irrigants and most frequently used is a combination of NaOCl and EDTA. NaOCl provides reduction of microorganisms and dissolution of organic part while EDTA acts on inorganic content and contributes significantly to the removal of dentine debris and smear layer from the root canal walls [2, 9, 10].

EDTA and various concentrations of citric acid are used as final rinse after instrumentation as well as various solutions of lactic, tannic acid, acetic acid, polyacrylic acid or tetracycline (MTAD) [3, 10, 11]. Chitosan can also be used to remove smear layer. It represents natural polysaccharide solution, which contains chlorhexidine and has a slight chelating effect [10, 12]. Another means for smear layer removal include ultrasound or laser techniques [3, 13, 14]. It has been confirmed that the use of flexible microbrushes can reduce debris and remove smear layer from root canal walls [2, 15]. Removal of smear layer from the canal walls before final obturation significantly increases sealer adhesion and reduces the incidence of microlleakage along the canal walls [16, 17]. However, none available technique provides complete and efficient removal of smear layer therefore, research is directed towards finding new resources and instruments to remove smear layer effectively.

The aim of this study was to evaluate using SEM analysis the effectiveness of a new instrument XP-endo Fin-

isher in cleaning root canal walls after instrumentation with BioRaCe NiTi rotary instruments.

## MATERIAL AND METHODS

This *in vitro* study included 30 single-rooted teeth extracted for orthodontic or periodontal reasons. Prior to the experiment, teeth were stored in saline at 4°C. Access cavity in all teeth was prepared using high speed handpiece and diamond bur. Glide path was achieved using ISO 15 and working length determined 1 mm shorter than the length when the file appears at the apex. Apex of each tooth was closed with pink wax to prevent leakage of the irrigant through the apical foramen during canal preparation. The teeth were divided into two groups (15 teeth each).

Instrumentation of all canals was done using a basic set of NiTi rotary instrument BioRaCe (FKG Dentaire, Swiss) according to the manufacturer's instructions [18]. Handpiece with reduced number of revolutions (16: 1) and endomotor TCM ENDO V (Nouvag AG, Swiss) was used. During instrumentation, all teeth were irrigated with 2 ml of 2% sodium hypochlorite solution (Chlorax, Cerkamed, Poland) after each instrument. At the end of instrumentation canals were flushed with 5ml of 2% solution of NaOCl. Plastic syringes of 2 ml (during instrumentation) and 5 ml (for final rinse) volume and an appropriate needle size 27 bent at the angle of 30° were used for irrigaton.

In the first group of teeth, after complete instrumentation, smear layer was removed using a new instrument XP-endo Finisher (FKG Dentaire, Swiss), while the second group of teeth served as control (no smear layer removal). XP-endo Finisher was taken from sterile packaging and placed in the handpiece. Working length for each canal was determined using plastic tube and stopper. XP-endo Finisher instrument was cooled using spray ENDO Frost (RSA, Colten, Whaledent GmBH, Germany) through the plastic tube and placed in the canal filled with irrigant. Using gentle movements of insertion and withdrawal XP-endo Finisher was applied in each canal during one minute. After on minute canals were washed with the rest of the NaOCl solution.

After complete procedure, crowns of all teeth were cut using a diamond disc, roots were split longitudinally and selected halves prepared for SEM (JEOL, JSM 6460 LV, JAPAN). Dentinal wall of each tooth was observed under the SEM in the region of coronal, middle and apical thirds using different magnifications and photomicrographs were done. Qualitative assessment of smear layer on root canal walls was based on criteria given by Hulsmann et al. [19]: Grade 1 – no smear layer, dentinal tubules open; Grade 2 – there is a small amount of smear layer, open some dentinal tubules; Grade 3 – homogeneous smear layer covering canal walls, a few dentinal tubules open; Grade 4 – complete canal wall covered with homogenous smear layer, dentinal tubules closed; Grade 5 – ordinary homogeneous smear layer covering the entire canal walls.

The obtained results were analyzed using the Mann-Whitney U-test.

## RESULTS

The average scores for the smear layer in a group where XP-endo Finisher was used were significantly lower than in the group where smear layer was not removed ( $p=0.013$ ) (Table 1). Mann-Whitney U-test did not show statistically significant differences in smear layer scores between the two groups in the coronal, middle or apical third of canals (Table 2).

After applying XP-endo Finisher clean walls were observed in the coronal third, no smear layer and open dentinal tubules in the middle third (Figure 1) and shreds of smear layer with number of open dentinal tubules in the apical third of the canals (Figure 2). Instrumentation using BioRaCe instruments produced more smear layer on the canal walls in the middle (Figure 3) than in the apical third of the canal (Figure 4).

**Table 1.** Average grade of smear layer in the coronal, middle and apical third of root canals

**Tabela 1.** Prosečna ocena razmaznog sloja u kruničnoj, srednjoj i apeksnoj trećini kanala korena

Instrument Instrument	Canal third Trećina kanala	Smear layer Razmazni sloj			
		N	$\bar{X}$	SD	CV
Bio RaCe + XP-endo Finisher	Coronal Krunična	15	1.07	0.26	24.30
	Middle Srednja	15	1.07	0.26	24.30
	Apical Apeksna	15	1.13	0.35	30.97
	Total Ukupno	45	1.09	0.29	26.61
BioRaCe	Coronal Krunična	15	1.27	0.46	36.22
	Middle Srednja	15	1.33	0.62	46.62
	Apical Apeksna	15	1.47	0.74	50.34
	Total Ukupno	45	1.36	0.61	44.85

N – number of teeth;  $\bar{X}$  – mean value; SD – standard deviation;

CV – coefficient of variation

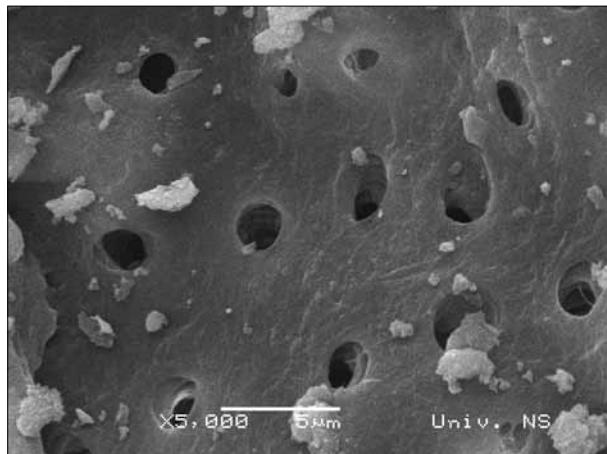
N – broj zuba;  $\bar{X}$  – aritmetička sredina; SD – standardna devijacija;

CV – koeficijent varijacije

**Table 2.** Assesment of smear layer in the coronal, middle and apical third of root canals

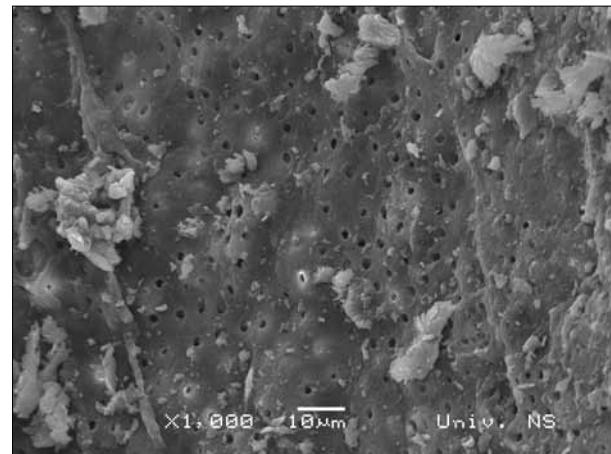
**Tabela 2.** Procena razmaznog sloja u kruničnoj, srednjoj i apeksnoj trećini kanala korena

Instrument Instrument	Canal third Trećina kanala	Grade Ocena				
		1	2	3	4	5
Bio RaCe + XP-endo Finisher	Coronal Krunična	14	1	0	0	0
	Middle Srednja	14	1	0	0	0
	Apical Apeksna	13	2	0	0	0
Bio RaCe	Coronal Krunična	11	4	0	0	0
	Middle Srednja	11	3	1	0	0
	Apical Apeksna	10	3	2	0	0



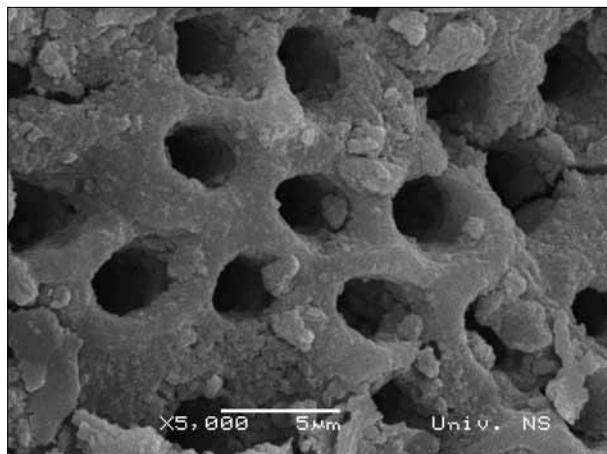
**Figure 1.** Middle third of the canal wall after applying XP-endo Finisher (SEM, 5000x)

**Slika 1.** Srednja trećina zida kanala korena nakon primene instrumenta XP-endo Finisher (SEM,  $\times 5000$ )



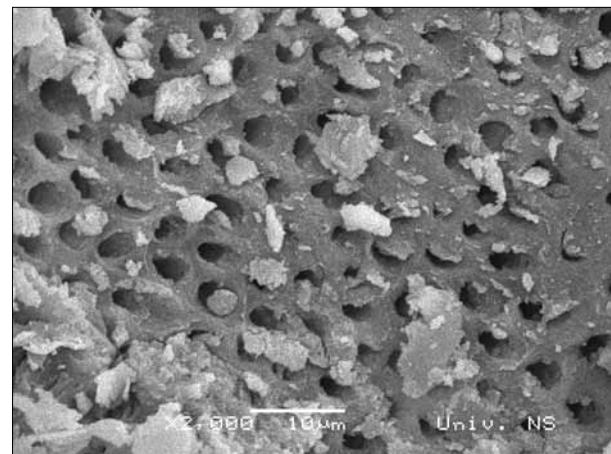
**Figure 2.** Apical third of the canal wall after applying XP-endo Finisher (SEM 1000x)

**Slika 2.** Apeksna trećina zida kanala korena nakon primene instrumenta XP-endo Finisher (SEM,  $\times 1000$ )



**Figure 3.** Smear layer in the middle third of the canal wall after instrumentation with BioRaCe rotary NiTi instruments (SEM 5000x)

**Slika 3.** Razmazni sloj u srednjoj trećini zida kanala korena nakon instrumentacije setom BioRaCe rotirajućih NiTi instrumenata (SEM,  $\times 5000$ )



**Figure 4.** Smear layer in the apical third of the canal wall after instrumentation with BioRaCe rotary NiTi instruments (SEM 2000x)

**Slika 4.** Razmazni sloj u apeksnoj trećini zida kanala korena nakon instrumentacije setom BioRaCe rotirajućih NiTi instrumenata (SEM,  $\times 2000$ )

## DISCUSSION

The main goal of endodontic treatment is to instrument and irrigate root canal walls and ensure effective cleaning of endodontic space, including complete removal of necrotic or vital pulp, i.e. all bacteria from the root canal system [20]. Removal of smear layer that forms along the walls during instrumentation is an important clinical parameter for the success of endodontic treatment [1, 2, 4, 21].

In our study, all teeth were instrumented and irrigated using the same protocol (done by the same practitioner), therefore, results can be regarded solely as a function of the final cleaning of the canal system. The results showed a significantly more efficient removal of the smear layer from the root canal walls after using XP-endo Finisher. The use of this instrument resulted in more efficient cleaning of the canal system and considerably less smear layer at all levels (coronal, middle, apical). Instrumentation techniques [6, 9, 16, 22] and the choice of irrigants and irrigation techniques [3, 10, 22, 23, 24] are the key factors for the success of endodontic treatment. Although due to the

complex anatomy it is difficult to achieve the shape of an elongated cone [25], crown-down technique using NiTi rotary instruments provides efficient cleaning and shaping of canals for significantly shorter time [21, 22, 26, 27].

In the current study, the efficacy of NiTi rotary files in the cleaning of root canals was evaluated using numerical evaluation of smear layer in coronal, middle and apical third of the canal, which is consistent with the findings of other researchers [7, 10, 17, 19, 27]. In the control group BioRaCe rotary files produced a small amount of smear layer along the canal walls. This result can be attributed primarily to their flexibility, design and electrochemically polished surface [28, 29]. File design with alternating active (to cut) and non-active parts (to eliminate dentin debris) and copious irrigation provide efficient cleaning of canal walls [29, 30, 31]. Small amount of smear layer also could be attributed to the fact that instrumentation was done in straight canals only and with copious irrigation. File design also had influence on low amount of smear layer [17, 21, 22]. Coronal and middle third of canals were cleaner and showed smear layer than apical third.

This can be attributed primarily to larger diameter of the coronal part and better tissue-chemical contact during instrumentation and the fact that dentin is exposed to larger volume of irrigant [15, 22, 32]. Also, BioRaCe NiTi rotary files provide wide and funnel shaped canal with larger apical conicity (6%) allowing deeper application of needle and irrigants [15, 22, 31, 33, 34]. This endodontic system also shows significantly less transportation in the apical portion of the canal compared to other rotary NiTi systems [31]. Low amount of smear layer and dentinal debris found could be the consequence of the speed of file rotation. It has been shown earlier that slightly faster file rotation produce better cleaning effect (BioRaCe rotation speed is 600 r/min) compared to other rotary NiTi instruments (300-400 r/min) [17, 34].

Although combination of NaOCl and EDTA is gold standard in chemomechanical instrumentation of canals [11, 13, 21, 24, 32] in the current study only NaOCl was used [31, 35, 36]. As the main goal of the current study was to evaluate cleaning effect of BioRaCe NiTi rotary files, to avoid the effect of chelating agents in smear layer removal [21, 31, 36] only sodium hypochlorite was used as irrigant. Sodium hypochlorite shows dissolving efficacy on the organic part of dentin, but also extraordinary antibacterial activity [11, 31]. Although complete cleaning was not achieved, effective cleaning and removal of smear layer was noticed at all levels of the canal. It is important to note that with the use of EDTA results would have been better and smear layer removed more effectively in the apical portion of canals [21, 31, 32, 35, 36].

After canal instrumentation using BioRaCe NiTi rotary files, XP-endo Finisher was used to remove smear layer and effective action at all canal levels was found. Noticable in the current study was effective removal of smear layer in the apical portion of the canal. This can be attributed to wider diameter of used files (ISO40) and better efficiency of irrigants [11, 15, 31, 35, 36]. It has been confirmed that rotary NiTi files during instrumentation come into contact with only 40-45% of the canal walls, therefore, large portion of the canal surface remains untreated [21, 27]. Instrumentation removes only dentin that comes in contact with rotating file and at the same time a large portion of dentin debris stays in these untreated areas [21, 26]. It can be removed only using copious and effective irrigation [11, 32]. Due to specific design, XP-endo Finisher can reach those inaccessible parts of the canal and provide better cleaning [18]. Small diameter (ISO 25) and the fact that it can change its shape during rotation in the canal (M and A phase) allow this file to reach inaccessible areas of the canal wall and efficiently remove dentin debris and smear layer [18]. XP-endo Finisher is rotary NiTi file without taper which with efficient irrigation in instrumented canals can remove smear layer and dentin debris from inaccessible areas.

## CONCLUSION

Within the limits of this study it can be concluded that chemomechanical instrumentation with BioRaCe rotary

NiTi files provided good cleaning of the root canal walls. Application of XP-endo Finisher after instrumentation in a single-rooted teeth removed smear layer from root canal walls in all segments.

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# XP-endo Finisher: novo rešenje za uklanjanje razmaznog sloja nakon instrumentacije kanala

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## KRATAK SADRŽAJ

**Uvod** Cilj ovog rada je bio da se SEM analizom proveri efikasnost novog instrumenta XP-endo Finisher na kvalitet čišćenja zidova kanala korena zuba nakon instrumentacije BioRaCe NiTi rotirajućim instrumentima.

**Materijal i metode rada** Istraživanja su izvedena u uslovima *in vitro* na 30 ekstrahovanih jednokorenih zuba podeljenih u dve grupe. Instrumentacija svih kanala je realizovana osnovnim setom BioRaCe NiTi rotirajućih instrumenata uz irigaciju dvoprocentnim rastvorom NaOCl. U prvoj grupi je nakon instrumentacije za uklanjanje razmaznog sloja korišćen XP-endo Finisher, a druga grupa je služila kao kontrolna. Korenovi svih zuba su uzdužno podeljeni i SEM metodom je analiziran kvalitet čišćenja kanala korena, odnosno postojanje razmaznog sloja u kruničnoj, srednjoj i apeksnoj trećini. Podaci su statistički analizirani Man–Vitnjievim (Mann–Whitney) U-testom ( $p<0,05$ ).

**Rezultati** Dobijeni rezultati su pokazali da je ukupna srednja vrednost postojanja razmaznog sloja na zidovima kanala u grupi gde je korišćen XP-endo Finisher bila statistički značajno manja nego u kontrolnoj grupi uzoraka ( $p<0,05$ ).

**Zaključak** XP-endo Finisher posle obrade kanala NiTi rotirajućim instrumentima efikasno čisti kanal i uklanja razmazni sloj sa zidova kanala.

**Ključne reči:** XP-endo Finisher; razmazni sloj; NiTi rotirajući instrumenti; SEM

## UVOD

Uspeh endodontskog lečenja umnogome zavisi od kvaliteta čišćenja i oblikovanja kanalnog sistema zuba. Međutim, odgovarajuću preparaciju kanala, koja podrazumeva mehanički (instrumentacija) i hemijski aspekt (irigacija), uglavnom je teško ostvariti zbog složene morfologije kanala [1].

Ručnom ili mašinskom instrumentacijom se kao posledica sečenja dentina na površini zidova kanala stvara razmazni sloj različite debljine [2]. Ovaj sloj sadrži ostatke dentina pulpnog tkiva, mikroorganizme i uglavnom pokriva instrumentirane zidove kanala [2, 3]. Postojanje razmaznog sloja i debrisa, posebno u apeksnom delu kanala, od kliničkog je značaja jer bakterije u kombinaciji s nepovoljnim lokalnim faktorima mogu biti uzrok neuspeha endodontskog lečenja [4]. Osim toga, ovaj sloj zatvara dentinske tubule i umanjuje efekat sredstva za irigaciju, a bitno utiče i na kvalitet opturacije i ishod endodontskog lečenja [3, 4].

Rotirajući instrumenti od nikl-titanijuma (NiTi) jesu relativno nova sredstva u preparaciji kanala, ali efikasno čišćenje kompleksnog kanalnog sistema je i dalje izazov za većinu stomatologa praktičara [2, 5]. Potvrđeno je da ovi instrumenti mogu da obezbede bržu i kvalitetniju preparaciju kanala u obliku izduženog konusa i sa veoma malim rizikom od transportacije [6–9]. Međutim, zbog ograničene efikasnosti instrumenata u čišćenju kanala korena, neophodno je tokom i posle mehaničkih procedura kanale isprati odgovarajućim hemijskim agensima [3]. Irigansi, između ostalog, svojim fizičkim i hemijskim delovanjem omogućavaju rastvaranje razmaznog sloja na zidovima kanala i njegovo delimično uklanjanje [1, 3]. Tokom irigacije je neophodno koristiti kombinaciju različitih irigansa, a najčešće primenjivana je kombinacija rastvora NaOCl i EDTA. Rastvor NaOCl obezbeđuje redukciju mikroorganizama i rastvaranje organskog dela, a EDTA svoje delovanje ispoljava na neorganiskom sadržaju i znatno doprinosi uklanjanju dentinskog debrisa i razmaznog sloja sa zidova kanala korena [2, 9, 10].

Za uklanjanje razmaznog sloja posle završene instrumentacije kanala najčešće se koriste rastvor EDTA i različite koncentracije limunske kiseline, a mogu se koristiti i rastvori mlečne, taninske, sirčetne i poliakrilne kiseline, odnosno rastvori tetraciklina (MTAD) [3, 10, 11]. Kao sredstvo za uklanjanje razmaznog sloja koristi se i hitosan, rastvor prirodnog polisaharida, koji sadrži hlorheksidin i ima blago helirajuće dejstvo [10, 12]. Važno mesto u uklanjanju razmaznog sloja pripada i ultrazvučnim, odnosno laserskim tehnikama [3, 13, 14]. Potvrđeno je da i korišćenje fleksibilnih mikročetkica može pomoći u smanjenju debrisa i razmaznog sloja na zidovima kanala [2, 15]. Brojna sredstva i tehnike za njegovo uklanjanje sa zidova kanala pre konačne opturacije značajno povećavaju prijanjanje paste za zidove i smanjuju pojavu mikrocurenja duž zidova kanala korena [16, 17]. Međutim, kako nijedno sredstvo i nijedna tehnika ne obezbeđuju potpuno i efikasno uklanjanje razmaznog sloja sa zidova kanala, danas je posebna pažnja usmerena ka pronađenju novih sredstava i instrumenata za uklanjanje ovog sloja.

Cilj ovog rada je bio da se SEM analizom proveri efikasnost novog instrumenta XP-endo Finisher na kvalitet čišćenja zidova kanala korena zuba nakon instrumentacije BioRaCe NiTi rotirajućim instrumentima.

## MATERIJAL I METODE RADA

Ispitivanja su izvedena u uslovima *in vitro* na 30 jednokorenih zuba ekstrahovanih iz ortodontskih ili parodontoloških razloga. Do početka eksperimenta zubi su čuvani u fiziološkom rastvoru na 4°C. Pristupni kavitet kod svih zuba je formiran visokotražnom bušilicom i dijamantskim svrdлом. Prohodnost kanala proveravana je instrumentom ISO15, a radna dužina preparacije određena je 1 mm kraće od dužine na kojoj se vrh turpije pojavljuje na apeksu. Vrh korena svakog zuba je prekriven roze

voskom, kako bi se sprečilo isticanje irigansa kroz apeksni otvor tokom preparacije kanala. Zubi su svrstani u dve grupe od po 15 zuba.

Svi kanali su obrađeni primenom osnovnog seta NiTi rotirajućih instrumenta BioRaCe (*FKG Dentaire, Švajcarska*) uz poštovanje uputstva proizvođača o načinu i redosledu njihovog korišćenja tokom preparacije [18]. Korišćeni su kolenjak s redukovanim brojem obrtaja (16:1) i endomotor TCM ENDO V (*Nuvag, AG, Švajcarska*). Tokom instrumentacije svi zubi su ispirani dvopercentnim rastvorom NaOCl (*Chlorax, Cerkamed, Poljska*) u količini od 2 ml između svakog instrumenta. Po završenoj instrumentaciji kanal je ispiran sa još 5 ml dvopercentnog rastvora NaOCl. Za ispiranje su korišćeni plastični špricevi zapremine 2 ml (tokom instrumentacije) i 5 ml (tokom finalnog ispiranja) i odgovarajuće igle veličine 27 savijene pod uglom od 30 stepeni.

U prvoj grupi je nakon mašinske instrumentacije razmazni sloj uklanjan korišćenjem novog instrumenta XP-endo Finisher (*FKG Dentaire, Švajcarska*), a druga grupa instrumentiranih zuba je služila kao kontrolna. U prvoj grupi je svaki kanal posle instrumentacije ispunjavam irigansom, a potom uziman XP-endo Finisher iz sterilnog pakovanja i postavljen u kolenjak. Radna dužina je za svaki kanal određivana pomoću plastične tube i stopera. Pre svakog unošenja instrument je ohlađen sprejom Endo Frost (*Roeko, Colten, Whaledent GmbH, Nemačka*) preko plastične tube i postavljen u kanal. XP-endo Finisher je korišćen nežnim pokretima uvlačenja i izvlačenja tokom jednog minuta u kanalu. Posle izvlačenja instrumenta kanal je ispran ostatkom rastvora NaOCl.

Krunice zuba su potom uklonjene dijamantskim diskom, a korenovi uzdužno podeljeni i odabrane polovine pripremljene za posmatranje na svetlosnoelektronskom mikroskopu (*JEOL, JSM 6460 LV, Japan*). Dentinski zid svakog zuba je posmatran u predelu krunične, srednje i apeksne trećine na različitim uveličanjima i napravljene su fotomikrografije. Za kvalitativnu procenu postojanja razmaznog sloja na zidovima kanala korena korišćeni su kriterijumi Hilsmana (*Hülsmann*) i saradnika [19]: ocena 1 označavala je da nema razmaznog sloja i da su dentinski tubuli otvoreni; ocena 2 – zastupljena mala količina razmaznog sloja, otvoreno nekoliko dentinskih tubula; ocena 3 – homogeni razmazni sloj prekriva zid kanala korena, otvoreno samo nekoliko dentinskih tubula; ocena 4 – celokupan zid kanala prekriven homogenim razmaznim slojem, dentinski tubuli nisu otvoreni; ocena 5 – običan nehomogeni razmazni sloj prekriva celokupan zid kanala korena.

Dobijeni rezultati su analizirani primenom Man–Vitnijevog (Mann–Whitney) U-testa.

## REZULTATI

Ukupne srednje vrednosti skorova za razmazni sloj u grupi gde je korišćen XP-endo Finisher bile su statistički značajno manje nego u grupi gde je instrumentacija urađena samo NiTi rotirajućim instrumentima BioRaCe ( $p=0,013$ ) (Tabela 1). Man–Vitnijev U-test nije pokazao statistički značajne razlike u skorovima razmaznog sloja između grupa ni u kruničnim, ni u srednjim, niti u apeksnim trećinama kanala (Tabela 2).

Posle primene XP-endo Finisher uočeni su čisti zidovi u kruničnoj trećini, bez razmaznog sloja i s otvorenim dentinskim kanalićima u srednjoj (Slika 1), odnosno s opiljcima razmaznog

sloja i sa dosta otvorenih dentinskimi kanalića u apeksnoj trećini kanala (Slika 2).

Instrumentacija kanala BioRaCe rotirajućim instrumentima je proizvela nešto više razmaznog sloja na zidovima kanala u srednjoj (Slika 3), odnosno apeksnoj trećini kanala (Slika 4).

## DISKUSIJA

Osnovni zadatak endodontskog lečenja je da se instrumentacijom i irrigacijom obezbedi efikasno čišćenje endodontskog prostora, koje podrazumeva potpuno uklanjanje nekrotičnog ili vitalnog tkiva, odnosno svih bakterija iz kanalnog sistema zuba [20]. Eliminacija razmaznog sloja koji se stvara duž zidova kanala korena tokom instrumentacije značajan je klinički parametar za uspeh endodontskog lečenja [1, 2, 4, 21].

U ovom istraživanju svi uzorci su instrumentisani i ispirani prema istom protokolu (a u radio ih je isti praktičar), tako da se dobijeni rezultati mogu posmatrati jedino u funkciji finalnog čišćenja kanalnog sistema. Dobijeni rezultati su ukazali na značajno efikasnije uklanjanje razmaznog sloja sa zidova kanala korena nakon korišćenja XP-endo Finisher. Primena ovog instrumenta dovela je do efikasnijeg čišćenja kanalnog sistema i znatno manje količine razmaznog sloja na svim nivoima kanala (krunična, srednja, apeksna). Ključni deo čišćenja kanalnog sistema zuba zavisi od tehnike instrumentacije [6, 9, 16, 22] i izbora irigansa i tehnike irrigacije kanala korena [3, 10, 22, 23, 24]. Iako je zbog kompleksne anatomije teško ostvariti formu izduženog, levkasto oblikovanog konusa [25], sigurno je da se tzv. *crown-down* tehnikom preparacije i primenom NiTi rotirajućih instrumenata može ostvariti vrlo efikasno čišćenje i oblikovanje kanala za značajno kraće vreme [21, 22, 26, 27].

U ovoj studiji je efikasnost čišćenja kanala korena primenom seta NiTi rotirajućih instrumenata proveravana na osnovu numeričke procene postojanja razmaznog sloja u kruničnoj, srednjoj i apeksnoj trećini kanala, što je u saglasnosti s nalazima drugih istraživača [7, 10, 17, 19, 27]. U kontrolnoj grupi set BioRaCe rotirajućih instrumenata je stvarao manje količine razmaznog sloja u svim segmentima kanala korena. Ovakav rezultat se može pripisati, pre svega, velikoj fleksibilnosti, odnosno dizajnu i elektrohemski poliranju površini radnog dela instrumenta [28, 29]. Naime, dizajn aktivnog dela ove turpije s naizmeničnim kosim (koji sekut) i ravnim delovima (koji eliminuju sečeni dentin) uz obilnu irrigaciju, obezbeđuje efikasno čišćenje zidova kanalnog sistema [29, 30, 31]. Manja količina razmaznog sloja može biti i posledica činjenice da je instrumentacija izvedena isključivo kod pravih kanala i uz obilnu irrigaciju, gde je dizajn instrumenta posebno uticao na izostanak formiranja ovog sloja na zidovima kanala [17, 21, 22].

Krunična i srednja trećina kanala su bile čistije i s manje razmaznog sloja nego apeksna. Ovo se može pripisati, pre svega, većem prečniku ovog regiona i boljem tkivnohemiskom kontaktu tokom instrumentacije, odnosno činjenici da je dentin izložen većoj količini irigansa [15, 22, 32]. Takođe, preparacija setom BioRaCe NiTi rotirajućih instrumenata obezbeđuje širok i levkast zid s većom apeksnom koničnošću (6%), što omogućava bolje prodiranje igle i rastvora za irrigaciju, a time i efikasnije uklanjanje razmaznog sloja [15, 22, 31, 33, 34]. Preparacija kanala RaCe instrumentima dovodi do značajno manje transportacije u apeksnom delu kanala u odnosu na druge NiTi

rotirajuće instrumente [31]. Na formiranje manjih količina razmaznog sloja i dentinskog debrisa mogla je uticati i brzina rotacije instrumenta. Potvrđeno je da nešto veće brzine ostvaruju bolji efekat čišćenja (brzina rotacije BioRaCe je 600 obrtaja u minuti) u odnosu na najčešće brzine rotirajućih NiTi instrumenata (300–400 obrtaja u minuti) [17, 34].

Iako je kombinacija rastvora NaOCl i EDTA zlatni standard u hemomehaničkoj preparaciji kanala [11, 13, 21, 24, 32], u ovoj studiji je izabran jednostavan irigacioni protokol i tokom instrumentacije je korišćen samo rastvor NaOCl [31, 35, 36]. Osnovni cilj je bio da se proveri efekat čišćenja kanala setom BioRaCe NiTi rotirajućih instrumenata i izbegne nesumnjiv uticaj helatnih agensa na uklanjanje razmaznog sloja [21, 31, 36]. Rastvor NaOCl je najčešće korišćeno sredstvo za irigaciju kanala korena, prvenstveno zbog svog rastvaračkog efekta na organski deo dentina, ali i izvanrednog antibakterijskog delovanja [11, 31]. Iako nisu obezbeđeni potpuno čisti kanali, ovakvim protokolom je potvrđeno dosta efikasno čišćenje i uklanjanje razmaznog sloja na svim nivoima kanala. Važno je napomenuti da bi korišćenjem rastvora EDTA dobijeni rezultat bio sigurno bolji, a uklanjanje razmaznog sloja verovatno još efikasnije i u apeksnom delu kanala [21, 31, 32, 35, 36].

U grupi gde je nakon preparacije kanala setom BioRaCe NiTi rotirajućih instrumenata za uklanjanje razmaznog sloja korišćen novi instrument XP-endo Finisher ostvareno je vrlo efikasno čišćenje na svim nivoima kanala. Ono što se na osnovu ove studije može zapaziti jeste vrlo efikasno uklanjanje razmaznog sloja i u apeksnom delu kanala. To se može pripisati širem prečniku ovog regiona (ISO40) i većoj efikasnosti korišćenog irrigansa u uklanjanju razmaznog sloja [11, 15, 31, 35, 36]. Po-

tvrđeno je takođe da standardni rotirajući NiTi instrumenti pri obradi kanala dolaze u kontakt sa samo 40–45% zidova kanala, tako da veliki deo kanalne površine ostaje neobrađen [21, 27]. Preparacijom kanala se uklanja samo sloj dentina koji dolazi u kontakt s rotirajućim instrumentom i pri tome veliki deo sečenog dentina zaostaje upravo u tim neobrađenim segmentima kanalnog zida [21, 26]. Ovaj deo dentina se može ukloniti samo obilnom i efikasnom irigacijom [11, 32]. Zahvaljujući specifičnom dizajnu, instrument XP-endo Finisher bolje čisti kanal, jer može da dopre i do tih nepristupačnih delova kanala [18]. Mali prečnik ovog NiTi instrumenta (ISO25) i činjenica da može da menja svoj oblik tokom rotacije u kanalu (M i A faza) omogućava mu da u fazi rotacije može dopreti do nepristupačnih mesta u kanalnom sistemu i obezbediti efikasno uklanjanje debrisa i razmaznog sloja [18]. XP-endo Finisher je rotirajući NiTi instrument bez koničnosti koji uz efikasnu irigaciju dobro proširenog kanalnog sistema dobro čisti zidove kanala i uklanja razmazni sloj sa zidova kanala, ali i sečeni dentin iz nepristupačnih segmenta kanalnog sistema.

## ZAKLJUČAK

U okviru ograničenja ove studije može se zaključiti da se nakon instrumentacije kanala korena BioRaCe NiTi rotirajućim instrumentima obezbeđuje dobro hemomehaničko čišćenje kanalnog sistema zuba i njegovih zidova. Primena XP-endo Finisher nakon instrumentacije kanala jednokorenih zuba obezbeđuje efikasno uklanjanje razmaznog sloja sa zidova kanala u svim njegovim segmentima.

# Correlation Between Pulpal and Carotid Arteries Blood Flow in Two Age Groups

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## SUMMARY

**Introduction** Vascular network of dental pulp is supplied through common and external carotid artery and terminal dental branches that supply each pulp tissue. Age related changes of pulp tissue influence pulpal vascularization as well. The aim of this study was to compare and correlate pulpal and common and external carotid artery blood flow in young and middle age individuals of general population.

**Material and Methods** Two groups of 10 participants were included in the study, young (20-25 years) and middle age (50-55 years) group. Pulpal blood flow (PBF) measurements on intact right and left upper central incisors were performed using laser Doppler flowmetry (LDF) method. Carotid arteries blood flow was assessed using carotid ultrasonography.

**Results** PBF levels were significantly higher in young ( $3.11 \pm 0.67$  and  $3.46 \pm 1.11$ , right and left upper central incisors, respectively) compared to middle age ( $1.93 \pm 0.47$  and  $2.30 \pm 0.64$ , right and left upper central incisors, respectively) participants (independent sample t test;  $p < 0.05$ ). There was no correlation between common and external carotid artery blood flow and upper central incisors PBF in young as well as middle age participants, for right or left side.

**Conclusion** Absence of correlation between carotid arteries blood flow and PBF suggests that reduced PBF in middle age participants was probably not due to reduced blood supply from carotid arteries but it was result of age related changes at the level of pulpal blood vessels.

**Keywords:** dental pulp; blood flow; aging; carotid artery; laser Doppler flowmetry

## INTRODUCTION

Dental pulp is well vascularized tissue with relatively high resting blood flow compared to other oral tissues [1]. Pulpal vasculature consists of arterial vessels that enter the pulp space through the apical foramina and additional blood vessels running into the pulp through lateral channels. From apical to coronal region of the pulp this network gives off numerous branches and terminates in a capillary plexus [2, 3]. The pulp is enclosed within rigid walls of dentin and any change in blood vessels volume might result in disturbed tissue pressure, which in turn could affect capacity for regeneration turnover as well as the excitability of intradental nerves [4, 5]. Such low-compliance environment augments age-related changes that influence pulpal vascularization. As tooth gets older pulp space volume decrease [6] and consequently vascular, lymphatic and nerve supply is compromised [7, 8].

In common with all tissues, the ability of a tooth to survive is dependent of a viable blood supply. Vascular network of dental pulp is supplied through common carotid, external carotid and maxillary artery that gives terminal dental branches, which supply each individual

pulp. Carotid arteries, as well as tissues they supply, are subjected to regressive structural and functional changes in the process of physiological aging [9, 10, 11].

Up to date there are no data concerning relationship between PBF and carotid arteries blood flow in general population and the effect of aging on this relationship. Thus, the aim of this study was to compare and correlate pulpal and common and external carotid artery blood flow in young and middle age individuals of general population.

## MATERIAL AND METHODS

### Participants

Two groups of participants who were treated at the Department of restorative odontology and endodontics, School of Dentistry, University of Belgrade were enrolled in the study. The young group consisted of 5 male and 5 female healthy participants between 20 and 25 years of age. The middle age group consisted of 5 male and 5 female healthy participants between 50 and 55 years of

age. Presence of any systemic disease or taking of any medication were general exclusion criteria, while caries, restorations, poor oral hygiene, gingivitis, periodontitis and tooth sensitivity of maxillary central incisors were local exclusion criteria. LDF recordings were performed at the Department of restorative odontology and endodontics, School of Dentistry, University of Belgrade while carotid ultrasonography recordings were performed at Vascular Surgery Clinic, "Dedinje" Cardiovascular Institute, Belgrade. The participants were informed about the procedures involved and informed consent was received. The protocol was approved by the Ethical Committee of School of Dentistry, University of Belgrade, and it was in accordance with the Helsinki Declaration of 1975.

### Laser Doppler flowmetry

LDF recordings were done on healthy, intact upper central incisors. Tooth responsiveness to external stimuli was evaluated by conventional electrical and thermal tests. Radiographs were taken to determine normal periapical status of the tooth.

PBF measurements were performed with a laser Doppler flowmeter (PeriFlux PF 5001, Perimed, Jarfalla, Sweden). A 1-mW laser produced light of 623.8 nm wavelengths. A round probe (407-2, Perimed) with a cross-sectional diameter of 1 mm and 3 optical fibers with diameter of 125 µm (fiber-to-fiber distance 250 µm) were used. The active artifact filter and sampling frequency of 32Hz were used. Before each data collection the flowmeter was calibrated to a specific value of 250 perfusion units (PU), with a colloidal suspension of latex micro particles (Perimed Motility Standard). The PBF was expressed in PU and monitored using data processing software (Perisoft Version 2.50; Perimed, Stockholm, Sweden). The mean PU values were determined using at least 3 minutes of recording.

For probe stabilization custom-made plastic splints (Bioplast, Schen-Dental, Iserlohn, Germany) were prepared providing appropriately placed holes with a diameter similar to that of the probe holder (pH 07-6 Perimed, Sweden). Splint and the probe holder positioned the probe on the labial, cervical third of the tooth crown, perpendicular to the tooth surface. LDF measurements were performed with a rubber dam placed. After having participant rest in a supine position in dental chair for 10 min, blood flow data were collected for at least 3 min. The same dentist performed all measurements in an environment with constant temperature.

### Carotid ultrasonography

Carotid arteries were examined bilaterally with a duplex ultrasound imaging (ALOKA, ALPHA 10) using a 4-7MHz linear array transducer. All recordings were performed with the participants in supine position, by the same trained sonographer. Scanning protocol of carotid arteries consisted of imaging in the longitudinal (antero-lateral,

lateral, postero-lateral views) and transverse planes. The examination consisted of an initial exploratory scans of the carotid system, followed by measurement of blood volume flow (VF) rates. VF rates were measured using preset carotid ultrasound software (ALOKA, ALPHA 10) and a 4-7 MHz scan head, maintaining a 60° angle of insonation. The sites of measurement were 1.0 to 1.5 cm below the carotid bifurcation for the common carotid artery (CCA) and 1.0 to 1.5 cm above the bifurcation for the external carotid artery (ECA). The carotid blood flow was expressed in ml/min.

### Statistical analysis

Mean values of PBF, common carotid artery blood flow (ACC-VF) and external carotid artery blood flow (ACE-VF) were obtained for the two participant groups and data were presented as mean ± standard deviation (SD). Independent sample *t* test was used to compare PBF, ACE-VF and ACC-VF between young and middle aged participants and Pearson's correlation to correlate PBF and ipsilateral ACC-VF as well as PBF and ipsilateral ACE-VF.

### RESULTS

PBF, ACC-VF and ACE-VF for the two participant groups are shown in Table 1 and Table 2 for right and left side, respectively. PBF levels were significantly higher in young compared to middle age participants. ACC-VF and ACE-VF were higher in middle age than young participants but there was no statistically significant difference between

**Table 1.** Pulpal blood flow (PBF) measured on the right upper central incisor, right common carotid artery blood flow (ACC-VF) and right external carotid artery blood flow (ACE-VF)

**Tabela 1.** Protok krvi kroz zubnu pulpu (PBF) meren na desnem gornjem centralnom sekutiću, kroz desnu zajedničku karotidnu arteriju (ACC-VF) i desnu spoljašnju karotidnu arteriju (ACE-VF)

Participants (years) Ispitanici (godine)	PBF	ACC-VF	ACE-VF
Young (20–25) Mladi (20–25)	3.11±0.67	533.20±105.39	224.40±69.88
Middle-aged (50–55) Srednje dobi (50–55)	1.93±0.47*	562.90±62.25	234.80±34.60

\* independent sample *t*-test; p<0.05

\* *t*-test za nezavisne uzorke; p<0.05

**Table 2.** Pulpal blood flow (PBF) measured on the left upper central incisor, left common carotid artery blood flow (ACC-VF) and left external carotid artery blood flow (ACE-VF)

**Tabela 2.** Protok krvi kroz zubnu pulpu (PBF) meren na levom gornjem centralnom sekutiću, kroz levu zajedničku karotidnu arteriju (ACC-VF) i levu spoljašnju karotidnu arteriju (ACE-VF)

Participants (years) Ispitanici (godine)	PBF	ACC-VF	ACE-VF
Young (20–25) Mladi (20–25)	3.46±1.11	537.60±128.86	233.70±73.83
Middle-aged (50–55) Srednje dobi (50–55)	2.30±0.64*	606.70±70.00	251.40±45.06

\* independent sample *t*-test; p<0.05

\* *t*-test za nezavisne uzorke; p<0.05

**Table 3.** Correlations between upper central incisors pulpal blood flow (PBF) and ipsilateral common carotid artery blood flow (ACC-VF) and external carotid artery blood flow (ACE-VF), for the two groups of participants

**Tabela 3.** Korelacija između protoka krvi kroz zubnu pulpu gornjih centralnih sekutića i ipsilateralnog protoka krvi kroz zajedničku karotidnu arteriju (ACC-VF) i protoka krvi kroz spoljašnju karotidnu arteriju (ACE-VF) za dve grupe ispitanika

P	ACC-VF	ACE-VF
Right incisor PBF Young (20-25) PBF na desnom sekutiću mladih ispitanika (20-25)	0.311	0.869
Left incisor PBF Young (20-25) PBF na levom sekutiću mladih ispitanika (20-25)	0.774	0.913
Right incisor PBF Middle-age (50-55) PBF na desnom sekutiću ispitanika srednje dobi (50-55)	0.774	0.184
Left incisor PBF Middle-age (50-55) PBF na levom sekutiću ispitanika srednje dobi (50-55)	0.355	0.109

the two groups. No significant correlation was found between ACC and ACE blood flow and upper central incisors PBF in young as well as middle age participants, for right or left side (Table 3).

## DISCUSSION

The present study concerns the relationship between PBF and blood flow in common and external carotid artery in the two age groups, young and middle age, of general population. This objective was met by quantifying pulpal blood flow by LDF and blood flow in carotid arteries by high-resolution carotid ultrasonography. LDF method has been extensively used in dental traumatology, maxillofacial surgery and orthodontic force application, as a measure of pulp vitality and help in treatment decision [12, 13, 14]. This technique was considered to provide valid comparative data, although measurements are sensitive to physiological oscillations of blood pressure as well as movements during measurement [15]. High-resolution carotid ultrasonography is noninvasive, sensitive and reliable indicator of hemodynamic status of ipsilateral carotid, cerebral and maxillofacial circulation [16-19].

Many studies have reported association of oral diseases, such as periodontitis with coronary and carotid diseases [20-23]. Possible underlying mechanisms of such association include the presence of periodontal bacterial pathogens, antigens, bacterial toxins and the consequent inflammatory mediators production [24-27]. However, we sought to investigate the influence of carotid arteries hemodynamics, as feeding arteries, on the pulpal blood supply.

Our results showed that in the middle age participants, ACC and ACE blood flows were higher than in young participants, but the difference was not statistically significant. This could be attributed to the well functioning vascular network between carotid arteries and its terminal dental branches and anastomoses in this network. Our finding is in accordance with studies indicating that in healthy humans changes in ACC blood flow do not appear to be strongly correlated with age [28, 29, 30].

On the other hand, the obtained results showed that upper central incisors PBF was significantly higher in younger than in older subjects, suggesting a clear age related decrease in PBF. Reduction of PBF levels with aging was also shown by Ikawa et al. [31], who suggested that observed PBF decrease was most probably underlined by age related changes in pulpal vascularity.

Major finding of our study is that there was no correlation between ACC and ACE blood flow and upper central incisors PBF in young as well as middle age participants. Concerning the fact that age related decrease in PBF existed, it could be proposed that reduced PBF in healthy, middle age participants was not due to reduced blood supply from ACC and ACE but it was result of age related changes at the level of pulpal blood vessels. Namely, early study of Bennett et al. [32] showed reduction in number of arteries supplying apical foramen in humans aged 10-20 vs. 20-40 vs. 40-70 years, while thickening of arterial intima and calcification of adventitia were observed from age 40 [7, 32]. Also, histological studies have confirmed age related regressive changes in structure and number of pulpal blood vessels [8, 33]. Measuring dentin deposition, Solheim found that coronal pulp cavity and pulp width strongly correlated with age [6]. Espina et al. showed that pulpal capillary endothelium experiences morphological changes during aging, such as increased transendothelial transport, cytoskeletal changes, hypertrophic Golgi complex and cytoplasmic deposits [34].

## CONCLUSION

Since there is no age related reduction in ACC and ACE blood flow, observed reduction in upper central incisors PBF in middle age (50-55) general population, is the most likely the consequence of age related changes in dental pulp microcirculation.

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# Nivo protoka krvi kroz zubnu pulpu i njegova korelacija s protokom krvi kroz karotidne arterije kod dve starosne grupe opšte populacije

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## KRATAK SADRŽAJ

**Uvod** Vaskularna mreža zubne pulpe dobija dotok krvi preko zajedničke i spoljašnje karotidne arterije i završnih zubnih grana koje snabdevaju svaku pojedinačnu pulpu. Mala fleksibilnost okruženja zubne pulpe pojačava promene vezane za starenje koje utiču na vaskularizaciju pulpe. Cilj ovog rada je bio da se uporedi i utvrdi međusobna povezanost pulpnog i protoka krvi u zajedničkoj i spoljašnjoj karotidnoj arteriji kod mlađih i osoba srednje životne dobi opšte populacije.

**Materijal i metode rada** Dve grupe od po 10 ispitanika su učestvovalo u studiji: mlađi (20–25 godina) i ispitanici srednje životne dobi (50–55 godina). Merenja protoka krvi kroz zubnu pulpu (PBF) na intaktnim desnim i levim gornjim centralnim sekutićima izvedena su metodom laser Doppler floumetrije (LDF). Protok krvi kroz karotidne arterije je procenjivan ultrazvučnim pregledom.

**Rezultati** Nivoi PBF bili su značajno viši kod mlađih ispitanika (desni gornji centralni sekutići:  $3,11 \pm 0,67$ ; levi gornji centralni sekutići:  $3,46 \pm 1,11$ ) u odnosu na ispitanike srednje dobi (desni gornji centralni sekutići:  $1,93 \pm 0,47$ ; levi gornji centralni sekutići:  $2,30 \pm 0,64$ ) (Studentov t-test za nezavisne uzorce,  $p < 0,05$ ). Nije bilo korelacije između protoka krvi kroz zajedničke i spoljašnje karotidne arterije i PBF gornjih sekutića kod mlađih, niti kod ispitanika srednje dobi, za desnu i levu stranu.

**Zaključak** Nepostojanje veze između protoka krvi kroz karotidne arterije i PBF ukazuje na to da smanjenje PBF kod ispitanika srednje životne dobi verovatno nije posledica smanjenog dotoka krvi iz karotidnih arterija, već rezultat promena u vezi sa starenjem na nivou pulpnih krvnih sudova.

**Ključne reči:** zubna pulpa; protok krvi; starenje; karotidna arterija; laser Doppler floumetrija

## UVOD

Zubna pulpa je dobro vaskularizovano tkivo s relativno visokim osnovnim protokom krvi u poređenju sa drugim oralnim tkivima [1]. Pulpna vaskularna mreža se sastoji od arterija koje ulaze u prostor komore pulpe kroz apikalne otvore i dodatnih krvnih sudova koji ulaze u pulpu kroz bočne kanale. Od apikalne do koronarne regije pulpe ova mreža daje brojne grane i završava se kapilarnim pleksusom [2, 3]. Pulpa je zatvorena unutar čvrstih dentinskih zidova i bilo kakve promene u volumenu krvnih sudova mogu dovesti do poremećaja u tkivnom pritisku, što zauzvrat može uticati na regenerativne sposobnosti i nadražljivost intradentalnih nerava [4, 5]. Takvo slabo fleksibilno okruženje dodatno naglašava promene vezane za starenje koje utiču na vaskularizaciju pulpe. Starenjem zuba pulpna komora se smanjuje [6], a posledično je ugrožena i vaskularna, limfna i nervna mreža pulpe [7, 8].

Kao i kod svih tkiva, sposobnost zuba da opstane zavisi od održivog dotoka krvi. Vaskularna mreža zubne pulpe se ishranjuje preko zajedničke i spoljašnje karotidne arterije i maksilarne arterije, koja daje završne zubne grane koje snabdevaju svaku pojedinačnu pulpu. Karotidne arterije, kao i tkiva koja ishranjuju, podležu regresivnim strukturnim i funkcionalnim promenama u procesu fiziološkog starenja [9, 10, 11].

Do danas ne postoje podaci o odnosu između protoka krvi kroz zubnu pulpu (PBF) i protoka krvi kroz karotidne arterije u opštoj populaciji, kao ni o efektu starenja na taj odnos. Stoga je cilj ovog istraživanja bio da se uporedi i utvrdi međusobna povezanost pulpnog i protoka krvi u zajedničkoj i spoljašnjoj karotidnoj arteriji kod mlađih i pojedinaca srednje životne dobi opšte populacije.

## MATERIJAL I METODE RADA

### Ispitanici

Dve grupe ispitanika koji su bili lečeni na Klinici za bolesti zuba Stomatološkog fakulteta Univerziteta u Beogradu učestvovalo su u studiji. Grupa mlađih zdravih ispitanika sastojala se od pet muškaraca i pet žena starosti između 20 i 25 godina. Grupa zdravih ispitanika srednje životne dobi sastojala se od pet muškaraca i pet žena starosti između 50 i 55 godina. Postojanje bilo koje sistemskе bolesti ili korišćenje bilo kakvih lekova bili su opšti kriterijumi za isključenje iz studije, dok su karijes, restauracije, loša oralna higijena, gingivitis, parodontitis i osetljivost gornjih centralnih sekutića bili lokalni kriterijumi za isključenje. Snimanja laser Doppler floumetrijom (LDF) su urađena na Klinici za bolesti zuba i endodonciju Stomatološkog fakulteta Univerziteta u Beogradu, dok su ultrazvučni pregledi karotidnih arterija urađeni na Klinici za vaskularnu hirurgiju Instituta za kardiovaskularne bolesti „Dedinje“ u Beogradu. Ispitanici su bili upoznati s protokolom istraživanja i dali su svoj pisani pristanak za učestvovanje u studiji. Protokol je odobrio Etički odbor Stomatološkog fakulteta Univerziteta u Beogradu, i on je bio u skladu s Helsinškom deklaracijom iz 1975. godine.

### Laser Doppler floumetrija

LDF snimanja su rađena na zdravim, intaktnim gornjim centralnim sekutićima. Reakcija zuba na nadražaje procenjena je konvencionalnim elektro i termo testovima. Radiogramima je potvrđeno normalno stanje periapeksa zuba.

Merenja PBF izvedena su laser Doppler meračem protoka (*PeriFlux PF 5001, Perimed, Jarfala, Švedska*). Svetlo talasne dužine od 623,8 nm proizvodio je 1-mW laser. Korišćena je okrugla sonda (407-2, *Perimed*) s poprečnim presekom od 1 mm i tri optička vlakna promera 125 µm (udaljenost vlakna od vlakna bila je 250 µm). Artefakt filter je bio aktiviran, a učestalost merenja je bila 32 Hz. Pre svakog prikupljanja podataka merač protoka je kalibriran na određenu vrednost od 250 perfuzionih jedinica (PU), s koloidnom suspenzijom lateks mikročestica (*Perimed Motility Standard*). PBF je izražavan u PU i praćen pomoću softvera za obradu podataka (*Perisoft verzija 2,50, Perimed, Stokholm, Švedska*). Prosečne vrednosti protoka određivane su korišćenjem najmanje tri minuta snimljenog zapisu.

Za stabilizaciju sonde izrađivan je individualni splint od tvrde plastike (*Bioplast, Schen-Dental, Izerlon, Nemačka*) sa odgovarajuće postavljenim rupama promera sličnog promeru držača sonde (pH 6/7, *Perimed, Švedska*). Splint i držač sonde pozicionirali su sondu na labijalnoj, vratnoj trećini krunice, upravno na površinu zuba. LDF merenja su izvedena uz korišćenje koferdama. Nakon odmora ispitanika od 10 minuta u ležećem položaju, u stomatološkoj stolici, protok krvi je meren tokom najmanje tri minuta. Sva merenja izvedena su pri konstantnoj ambijentalnoj temperaturi od strane istog stomatologa.

### **Ultrazvučni pregled karotidnih arterija**

Karotidne arterije su ispitivane bilateralno ultrazvučnim apatom (*ALOKA, ALPHA 10*) pomoću linearne sonde od 4–7 MHz. Sva snimanja su izvedena na ispitanicima u ležećem položaju od strane istog iskusnog lekara. Protokol se sastojao od snimanja karotidnih arterija u uzdužnoj (anterolateralnom, bočnom, posterolateralnom pogledu) i poprečnoj ravni. Ispitivanje se sastojalo od inicijalnog snimanja karotidnog sistema, nakon čega je sledilo merenje protoka krvi (VF). Protok krvi je meren pomoću softvera (*ALOKA, ALPHA 10*) i sonde od 4–7 MHz, održavajući ugao insonacije od 60°. Mesta merenja su bila od 1,0 do 1,5 cm ispod karotidne bifurkacije za zajedničku karotidnu arteriju (CCA) i od 1,0 do 1,5 cm iznad bifurkacije za spoljašnju karotidnu arteriju (ECA). Protok krvi kroz karotidne arterije je izražavan u ml/min.

### **Statistička analiza**

Računate su srednje vrednosti PBF, protoka krvi kroz zajedničku karotidnu arteriju (ACC-VF) i protoka krvi kroz spoljašnju karotidnu arteriju (ACE-VF) za dve grupe ispitanika, a podaci su prikazani kao srednja vrednost ± standardna devijacija (SD). Studentov t-test za nezavisne uzorke korišćen je za poređenje PBF, ACC-VF i ACE-VF između mlađih i ispitanika srednje životne dobi, a Pirsonov (*Pearson*) test za korelaciju PBF i ipsilateralnog ACC-VF, kao i PBF i ipsilateralnog ACE-VF.

### **REZULTATI**

Rezultati PBF, ACC-VF i ACE-VF kod dve grupe ispitanika prikazani su u tabelama 1 i 2 za desnu i levu stranu. Nivoi PBF bili

su značajno viši kod mlađih ispitanika u odnosu na ispitanike srednje dobi. ACC-VF i ACE-VF su bili veći kod ispitanika srednje dobi nego kod mlađih, ali nije bilo statistički značajne razlike između grupa. Nije utvrđena značajna korelacija između ACC i ACE protoka krvi i PBF gornjih centralnih sekutića ni kod mlađih, ni kod ispitanika srednje dobi, kako za desnu, tako i za levu stranu (Tabela 3).

### **DISKUSIJA**

Cilj ove studije je bio da istraži odnos između PBF i protoka krvi u zajedničkoj i spoljašnjoj karotidnoj arteriji u dve starosne grupe – kod mlađih i ispitanika srednje dobi u opštoj populaciji. Ovaj cilj je ispunjen određivanjem protoka krvi kroz Zubnu pulpu pomoću LDF metode i protoka krvi kroz karotidne arterije pomoću ultrazvučnog pregleda. LDF metoda je opšte poznata u dentalnoj traumatologiji, maksilofacialnoj hirurgiji i ortodonciji kao merilo vitaliteta pulpe i pomoć u terapiji [12, 13, 14]. Smatra se da ova tehnika daje valjane, uporedive podatke, iako su merenja osetljiva na fiziološke oscilacije krvnog pritiska, kao i na pokretanje ispitanika tokom merenja [15]. Ultrazvučni pregled karotidnih arterija je neinvazivan, vrlo osetljiv i pouzdan pokazatelj hemodinamskog statusa ipsilateralne karotidne, moždane i cirkulacije u maksilofacialnoj regiji [16-19].

Mnoge studije su proučavale povezanost oralnih bolesti, kao što je parodontitis, s koronarnom i karotidnom bolešću [20-23]. Mogući mehanizmi takve povezanosti su parodontalni bakterijski patogeni, antigeni, bakterijski toksini i posledična proizvodnja medijatora zapaljenja [24-27]. Međutim, u ovom radu namera je bila da se ispita uticaj hemodinamike karotida, kao dovodnih arterija, na dotok krvi u Zubnu pulpu.

Rezultati su pokazali da je kod ispitanika srednje životne dobi protok krvi kroz ACC i ACE bio veći nego kod mlađih ispitanika, ali razlika nije bila statistički značajna. To se može pripisati dobroj funkcionalnosti vaskularne mreže između karotidnih arterija i njihovih terminalnih zubnih grana i anastomozama ove mreže. Ovaj nalaz je u skladu s istraživanjima koja su pokazala da kod zdravih ljudi promene protoka krvi kroz ACC nisu značajno povezane sa starosnom dobi [28, 29, 30].

S druge strane, dobijeni rezultati su pokazali da je PBF centralnih gornjih sekutića bio značajno veći kod mlađih nego kod starijih ispitanika, što jasno ukazuje na smanjenje PBF uslovljeno starenjem. Smanjenje nivoa PBF sa starenjem takođe su pokazali Ikava (*Ikawa*) i saradnici [31] tumačeći uočeno smanjenje PBF kao verovatno uslovljeno promenama u vaskularizaciji pulpe usled starenja.

Glavni nalaz ove studije je da ne postoji korelacija između protoka krvi u ACC i ACE i PBF gornjih sekutića kod mlađih, kao ni kod ispitanika srednje dobi. Imajući u vidu postojanje smanjenja PBF usled starenja, moglo bi se prepostaviti da kod zdravih ispitanika srednje dobi ono nije uzrokovan smanjenjem dotokom krvi iz ACC i ACE, već je rezultat promena na nivou pulpnih krvnih sudova uzrokovanih starenjem. Naime, rana studija Beneta (*Bennett*) i saradnika [32] pokazala je smanjenje broja arterija koje ulaze u pulpu kroz apikalni otvor kod ljudi uzrasta 10–20 godina u odnosu na ispitanike starosti 20–40 i 40–70 godina, dok su zadebljanje intime arterija i kalcifikacije adventicije uočeni kod starijih od 40 godina [7]. Autori su

takođe u histološkim studijama pokazali regresivne promene vezane za starenje u strukturi i broju krvnih sudova pulpe [8, 33]. Merenjem depozicije dentina, Zolhajm (*Solheim*) [6] je pronašao korelaciju širine pulpne komore i starosti. Espina (*Espina*) i saradnici [34] su otkrili da sa starenjem kapilarni endotel pulpe doživljava morfološke promene, kao što su povećan transendotelni transport, promene citoskeleta, hipertrofija Goldžijevog kompleksa i citoplazmatskih depozita.

## ZAKLJUČAK

Budući da nije bilo smanjenja protoka krvi u ACC i ACE vezanog za starenje, uočeno smanjenje PBF gornjih centralnih sekutića kod ispitanika srednje životne dobi (50–55) opšte populacije verovatno je posledica promena vezanih za starenje u mikrocirkulaciji zubne pulpe.

# Oral Clinical Factors Affecting Self-Perception of Oral Health

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## SUMMARY

**Introduction** Self-assessment of oral health is simple, non-invasive and cost-effective method of collecting data that takes into account psychosocial aspects of oral health. The aim of this study was to investigate the effect of clinical factors on the self-perception of oral health in middle-aged patients in Republika Srpska (Bosnia and Herzegovina).

**Material and Methods** The study included 126 subjects of both genders (34.1% male and 65.9% female) aged 24-54 years. Data were collected through questionnaires and clinical examination. Anonymous questionnaire contained questions related to socio-demographic characteristics of respondents. Clinical examination included teeth condition and the presence of prosthetic restorations. Self-perception of oral health was determined by one question.

**Results** Bivariate analysis indicated significant effect of carious ( $p<0.001$ ), missing ( $p<0.001$ ) and filled teeth ( $p=0.022$ ) but not the prosthetic status on self-perception of oral health. Correlation between the number of carious and missing teeth with self-perception of oral health was significant in regression analysis.

**Conclusion** The number of carious and missing teeth had significant impact on self-assessment of oral health in studied population. Knowledge of effects of oral clinical variables on self-perception of oral health is very important to obtain clearer insight into the association between objectively and subjectively assessed oral health.

**Keywords:** evaluation of oral health; caries; socioeconomic factors

## INTRODUCTION

Clinical indicators are most commonly used for the evaluation of oral health in clinical and epidemiological research [1]. This way of oral health assessment has many advantages, however, disadvantages include no consideration of psychosocial aspects and individual perception of oral health [2]. Individual assessment of oral health can provide useful information [3]. This method is easy to use and economically more acceptable than clinical trials [4, 5, 6]. Self-perception of oral health is based usually on one question only [6].

Many studies have found association between the self-perception of oral health determined on one question and number of clinical indicators of oral health [4, 7-10]. Persons with larger number of carious and extracted teeth usually assess their oral health as poor [5, 7, 10], while those with large number of restored teeth assess their oral health as good [5, 7]. Poor oral health is associated with high DMFT index, malocclusion, toothache and TMJ pain, prosthetic status and need for dental treatment [5, 7, 11, 12].

One study done in Serbia showed that nearly half of adult population (45.5%) assessed their teeth and mouth condition as good or very good [13]. It has also been shown that the assessment of oral health is related to total household income, education, gender and geographical region [13].

The aim of this study was to investigate the effect of clinical factors on the assessment of oral health in middle-aged patients in Republika Srpska (Bosnia and Herzegovina).

## MATERIAL AND METHODS

Cross-sectional study was conducted at the Department of Restorative Dentistry and Endodontics, Faculty of Medicine Foča, University of East Sarajevo, Republika Srpska (B&H), from January to July 2013. The sample consisted of 126 respondents of both genders (34.1% male and 65.9% female) aged 24-54 years (mean age  $\pm$  standard deviation:  $32.36 \pm 5.93$  years). The target population was selected randomly from patients of the Department of Restorative Dentistry and Endodontics, Faculty of Medicine, Foča. After explanation about objectives and expected outcomes of the research, all subjects signed informed consent to participate in research.

Data were collected through questionnaires and clinical examination. The anonymous questionnaire contained questions related to socio-demographic characteristics: age, gender, level of education (completed elementary school, completed high school, completed college, university and more), employment (employed full-time, employed part-time, unemployed), the total monthly income of all household members (< than one average salary in RS, 1-2 average salaries in RS, 2-3 average salaries in RS, > 4 average salaries in RS (in the period when survey was conducted)), smoking habits in the past year (yes, no) and the time since last visit to the dentist (visit within last 6 months, 6-12 months, between 1-2 years and more than 2 years). The studied variables were dichotomized for the purpose of statistical analysis. The level of education was classified into two categories: elementary and/or high

school and completed college and more; employment was classified as: employed (full-time, part-time) and unemployed; the total income of all household members: up to two average salaries in RS (<than one average salary in RS, 1-2 average salaries in RS) and income higher than two average salaries (2-3 average salaries in RS, > 4 average salaries in RS). Dental visit in the last 12 months was also dichotomized to: visit within 12 months (visit in the last 6 and between 6-12 months) and visit more than 12 months ago (1-2 year, or more than 2 years).

Self-perception of oral health was based on one question: "How would you assess the health of your teeth?" Offered answers were: "excellent", "very good", "good", "average", "bad" and "poor". Because regression analysis was used, variables were dichotomized to the following: "excellent", "very good", "good" and "average" were combined into one category (good), and "bad" and "very poor" to another category (poor).

Clinical examination included the evaluation of teeth condition and presence of prosthetic restorations. It was performed by trained dentists at the Department of Restorative Dentistry and Endodontics, Faculty of Medicine in Foča with the use of artificial light, dental mirror and probe according to standards and criteria of the World Health Organization [14]. The prevalence of caries was determined by DMFT index and its components (D – decayed, M – missing, F – filled tooth). Intraexaminer repeatability was measured through coefficient kappa and it was 0.85. The analysis included third molars, and all surfaces

of teeth. The evaluation of prosthetic status of upper and lower jaw was based on the presence or absence of any kind of dentures. The respondents were classified into two groups: respondents who had at least one prosthetic restoration (partial and/or complete denture and/or fixed work) and those who did not have any prosthetic restoration.

### Statistical analysis

Statistical analysis was done using SPSS, version 19.0 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp., USA) for Windows. Data were presented as mean values and standard deviations (SD) for numerical and frequency for attributive characteristics. Differences in the self-assessment of oral health, depending on the examined variables in bivariate analysis were calculated using t-test for two independent samples and  $\chi^2$ -test. Using logistical regression the association of oral clinical variables and self-assessment of oral health was analyzed. Oral health assessed as good was chosen as reference category. Values of  $p<0.05$  were considered statistically significant in all analyzes.

### RESULTS

Socio-demographic characteristics of respondents and their habits are shown in Table 1. Bivariate analysis

**Table 1.** Distribution of socio-economic and behavioral parameters depending on self-perception of oral health  
**Tabela 1.** Raspodela socioekonomskih parametara i navika ponašanja u zavisnosti od samoprocene oralnog zdravlja

Parameter Parametar	Oral health perception (%) Procena oralnog zdravlja (%)		P
	Good Dobro	Poor Loše	
Age (years) Starost (godine)	31.13±4.90*	33.59±6.62*	0.019
Gender Pol	Male Muški	46.5	53.5
	Female Ženski	51.8	48.2
Level of education Stepen obrazovanja	High school, elementary school Srednja stručna spremja, osnovna škola	30.6	69.4
	College, university degree Viša škola, visoka stručna spremja	68.8	31.2
Employment Zaposlenje	Employed Zaposlen	58.5	41.5
	Unemployed Nezaposlen	41.0	59.0
Total household income Ukupan prihod domaćinstva	Less than two average salaries Manje od dve prosečne plate	40.7	59.3
	More than two average salaries Više od dve prosečne plate	52.5	47.5
Smoking Pušenje	Yes Da	23.9	76.1
	No Ne	65.0	35.0
Last visit to dentist Poslednja poseta stomatologu	Less than 12 months Manje od 12 meseci	54.0	46.0
	More than 12 months Više od 12 meseci	34.6	65.4

\* Values are presented as mean value ± standard deviation.

\*Vrednosti su prikazane kao srednja vrednost sa standardnom devijacijom.

**Table 2.** Distribution of oral clinical variables depending on the self-perception of oral health  
**Tabela 2.** Raspodela oralnih kliničkih varijabli u zavisnosti od samoprocene oralnog zdravlja

Variable Varijabla	Oral health assessment Procena oralnog zdravlja		P
	Good Dobro	Poor Loše	
Number of carious teeth Broj zuba sa karijesom	0.98±1.661	3.19±3063	0.000
Number of extracted teeth Broj ekstrahovanih zuba	2.92±2.484	7.27±4.378	0.000
Number of filled teeth Broj plombiranih zuba	11.37±4.356	9.67±3.852	0.022
Prosthetic restoration Protetička nadoknada	Yes Da	40.7%	59.3%
	No Ne	54.8%	45.2%
			0.295

showed that age ( $p=0.019$ ), educational level ( $p<0.0001$ ) and smoking ( $p\leq 0.0001$ ) are socio-demographic factors and habits that are associated with oral health perception (Table 1). Of the tested oral clinical variables, the number of carious, missing and filled teeth, but not prosthetic status, were significantly different in respondents who assessed their oral health as good and those who assessed their oral health as poor (Table 2).

After logistic regression analysis, variables that were found associated with oral health evaluation were number of carious ( $p\leq 0.0001$ ) and missing ( $p\leq 0.0001$ ) teeth. People with lower number of carious and missing teeth assessed their oral health as good (Table 3). The association between dental caries and missing teeth with self-perception of oral health remained significant even after adjusting for gender, age, educational level and smoking habit.

## DISCUSSION

Our study shows association between the number of carious and missing teeth and oral health perception.

There is indirect association between sociodemographic factors such as environmental factors, psychosocial factors, lifestyle and accessibility of dental care and evaluation of oral health [15]. Sociodemographic factors may also directly or indirectly affect individual's percep-

tion of oral health [15, 16]. Total household income have major impact on the assessment of oral health [17] and respondents with lower income more often evaluate their oral health as poor [17, 18]. Also, age, lower socioeconomic status and lower level of education are associated with oral health assessment as poor [19]. Similar findings were obtained in the current study. Of the tested socio-demographic characteristics significant relationship was observed between the assessment of oral health and age, educational level and smoking. Smoking may have an impact on the assessment of oral health [20] due to its effect on development of caries [21].

The analysis of individual components of DMFT index in the current study revealed significant difference in the number of carious, missing and filled teeth between those respondents who assessed their oral health as good and those who assessed their oral health as poor. Number of carious and missing teeth remained linked to the assessment of oral health after regression analysis was applied. People with lower number of carious and missing teeth assessed their oral health as good. Significant association between the number of untreated and missing teeth was recorded after inclusion of socio-demographic factors in the analysis, and specially those who have demonstrated significant impact on self-assessment in bivariate analysis. Our results are consistent with other studies which showed that likelihood of oral health assessed as poor increases with increased number of carious and missing teeth [5, 7, 10]. Possible reasons for strong association between the number of carious and missing teeth and assessment of oral health are unsatisfying appearance of mouth and teeth, reduced chewing efficiency, and need for prosthetic treatment. Higher number of restored tooth is associated with good oral health perception [5, 7], but this association was not found in the current study after inclusion of all factors in regression analysis.

Oral health perception has been associated with use of health care services and objective clinical indicators of oral health [22]. If people assess their oral health as poor or there is a specific oral problem, their health behavior can change (visits to dentist, oral hygiene), as well as oral status. Therefore, self-assessment of oral health can provide important information that will lead not only to improved promotion of oral health, but also improved health care.

**Table 3.** Non-adjusted and adjusted regression analysis for self assessment of oral health  
**Tabela 3.** Neprilagodena i prilagodena regresiona analiza za samoprocenu oralnog zdravlja

Teeth Zubi	Non-adjusted regression analysis Neprilagodena regresiona analiza				Adjusted regression analysis Prilagodena regresiona analiza			
	B	SE	(95% CI)	P	B*	SE*	(95% CI)*	P*
Carious Karijesni	0.424	0.120	1.208–1.933	<0.0001	0.454	0.140	1.198–2.071	0.001
Extracted Ekstrahovani	0.394	0.087	1.250–1.759	<0.0001	0.460	0.118	1.257–1.997	<0.0001
Filled Plombirani	-0.058	0.062	0.835–1.066	0.352	-0.057	0.073	0.818–1.091	0.438

\* adjusted for gender, age, educational level and smoking habit

B – regression coefficient; SE – standard error; CI – confidence interval

\* prilagodeno za pol, starosnu dob, stepen obrazovanja i naviku pušenja  
B – regresioni koeficijent; SE – standardna greška; CI – interval poverenja

## CONCLUSION

Number of carious and missing teeth significantly affected self-perception of oral health. Knowledge of the effects of oral clinical variables on the self-perception of oral health is of great importance to get clearer view about association between objectively and subjectively assessed oral health.

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# Uticaj oralnih kliničkih faktora na samoprocenu zdravlja usta i zuba

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## KRATAK SADRŽAJ

**Uvod** Procena sopstvenog oralnog zdravlja je jednostavan, neinvazivan i ekonomičan način prikupljanja podataka koji uzima u obzir i psihosocijalne aspekte zdravlja usta i zuba. Cilj ovog rada je bio da se utvrdi uticaj kliničkih faktora na samoprocenu stanja oralnog zdravlja osoba srednje životne dobi među stanovnicima Republike Srpske (Bosna i Hercegovina).

**Materijal i metode rada** Uzorak je činilo 126 ispitanika oba pola (34,1% muškaraca i 65,9% žena) starosti 24–54 godine. Podaci su prikupljeni na osnovu upitnika i kliničkog pregleda. Anonimni upitnik je sadržao pitanja u vezi sa sociodemografskim odlikama ispitanika. Klinički pregled je obuhvatio procenu stanja zuba i zastupljenost protetičkih nadoknada. Samoprocena oralnog zdravlja je određena na osnovu jednog pitanja.

**Rezultati** Bivarijantna analiza je ukazala na statistički značajan uticaj broja kariesnih ( $p<0,001$ ), ekstrahovanih ( $p<0,001$ ) i saniranih ( $p=0,022$ ) zuba, ali ne i protetičkog stanja na procenu oralnog zdravlja. Povezanost broja kariesnih i zuba koji nedostaju sa samoprocenom oralnog zdravlja je ostala statistički značajna i u regresionoj analizi.

**Zaključak** Broj kariesnih i zuba koji nedostaju značajno utiče na samoprocenu zdravlja usta i zuba u ispitivanoj populaciji. Poznavanje uticaja oralnih kliničkih varijabli na samoprocenu oralnog zdravlja je od velikog značaja, da bi se dobio jasniji uvid o povezanosti objektivnog i subjektivno procjenjenog oralnog zdravlja.

**Ključne reči:** procena oralnog zdravlja; karies; socioekonomski faktori

## UVOD

Za procenu zdravlja usta i zuba pojedinaca u kliničkim i epidemiološkim istraživanjima najčešće se koriste objektivni klinički pokazatelji [1]. Ovakav način procene oralnog zdravlja, pored niza prednosti, ima i svoje nedostatke, jer u obzir ne uzima psihosocijalne aspekte oralnog zdravlja i individualnu percepciju oralnog zdravlja [2]. U istraživanjima o zdravlju usta i zuba korisni podaci se mogu dobiti na osnovu individualne procene oralnog zdravlja [3]. Ova metoda, pored toga što je jednostavna za primenu, ekonomski je prihvatljiviji način prikupljanja podataka o oralnom zdravlju populacije u odnosu na klinička ispitivanja [4, 5, 6]. U poslednje vreme samoprocena zdravlja usta i zuba vrši se na osnovu jednog pitanja [6].

U brojnim istraživanjima uočena je povezanost samoprocene oralnog zdravlja, određene na osnovu jednog pitanja, i brojnih kliničkih pokazatelja zdravlja usta i zuba [4, 7, 8, 9, 10]. Osobe s većim brojem kariesnih i ekstrahovanih zuba najčešće procenjuju svoje oralno zdravlje kao loše [5, 7, 10], dok oni s većim brojem saniranih zuba smatraju da je njihovo oralno zdravlje dobro [5, 7]. Oralno zdravlje procenjeno kao loše povezuje se i s visokim vrednostima indeksa KEP, malokluzijom, zuboboljom i bolom temporomandibularnog zglobova, protetičkim statusom i potrebama za stomatološkim lečenjem [5, 7, 11, 12].

U istraživanju zdravlja stanovnika u regionu (Republika Srbija) navodi se da skoro polovina odraslog stanovništva (45,5%) procenjuje stanje svojih zuba i usne duplje kao dobro ili veoma dobro [13]. Takođe, rezultati ukazuju da je procena oralnog zdravlja povezana s ukupnim prihodima domaćinstva, stepenom obrazovanja, polom i područjem u kojem ispitanici žive [13].

Cilj ovog rada je bio da se utvrdi uticaj kliničkih faktora na procenu stanja oralnog zdravlja osoba srednje životne dobi koji žive na teritoriji Republike Srpske (Bosna i Hercegovina).

## MATERIJAL I METODE RADA

Studija preseka izvedena je od januara do jula 2013. godine na Odeljenju za bolesti zuba i endodonciju Medicinskog fakulteta u Foči, Univerziteta u Istočnom Sarajevu, u Republici Srpskoj (RS). Uzorak je činilo 126 ispitanika oba pola (34,1% muškaraca i 65,9% žena) starosti od 24 do 54 godine (prosečna starost bila je  $32,36 \pm 5,93$  godine). Ciljna populacija odabrana je metodom slučajnog izbora od osoba koje su se prvi put javile na Odeljenje za bolesti zuba i endodonciju Medicinskog fakulteta u Foči. Nakon upoznavanja s ciljevima i očekivanim ishodima studije, svi ispitanici su potpisali pristanak za učešće u istraživanju.

Podaci su prikupljeni na osnovu upitnika i kliničkog pregleda. Anonimni upitnik je sadržao pitanja u vezi sa sociodemografskim odlikama ispitanika: starost, pol, stepen obrazovanja (završena osnovna škola, srednja škola ili viša škola, završen fakultet i više), zaposlenje (zaposlen s punim ili nepunim radnim vremenom, nezaposlen), ukupan mesečni prihod svih članova domaćinstva (manje od jedne prosečne plate u RS, 1–2 prosečne plate u RS, 2–3 prosečne plate u RS, više od četiri prosečne plate u RS – u periodu kada je rađeno istraživanje), navika pušenja u poslednjih godinu dana (da, ne) i vreme proteklo od poslednje posete stomatologu (poseta u poslednjih šest meseci, 6–12 meseci, 1–2 godine i više od dve godine). Ispitivane varijable su radi statističke analize dihotomizirane. Stepen obrazovanja je klasifikovan u dve kategorije: završena osnovna i/ili srednja škola i završena viša škola, fakultet i više; zaposlenje na: zaposlen i nezaposlen; ukupan prihod svih članova domaćinstva: do dve prosečne plate u RS i prihod veći od dve prosečne plate. Poseta stomatologu u poslednjih 12 meseci je dihotomizirana na posetu u okviru 12 meseci i posetu od koje je prošlo više od 12 meseci.

Procena oralnog zdravlja utvrđena je na osnovu pitanja: „Kako biste ocenili zdravlje vaših zuba?“, a ponuđeni odgovori

su bili: „Odlično“, „Veoma dobro“, „Dobro“, „Prosečno“, „Loše“ i „Veoma loše“. Zbog regresione analize, varijabla je dihotomizirana, tako da su odgovori „Odlično“, „Veoma dobro“, „Dobro“ i „Prosečno“ svrstani u jednu kategoriju (Dobro), a odgovori „Loše“ i „Veoma loše“ u drugu (Loše).

Klinički pregled je obuhvatilo procenu stanja zuba i zastupljenost protetičkih nadoknada, a obavio ga je obučeni stomatolog na Odeljenju za bolesti zuba i endodonciju Medicinskog fakulteta u Foči uz primenu veštačkog osvetljenja, stomatološkog ogledalceta i sonde prema standardima i kriterijumima Svetske zdravstvene organizacije [14]. Rasprostranjenost karijesa određena je pomoću indeksa KEP i njegovih komponenti (K – karijesni zub, E – ekstrahovan zub, P – plombiran zub). Vrednost unutar istraživačke saglasnosti, merena koeficijentom kapa ( $\kappa$ ), bila je 0,85. Analiza je obuhvatila i treće molare, a prilikom pregleda ispitivana je svaka površina zuba. Procena protetičkog stanja gornje i donje vilice izvršena je na osnovu postojanja ili izostanka bilo koje vrste protetičke nadoknade, pa su ispitanci svrstani u dve grupe: ispitanci koji imaju bar jednu protetičku nadoknadu (parcijalna proteza i/ili totalna proteza i/ili fiksna nadoknada) i oni koji je nemaju.

## Statistička analiza

Statistička analiza je urađena u statističkom programu SPSS, verzija 19.0 (*IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp, USA*) za Windows. Podaci su prikazani u obliku srednjih vrednosti i standardnih devijacija za numerička obeležja i učestalosti za atributivna obeležja. Razlike u samoproceni oralnog zdravlja u zavisnosti od ispitivanih varijabli su u bivariatnoj analizi određene primenom Studentovog t-testa za dva nezavisna uzorka i  $\chi^2$ -testa. Primenom logističke regresije ispitana je povezanost oralnih kliničkih varijabli i samoprocene zdravlja usta i zuba. Oralno zdravlje procenjeno kao dobro je izabrano za referentnu kategoriju. Vrednosti  $p < 0,05$  smatrane su statistički značajnim u svim analizama.

## REZULTATI

Sociodemografske odlike ispitnika i navike prikazane su u tabeli 1. Bivariatna analiza je pokazala da su starosna dob ( $p=0,019$ ), stepen obrazovanja ( $p<0,0001$ ) i pušenje ( $p\leq0,0001$ ) sociodemografski faktori i navike koji su značajno povezani s procenom oralnog zdravlja (Tabela 1). Od ispitivanih oralnih kliničkih varijabli, broj karijesnih, ekstrahovanih i saniranih zuba, ali ne i protetički status, značajno se razlikuje između ispitnika koji su svoje oralno zdravlje procenili kao dobro i onih koji su oralno zdravlje procenili kao loše (Tabela 2).

Nakon logističke regresione analize varijable koje su ostale povezane s procenom oralnog zdravlja su broj karijesnih ( $p\leq0,0001$ ) i ekstrahovanih zuba ( $p\leq0,0001$ ). Osobe s manjim brojem karijesnih i ekstrahovanih zuba svoje oralno zdravlje procenile su kao dobro (Tabela 3). Povezanost broja karijesnih i zuba koji nedostaju sa samoprocenom oralnog zdravlja ostala je statistički značajna i posle prilagođavanja za pol, starosnu dob, stepen obrazovanja i naviku pušenja.

## DISKUSIJA

Ova studija pokazuje uticaj broja nesaniranih i zuba koji nedostaju na procenu oralnog zdravlja. Uticaj sociodemografskih faktora na procenu zdravlja usta i zuba indirektno je povezan s faktorima sredine, psihosocijalnim faktorima, načinom života i dostupnosti usluga stomatološke zdravstvene zaštite [15]. Osim toga, sociodemografski faktori mogu direktno ili indirektno uticati na odnos pojedinca ka oralnom zdravlju [15, 16]. Ukupni prihodi domaćinstva imaju veliki uticaj na procenu oralnog zdravlja [17], a ispitanci s manjim ukupnim prihodima mnogo češće svoje zdravlje ocenjuju kao loše [17, 18]. Takođe, starost, niži socioekonomski status i niži stepen obrazovanja povezuju se s lošijom procenom oralnog zdravlja [19]. Slični nalazi su dobiveni i u ovom istraživanju. Od ispitivanih sociodemografskih obeležja ispitnika, značajna povezanost je uočena između starosne dobi, stepena obrazovanja, pušenja i procene oralnog zdravlja. Navika pušenja može uticati na procenu zdravlja usta i zuba [20], jer postoje nalazi kojima se pušenje dovodi u vezu s nastankom karijesa [21].

Analizom pojedinačnih komponenata indeksa KEP u ovom istraživanju uočena je statistički značajna razlika u broju karijesnih, ekstrahovanih i saniranih zuba između ispitnika koji su svoje oralno zdravlje procenili kao dobro u odnosu na one koji su oralno zdravlje procenili kao loše. Broj karijesnih i eks-trahovanih zuba je ostao povezan s procenom oralnog zdravlja i nakon regresione analize. Osobe sa manjim brojem karijesnih i ekstrahovanih zuba oralno zdravlje su procenile kao dobro. Značajna povezanost broja nesaniranih i zuba koji nedostaju je zabeležena i posle uključivanja sociodemografskih faktora u analizu, i to onih koji su pokazali statistički značajan uticaj na samoprocenu u bivariatnoj analizi. Ovi rezultati su u skladu s nalazima drugih studija gde se verovatnoča da se oralno zdravlje proceni kao loše uvećava s povećanjem broja karijesnih i ekstrahovanih zuba [5, 7, 10]. Mogući razlozi povezanosti broja karijesnih i ekstrahovanih zuba i procene oralnog zdravlja mogu biti nezadovoljstvo izgledom usta i zuba, smanjenje žvačne efikasnosti, kao i potreba za protetičkim lečenjem. Veći broj saniranih zuba se dovodi u vezu s procenom oralnog zdravlja [5, 7], ali ta povezanost nije nađena u ovom istraživanju posle uključivanja svih faktora u regresionu analizu.

Procena oralnog zdravlja je povezana s korišćenjem usluga zdravstvene zaštite i stvarnim kliničkim pokazateljima oralnog zdravlja [22]. Ukoliko ljudi zdravlje svojih usta i zuba procenjuju kao loše ili ukoliko postoji određeni oralni problem, kao rezultat može doći do promena u zdravstvenom ponašanju pojedinca (poseta stomatologu, održavanje oralne higijene), ali i do promena u njihovom oralnom stanju. Stoga, samoprocena oralnog zdravlja može pružiti važne informacije koje će dovesti ne samo do poboljšanja promocije oralnog zdravlja, već i una-predjenja zdravstvene zaštite.

## ZAKLJUČAK

Broj karijesnih i zuba koji nedostaju značajno utiče na samoprocenu oralnog zdravlja u ispitivanoj populaciji. Poznavanje uticaja oralnih kliničkih varijabli na samoprocenu oralnog zdravlja od velikog je značaja radi dobijanja jasnijeg uvida o povezanosti objektivnog sa subjektivno procenjenim zdravljem usta i zuba.

## Da li ste pažljivo čitali radove?

1. Protetički status utiče na samoprocenu oralnog zdravlja pacijenta?
  - a) Da
  - b) Ne
  - c) Ponekad
2. U komparativnoj radiološkoj studiji marginalna kost je procenjivana oko:
  - a) 17 implantata
  - b) 29 implantata
  - c) 32 implantata
3. Marginalna mikropropustljivost je proveravana kod:
  - a) kalcijumaluminatnih sistema
  - b) kalcijumsilikatnih sistema
  - c) kalcijumfosfatnih sistema
4. Efikasnost instrumenta XP-endo Finisher je proveravana:
  - a) SEM analizom
  - b) svetlosnim mikroskopom
  - c) EDS analizom
5. Broj karijesnih zuba značajno utiče na samoprocenu oralnog zdravlja?
  - a) Da
  - b) Ne
  - c) Ponekad
6. U proceni kosti oko zubnih implantata rađena je komparativna:
  - a) radiološka studija
  - b) epidemiološka studija
  - c) hirurška studija
7. Marginalna mikropropustljivost novosintetisanih nanostruktturnih biomaterijala je proveravana testom:
  - a) prodora boje
  - b) prodora bakterija
  - c) prosvetljavanja
8. U proceni sopstvenog oralnog zdravlja uzorak je činilo:
  - a) 65 ispitanika
  - b) 35 ispitanika
  - c) 126 ispitanika
9. Intraoralna radiografija i digitalna ortopantomografija korišćene su kod:
  - a) 29 pacijenata
  - b) 42 pacijenta
  - c) 17 pacijenata
10. Najmanji linearni prodror boje je izmeren kod:
  - a) MTA
  - b) materijala CS
  - c) materijala HA-CS
11. Za ispiranje kanala korena tokom instrumentacije BioRaCe rotirajućim instrumentima korišćen je:
  - a) EDTA
  - b) NaOCl
  - c) fiziološki rastvor
12. Digitalna ortopantomografija se može koristiti za marginalnu procenu kosti oko implantata?
  - a) Da
  - b) Ne
  - c) Ponekad
13. SEM analiza kvaliteta čišćenja zidova kanala je urađena na:
  - a) 20 ekstrahovanih zuba
  - b) 30 ekstrahovanih zuba
  - c) 50 ekstrahovanih zuba
14. Kao kontrolni materijal u ispitivanjima marginalne propustljivosti korišćen je:
  - a) kalcijum-hidroksid
  - b) kalcijum-aluminat
  - c) MTA

15. Saglasnost u merenjima između različitih istraživača u proceni kosti oko implantata bila je:
  - a) umerena
  - b) dobra
  - c) vrlo dobra
16. Postojanje razmaznog sloja na zidovima kanala korena posle primene instrumenta XP-endo Finisher bilo je:
  - a) statistički značajno manje u odnosu na kontrolu
  - b) statistički značajno veće u odnosu na kontrolu
  - c) identično kontrolnoj grupi
17. Marginalna mikropustljivost je proveravana kod 34 ekstrahovana:
  - a) sekutića
  - b) premolara
  - c) molara
18. Instrumentacija zuba kod kojih je proveravan kvalitet čišćenja kanala korena je urađena setom instrumenata:
  - a) K3
  - b) PROFILE
  - c) BioRaCe
19. Procena sopstvenog oralnog zdravlja je:
  - a) jednostavan način prikupljanja podataka
  - b) neekonomičan način prikupljanja podataka
  - c) invazivan način prikupljanja podataka
20. Mikropustljivost materijala HA-CS je bila:
  - a) značajno veća u odnosu na materijal CS
  - b) jednaka kao i kod materijala CS
  - c) značajno manja u odnosu na materijal CS

**Odgovore slati na email adresu Uredništva časopisa „Stomatološki glasnik Srbije“. Tačni odgovori na pitanja će se vrednovati u skladu s Pravilnikom o kontinuiranoj medicinskoj edukaciji zdravstvenih radnika.**

## Dental links / Stomatološki linkovi

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**MEDLINE**

[http://www.nlm.nih.gov/databases/databases\\_medline.html](http://www.nlm.nih.gov/databases/databases_medline.html)

**OPERATIVE DENTISTRY**

<http://www.jopdent.org/journal/journal.php>

**JOURNAL OF CONTEMPORARY DENTAL PRACTICE**

<http://thejcdp.com/>

**JOURNAL OF THE AMERICAN DENTAL ASSOCIATION (JADA)**

<http://jada.ada.org/>

**BRITISH DENTAL JOURNAL**

<http://www.nature.com/bdj/index.html>

**JOURNAL OF DENTAL RESEARCH**

<http://www.iadr.com/>

**CANADIAN MEDICAL ASSOCIATION JOURNAL (CMAJ)**

<http://www.cmaj.ca/>

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