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Contents / Sadržaj

„Može li se neko ponašati kao pametan?
Može, ako je pametan.
A može li se neko ponašati kao lud?
Može, pod uslovom da je lud.“
Duško Radović

Prošla je još jedna „istorijska godina“ u kojoj je podivljala propaganda simuliranu stvarnost podigla na pijedestal, a svakodnevicu zaodenula etikom primitivizma. Narod omađijan iluzijama i besmislicama iz „kreativnog centra za obmane i laži“ svekoliki ambijent kiča doživljava kao vrednosni sunovrat i jedini izvesni „napredak u nazadovanju“.

Narcisoidni hvalospevi i „prostačka uniženja“ uvijena jeftinim staniolom bez osećaja „transfera blama“ pršte ko novogodišnja jelka i zamagljuju aktuelnu realnost. Besprizorni kodeks u kome „neki“ mogu sve i ambijent estrade u kome „džiberska estetika“ nadkriljuje svaku normalnost i istinu, kreiraju vrednosni put u bezizlaz.

U šizofrenoj situaciji koju živimo, kroz svaku poru našeg tela se neprestano sa „kontaminiranih“ medija ubrizgavaju neukus, laž, mržnja i strah. U takvoj „diplomatiji poniženja“ i politici „no kompas“ izlaz je uvek izvestan, ali cilj uvek promašen.

Prezir prema istini je institucionalizovan, a „institucije razorene“ i unižene jer u njima sede mediokriteti sa sumnjivim diplomama i plagiranim doktoratima. Najprestižnija kvalifikacija za svaki izbor je partijska pripadnost, a glavni kvalitet je upravo srazmeran stepenu poltronstva (čitaj lojalnosti), odnosno stepenu sopstvenog uniženja prema „preučenom“.

Vulgarne tekovine „naloga sveznajućih“ i izvitoperene manipulacije uokvirene „filovanom istinom“ (koja treba da zasladi prostotu) bujaju iz beskrajne praznine i uz hvalospeve tvorcu svega i ničega kreiraju društvenu zbilju „pobrkanih lončića“.

Raskošna čitanka naše svakodnevice, obogaćena besmislenim rijalitijima u svakom segmentu bitisanja, izopštila je kulturu i znanje iz svakog plana za sadašnjost i budućnost. Ljudi huliganske svesti koji se ničega ne stide „poganim jezikom“ nude „ideologiju propadanja“ sa mislima i idejama koje dopiru „samo do sutra“, a estetiku neukusa i bahatosti kao neprikosnoven model društvene stvarnosti.

Da li pobedonosni poraz može biti opcija opstanka?

Beg iz svekolikog posrnuća je uslov svih uslova. Sveprisutna apatičnost je posledica izneverenih očekivanja, niskog standarda i agresivne propagande koja kontinuirano seje mržnju i dezinformacije i agresivno „zaglupljuje i iritira“.

Znanje, moralni integritet i nadasve čestitost učenih i obrazovanih mora biti iskorak iz „trenutka koji predugo traje“ i iskra koja će osvetliti „tunel besmisla“ u kome uporno stojimo. Eliminacija nekulture kao nametnutog modela ponašanja mora nestati iz „kreature jednoumlja“, a borba za istinu ostati jedina „sveta destinacija“ za izvesniju budućnost.

Ovaj urednički komentar ću završiti onako kako sam i počeo i opet citatom velikog i premudrog Duška Radovića: „Samo je laž rečita. Istina je kratka i jasna“. Njegova hrabrost i vera, nadahnuta mudrošću koja pleni, oblikovala je kulturu jednog vremena i utrla put kritičnom sudu i odgovornom stvaranju u „vremenu teškom“ i prepunom strahova.

Prof. dr Slavoljub Živković

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Serbian Dental Journal, vol. 69, N° 4, 2022 | 151

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Histological evaluation of periapical tissue response after implantation of experimental nanostructured calcium aluminate cement – *in vivo* study

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SUMMARY

Introduction ALBO-HA (Vinca, Serbia) is new nanostructured calcium aluminate cement, synthesized as a potential alternative to mineral trioxide aggregate (MTA). The purpose of this study was to compare the periapical tissue response to new nanostructured calcium aluminate cement ALBO-HA with white MTA (MTA Angelus, Londrina, Brasil) as root-filling material into the root canal of sheep's teeth.

Material and methods Sixteen mandibular incisors from two 24-month-old sheep were used. Root canals were prepared and filled with ALBO-HA (group 1) or MTA (group 2) (eight teeth per group in each sheep). After four weeks the animals were sacrificed, teeth with surrounding tissue removed, and histologically processed. The sections were analyzed for determination of scores of the following parameters: periapical inflammatory infiltrate, newly mineralized apically formed tissue, apical periodontal ligament space thickness and resorption of dentin, cementum and bone. Data were analyzed statistically (α=0.05) using Mann-Whitney U test.

Results Slight inflammatory infiltrate was observed in 75.0% and 62.5% of samples in the group 1 and group 2, respectively ($p>0.05$). Partial newly mineralized apically formed tissue was found in 75.0% of samples in the group 1, and 87.5% of samples in group 2 ($p>0.05$). No significant difference was noted for periodontal ligament space thickness ($p>0.05$). Resorption of dentin, cementum or bone was not observed.

Conclusion ALBO-HA and white MTA Angelus had a similar effect on inflammation, newly mineralized apical tissue formation and thickness of periodontal ligament space after root canal filling under the present experimental conditions.

Keywords: calcium aluminate; MTA; sheep; periapical tissue response

INTRODUCTION

In the past two decades, mineral trioxide aggregate (MTA) and calcium silicate materials represent the "gold standard", as materials used for a large number of indications in endodontics. Biocompatibility, bioactivity, and sealing ability of MTA made it ideal for use as a root-end filling material, vital pulp therapy, root resorption, treatment of teeth with incomplete apexification, regenerative endodontic procedures and apical plug. However, some of its negative properties such as long setting times, difficulty with manipulating, low-flow capacity and potential for tooth discoloration. Physical and chemical properties of MTA are affected in an acidic environment, which leads to increasing efforts to create an alternative endodontic cement [1, 2].

Technological progress in recent years has led to synthesis of nanostructured materials for use in endodontics. Using the method of nanomodification of existing commercial calcium silicate cements, some researchers tried to improve their properties. What distinguishes nanomaterials from conventional ones is the greater difference between size and mass, as well as the surface reactivity of the particles. Smaller particles, in addition to having high reactivity, promote hydration of material, which favorably affects its faster bonding and hardening [3]. Saghiri et al. reported that nanomodified MTA showed higher microhardness, lower solubility in acidic and basic media compared to MTA, as well as a positive tissue response in an animal model. Also, the addition of 2% tricalcium aluminate to nano MTA affected the improvement of osteoinductive characteristics [4, 5, 6]. Preliminary studies of recently synthesized nanostructured calcium silicate materials indicated the absence of toxicity, good dentinogenic and osteogenic potential [7, 8, 9].

Calcium aluminate-based biomaterials for use in endodontics have been investigated in the last decade and the available scientific literature provides limited data. Calcium aluminate cement Endobinder (Binderware, São Carlos, SP, Brazil) has shown good biological properties, while physical properties and shear bond strength to root dentin are comparable to other commercial materials based on calcium silicate [10, 11, 12]. *In vivo* studies that investigated the effect of calcium aluminosilicate material

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(Quick-Set) and white MTA found that these materials have a similar effect on dentin and cementum formation as well as periapical tissue healing in dogs after pulpotomy and application in root canals [13]. Recently, a new nanostructured cement based on calcium aluminate (ALBO-HA, Vinča, Serbia) was developed in an attempt to use nanotechnology to synthesize a material with improved mechanical characteristics compared to MTA, without impairing biological properties. The material is a mixture of calcium aluminate in combination with calcium carbonate and barium sulfate for radiopacity. It was synthesized by the innovative sol-gel method and self-propagating combustion waves at high temperature. The manufacturer states that this method of synthesis allows for obtaining a specific nanostructure of particles with high activity and improved bonding time through accelerated hydration. Also, the addition of rheological modifiers to the mixture extended the working time and improved the manipulation ability [14]. Initial trials for ALBO-HA indicated similar biocompatibility to MTA [14, 15].

In addition to biocompatibility, one of the basic requirements for endodontic biomaterials that come into direct contact with vital pulp and periodontal tissue for a long period of time is to elicit a positive response and induce histological repairs. Certain components of the material can act as toxins and damage the cells of the periodontium. As a consequence, tissue damage or a prolonged repair process may occur.

The aim of this study was to evaluate the histological response of the periapical tissue after the application of an experimental nanostructured cement based on calcium aluminate (ALBO-HA) in the root canals of sheep teeth.

MATERIAL AND METHOD

The study was approved by the Ethical Commitete of Faculty of Medicine Foca. Experimental research was conducted in cooperation with Faculty of Veterinary Medicine, University of Belgrade. The study was conducted in accordance with the International standards ISO 7405 and ISO 10993-2 [16, 17]. Sixteen mandibular incisors were treated in two Wirtemberg sheep, aged 24 months, on average 50 kg in weight. During the implementation of the experiment, the sheep were kept and fed at a farm with a controlled diet and daily care. Premedication was done with Xylazine (2% Xylazin, CP, Pharma, Bergdorf, Germany) 0.2 mg/kg. After that the animal was introducted in general anesthesia using Ketamine Hydrochloride 10% 7.5 mg/kg i.v. The surgical procedure was performed in aseptic conditions. The teeth were cleaned with 2% chlorhexidine gluconate and class I cavities were prepared on the oral surfaces of mandibular incisors, using round diamond burs. After trepanation, coronal pulp tissue removed using sterile, round, carbide burs. The radicular pulp was removed with pulp extirpator and root canals were instrumented with K files #15-40 (Dentsply Maillefer, Ballaigues, Switzerland) using Crown-down technique, with irrigation with 1.0 % sodium hypochlorite solution. The apical cementum layer was perforated with the sequential use of a size #15-25 K file, in order to create a standardized apical opening for material contact with periapical tissue. A new set of endodontic instruments were used for each animal. After biomechanical preparation, final irrigation was performed with 5 ml 1.0 % sodium hypochlorite and 17.0% EDTA solution. The root canals were dried by suction and sterile paper points and filled with freshly mixed materials. Experimental, nanostructured cement ALBO-HA, was mixed with distilled water in 2:1. Control material, Mineral trioxide aggregate (White MTA, Angelus ® Soluões odontológicas, Londrina, Brazil) was mixed in a 3:1 powder to water ratio, according to manufacturers' instructions. The ALBO-HA was implanted in the four right mandibular incisors, while MTA was implanted in the four left mandibular incisors of the two animals. Into the root canals, materials were applied with a lentulo spiral and compacted by a hand compactor. All cavities were restored with glass-ionomer cement (GC Fuji VIII, GC Corporation, Tokyo, Japan). Postoperatively, the animals were given an analgesic dose of butorphanol (Butorfanol,10mg/ml, Richter Pharma AG Austria), 0.1 mg/kg body weight subcutaneously, for the next three days. After four weeks, the animals were sacrificed by prolonged general anesthesia with Ketamine i.v. and Potassium Chloride intracardiac.

After the removal of soft tissues and separation of the upper and lower jaw, the treatedteeth were cut with a diamond disk and fixed in 10% formalin. Following the decalcification, the tissue was fixed in semi-enclosed benchtop tissue processor (Leica TP1020, Leica Biosystems, Wetzlar, Germany) and then embedded in paraffin blocks. Serial tissue sections 5 μm thick (eight from each sample) were cut from the paraffin blocks. The slides were stained in haematoxylin and eosin, following the standard procedure. The microscopic slides were examined by optical microscopy, using Olympus Cell-B software package and Olympus 5 microscope at magnifications of ×10, ×40, and ×100. The following parameters for histological evaluation of periapical tissue response were evaluated: A. periapical inflammatory infiltrate: absent, slight, moderate, and severe; B. newly mineralized apical formed tissue: complete, partial, thin layer and absent; C. the apical periodontal ligament thickness: normal, slightly increased, moderately increased, and severely increased; D. cementum resorption: absent and present; E. dentin resorption: absent and present; F. bone tissue resorption: absent and present [18].

The statistical analysis was made using the SPSS 20.0 (IBM Corp., Armonk, NY, USA). Statistical analysis of these histologic parameters was performed using the Mann-Whitney U test with a significance level of $P = .05$.

RESULTS

The results of the histological analysis are shown in table 1. In 6 samples filled with ALBO-HA, slight inflammation was noted in the area of the apex, while in 2 samples moderate inflammation was observed. slight inflammation

Table 1. Histological analysis of periapical tissue after canal root filling for each material
Tabela 1. Histološka analiza periapikalnog tkiva posle punjenja korenskih kanala za oba materijala

	ALBO-HA	MTA	p value
	n (%)	n (%)	
Inflamation Zapaljenje			
Absent Bez zapaljenja	0 (0)	0 (0)	> 0.05
Slight Blago	6 (75)	5 (62.5)	
Moderate Umereno	2 (25)	3 (37.5)	
Severe Teško	0 (0)	0 (0)	
Newly calcified apical formed tissue Novostvoreno kalcifikovano tkivo			
Complete Kompletno	0 (0)	0 (0)	> 0.05
Partial Parcijalno	3 (37.5)	2 (25)	
Thin layer Tanak sloj	3 (37.5)	5 (62.5)	
Absent Odsutno	2 (25)	1 (12.5)	
Periodontal ligament space Širina periodontalnog ligamenta			
Normal Normalna	2 (25)	1 (12.5)	> 0.05
Slightly increased Blago povećana	4 (50)	6 (75)	
Moderately increased Umereno povećana	2 (25)	1 (12.5)	
Severely increased Izrazito povećana	0 (0)	0 (0)	
Dentin resorption Resorpcija dentina			
Absent Odsutna	8 (100)	8 (100)	> 0.05
Present Prisutna	0 (0)	0 (0)	
Cementum resorption Resorpcija cementa			
Absent Odsutna	8 (100)	8 (100)	> 0.05
Present Prisutna	0 (0)	0 (0)	
Bone resorption Resorpcija kosti			
Absent Odsutna	8 (100)	8 (100)	> 0.05
Present Prisutna	0 (0)	0 (0)	

n – number of samples
n – broj uzoraka

was observed in 5 root samples filled with MTA, and moderate inflammation in 3 samples. Partially calcified tissue, as well as a thin layer of calcified tissue, were observed in 3 samples of 1st group, while in the 2nd group of samples, the formation of partially calcified tissue was observed in 2 samples, that is, in 2 samples a thin layer of calcified tissue was observed. The periodontal ligament space thickness was slightly increased in half of the samples of group 1, that is, in 75% of the samples of group 2. Dentin, cementum, and alveolar bone resorptions were not recorded in any sample for both tested materials. Statistical analysis of the obtained data did not reveal any significant difference between the examined groups in relation to the observed parameters.

DISCUSSION

Unlike *in vitro* tests on cell cultures, research conducted on experimental animals provides better data on the biocompatibility of materials, as well as different forms of the organism's biological response to the tested material [19]. In *in vivo* studies proteins, tissue fluids and immune system factors can reduce the toxic effect of the material [20]. The histological reaction of soft tissues to a biomaterial is a frequently used method for assessing biocompatibility as well as tissue irritation caused by the material. Wirtemberg sheep were used as an animal model in this study. The advantage of larger animal models for dental research lies in the fact that they can be more relevant, as surgical procedures can be performed using identical clinical instruments used on human teeth [21]. Examination of the anatomy of sheep teeth showed that the length of the roots, the thickness of the dentin and the diameter of the apical foramen are comparable to the same structures on human teeth. The 2-year age of the animals was chosen due to the fact that at this age a larger number of teeth can be used for research, as well as the diameter of the apical foramen of 1 mm width and more can simulate teeth with an open apex [22]. MTA is characterized by high biocompatibility, osteoinductive properties, slow release of Ca^{2+} ions and alkaline pH, as well as exceptional hydrophilicity, which enables use in clinical conditions in a humid environment [1, 2]. For the reasons stated before, MTA was used, in this study, as a control material.

The results of the study showed that the inflammatory reaction of the periapical tissue after the implementation of the tested materials was assessed as mild in the largest number of samples of both groups and is in accordance with the results of previous research, in which materials of similar chemical composition were used and applied to the root canals of experimental animals. Although there was no statistically significant difference in the intensity of inflammation between the tested materials, calcium aluminate produced a slightly lower inflammatory response. Continuous calcified tissue was not observed, while the formation of a thin layer of discontinuous calcified tissue with foci of vascular fibroblastic proliferation was observed in the majority of samples of examined materials in the area of the root apex. The appearance of tissue formed in this way with mild inflammation in the short time interval of observation used in this research represents a positive result and confirmation that the tested materials have inductive potential. The assumption is that over time there could be further mineralization and the formation of regular continuous mineralized tissue with the disappearance of fibroblastic foci. Both investigated materials

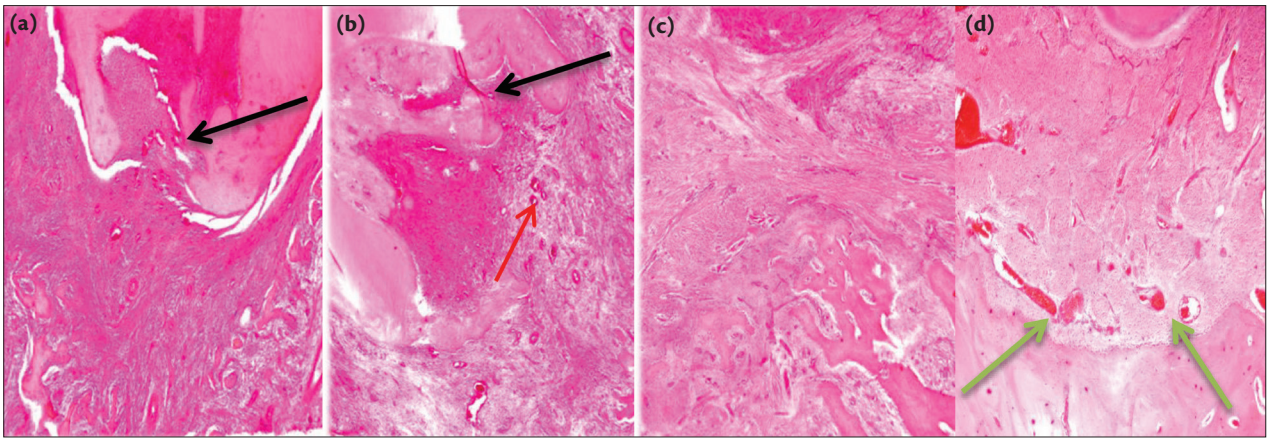

Figure 1. Material ALBO-HA
(a) Discontinuous newly formed calcified tissue of the root apex (black arrow), Mesenchymal cells with osteoblastic differentiation on the periphery of the calcified tissue
(b) thin layer of calcified tissue with connective vascular tissue, Slight inflammatory reaction of root apex (red arrow)
(c) No significant vital reaction of the bone tissue is observed in the area root apex, (d) chronic proliferative inflammation of a moderate intensity with signs of angiogenesis and acute hyperemia of the root apex (green arrows) (HE ×40).
Slika 1. Materijal ALBO-HA
(a) Na preparatu se u predelu apeksa zuba uočava hipercelularno diskontinuirano novostvoreno, kalcifikovano tkivo (crna strelica). U neposrednoj okolini uočavaju se mezenhimalne ćelije sa osteoblastnom diferencijacijom.
(b) Tanak sloj kalcifikovanog tkiva prožetog fokusima vezivno-vaskularnog tkiva. Uočava se blaga inflamatorna reakcija sa elementima hroničnog zapaljenja (crvena strelica).
(c) Ne uočava se značajna vitalna reakcija koštanog tkiva u predelu apeksa zuba.
(d) Hronično proliferativno zapaljenje umerenog intenziteta u predelu apeksa sa znacima neoangiogeneze i akutne hiperemije (zelene strelice) (HE, ×40).

belong to the group of bioactive materials characterized by the release of calcium ions during binding. In the process of hydration of calcium aluminate cement, calcium aluminate (CA) hydrate and aluminium hydroxide hydrate are formed. The release of Ca^{2+} ions is the result of the decomposition of CA hydrate, whose decomposition during the hydration process leads to the release of $Al(OH)_4$ and OH^- ions [14]. The continuous release of these biologically active ions induces the formation of calcified tissue, regulates the proliferation, differentiation and mineralization of cells. Calcium-releasing materials can also induce the proliferation of periodontal fibroblasts osteoblasts and cementoblasts [23, 24]. Due to the biological decomposition of materials in contact with tissue fluids, the released ions create an alkaline environment. On the other hand, in an alkaline environment, the neutralization of lactic acid released from osteoclasts occurs. In this way, the dissolution of the mineral components of dentin is prevented. The alkaline environment leads to the activation of alkaline phosphatase, which plays a significant role in the processes of creating hard dental tissues. Calcium aluminate cement was found to stimulate the expression of RUNX2, alkaline phosphatase, bone sialoprotein and osteopontin which are biochemical markers of mineralization. The RUNX2 gene encodes a transcription factor that plays a key role in the differentiation of pluripotent mesenchymal cells into osteoblasts [25]. Also, it was confirmed that the nanostructured surface of the material affects the behavior and activity of cells in terms of increased osteoblastic adhesion, proliferation and differentiation [26].

The research results for ALBO-HA cannot be directly compared with those from other studies due to the lack of relevant literature, because it is a new material whose application in endodontics is still at the level of preclinical and *in vivo* experiments on animals. However, the induction of mineralized tissue after the application of calcium aluminate-based materials to the dental pulp and root canal of experimental animals is consistent with the results of other studies [13, 27]. Kramer et al. investigated pulp inflammatory reaction, dentin bridge formation in rats after pulpotomy with calcium aluminosilicate cement (Quick-Set). ProRoot MTA and MTA Plus were used as control materials. The inflammatory response of the covered pulp measured by the quantification of inflammatory cytokines, interleukins IL-1α and IL-1β was approximately the same in all three treated materials. Dentin bridges were observed already 30 days after pulpotomy in all materials, while pulp vitality was preserved even after 60 days [28]. In a study by Kohout et al. it was determined that Quick set and white MTA after apicotomy and application to the roots of Beagle dogs had a similar effect on tissue healing promoting regeneration, periodontal ligament formation and cement deposition on the periodontal side of the material [13]. In a more recent study, Walsh et al. investigated the dentinogenic and osteogenic potential of modified variants of the materials used in the previous two mentioned studies in contact with the pulpal and periradicular tissue of Beagle dogs. After an observation period of 90 days, healing of the pulp and periapical tissue with the formation of a dentine bridge and cementum deposition was reported under both materials (Quick-Set 2 and NeoMTA plus) [29].

Calcium aluminate cement synthesized for use in endodontics has shown good results in the available literature in terms of biocompatibility after subcutaneous and intraosseous implementation in experimental animals

[10]. Moraes et al. indicated the possibility of using calcium aluminate as a scaffold and biomembrane in bone regeneration [30]. The biocompatibility of nanostructured calcium aluminate with the same composition as the material used in this research was examined after subcutaneous implementation in the subcutaneous tissue of rats. After observation periods of 7, 15 and 30 days, the mutual relationship between inflammation and the thickness of the fibrous capsule was observed. It was observed that with the reduction of inflammation during the observation period, there is an increase in the thickness of the fibrous capsule around the implemented materials, which indicates a good tissue tolerance to these materials [31].

CONCLUSION

Using nanostructured ALBO-HA and MTA in this study, it was observed that both materials cause a similar inflammatory effect and ability to induce calcified tissue after 30 days on sheep teeth. The favorable biological response of the tissue after the application of the experimental calcium aluminate cement represents a good basis for its further testing in *in vivo* conditions and possible modifications in the composition in order to improve its physical and biological characteristics.

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Histološka analiza reakcije periapikalnog tkiva posle implantacije eksperimentalnog nanostrukturnog cementa na bazi kalcijum-aluminata – *in vivo* studija

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KRATAK SADRŽAJ

Uvod ALBO-HA (Vinča, Srbija) novi je eksperimentalni nanostrukturni cement na bazi kalcijum-aluminata sintetisan kao moguća alternativa komercijalnom mineralnom trioksidnom agregatu (MTA). Cilj ovog rada bio je da se proceni histološka reakcija periapikalnog tkiva posle implantacije nanostrukturnog cementa na bazi kalcijum-aluminata i MTA (MTA Angelus) u kanale korenova zuba ovaca.

Materijal i metode U studiji je korišćeno ukupno 16 mandibularnih sekutića dve ovce starosti oko 24 meseca. Korenski kanali su hemomehanički obrađeni primenom krunično-apeksne tehnike i ispunjeni sa ALBO-HA (grupa 1) i MTA (grupa 2) (po osam zuba za svaki materijal). Posle četiri nedelje životinje su eutanazirane, a zubi sa okolnim tkivom odsečeni i pripremljeni za histološku analizu. Posmatrani su sledeći parametri: intenzitet inflamacije, apikalno novostvoreno kalcifikovano tkivo, širina periodontalnog ligamenta i resorpcija dentina cementa i kosti. Podaci su analizirani statistički ($\alpha = 0,05$) korišćenjem Man–Vitnijevog U testa.

Rezultati Blaga zapaljenska reakcija uočena je kod 75% uzoraka grupe 1, odnosno 62,5% uzoraka grupe 2 ($p > 0,05$). Novostvoreno diskontinuirano kalcifikovano tkivo u predelu apeksa je uočeno kod 75% uzoraka u grupi 1, dok je u drugoj grupi taj procenat iznosio 87,5%. Nije zabeležena značajna razlika za širinu prostora periodontalnog ligamenta između grupa ($p > 0,05$). Resorpcija dentina, cementa ili kosti nije uočena ni u jednom uzorku.

Zaključak ALBO-HA i MTA imali su sličan učinak na pojavu inflamacije, formiranje novog kalcifikovanog apikalnog tkiva i debljinu periodontalnog ligamentnog prostora posle punjenja korenskih kanala zuba ovaca u eksperimentalnim uslovima.

Ključne reči: kalcijum-aluminat; MTA; ovca; reakcija periapikalnog tkiva

UVOD

U protekle dve decenije mineralni trioksidni agregat (MTA) i kalcijum-silikatni materijali predstavljaju „zlatni standard" kao materijali koji se koriste u velikom broju indikacija u endodonciji. Biokompatibilnost, bioaktivnost i sposobnost zaptivanja čine MTA idealnim za upotrebu kao materijala za punjenje kanala korena, za terapiju vitalne pulpe, lečenje korenskih perforacija i apeksifikaciju. Takođe se koristi tokom regenerativnih endodontskih procedura i kao apikalni čep posle endodontske hirurgije. Međutim, neka od njegovih negativnih svojstava, kao što su dugo vreme stvrdnjavanja, poteškoće tokom manipulacije, mogućnost promene boje zuba, kao i izmena fizičkih i hemijskih karakteristika samog materijala u kiseloj sredini, doveli su do povećane potrebe za stvaranjem alternativnih endodontskih cemenata [1, 2].

Tehnološki napredak poslednjih godina doveo je do sinteze nanostrukturnih materijala za primenu u endodonciji. Metodom nanomodifikacije postojećih komercijalnih kalcijum-silikatnih cemenata neki istraživači su pokušali da poboljšaju njihova svojstva. Ono što razlikuje nanomaterijale u odnosu na konvencionalne jeste veća razlika između veličine i mase, kao i površinska reaktivnost čestica. Čestice manje veličine, pored toga što poseduju veliku reaktivnost, pospešuju i hidrataciju materijala, što povoljno utiče na njegovo brže vezivanje i očvršćavanje [3]. Saghiri i saradnici su pokazali da je nanomodifikovani MTA pokazao veću mikrotvrdoću, manju rastvorljivost u kiseloj i baznoj sredini u odnosu na MTA, kao i pozitivan odgovor tkiva na animalnom modelu. Takođe, dodatak 2% trikalcijum-aluminata u nano MTA uticao je na poboljšanje osteoinduktivnih karakteristika [4, 5, 6]. Preliminarna istraživanja nedavno sintetisanih nanostrukturnih kalcijum-silikatnih materijala ukazala su na odsustvo toksičnosti, dobar dentinogeni i osteogeni potencijal [7, 8, 9].

Biomaterijali na bazi kalcijum-aluminata za primenu u endodonciji se ispituju u poslednjoj deceniji i malo je dostupnih podataka u naučnoj literaturi. Kalcijum-aluminatni cement Endobinder (Binderware, São Carlos, SP, Brazil) pokazao je dobre biološke osobine, dok su fizička svojstva i adhezivnost za dentin komparabilna sa drugim komercijalnim materijalima na bazi kalcijum-silikata [10, 11, 12]. U *in vivo* studijama u kojima je ispitivan efekat kalcijum-aluminosilikatnog materijala (Quick-Set) i belog MTA utvrđeno je da ovi materijali imaju sličan efekat na formiranje dentina i cementa, kao i zarastanje periapikalnog tkiva kod pasa posle pulpotomije i aplikacije u korenske kanale [13]. Nedavno je razvijen novi nanostrukturni cement na bazi kalcijum-aluminata (ALBO-HA, Vinča, Srbija) u pokušaju da se primenom nanotehnologije sintetiše materijal sa poboljšanim mehaničkim karakteristikama u odnosu na MTA, bez narušavanja bioloških osobina. Materijal predstavlja smešu kalcijum-aluminata u kombinaciji sa kalcijum-karbonatom i barijum-sulfatom kao rendgenskim kontrastnim sredstvom. Sintetisan je inovativnom sol-gel metodom i metodom samosagorevajućih talasa na visokoj temperaturi. Proizvođač navodi da ovakav način sinteze omogućava dobijanje specifične nanostrukture čestica visoke aktivnosti, uz poboljšano vreme vezivanja, kroz ubrzanu hidrataciju. Takođe, dodavanje reoloških modifikatora u smešu produžilo je radno vreme i poboljšalo sposobnost manipulacije [14]. Inicijalna ispitivanja za ALBO-HA ukazala su na sličnu biokompatibilnost sa MTA [14, 15].

Pored biokompatibilnosti, jedan od osnovnih zahteva za endodontske biomaterijale koji dolaze u neposredan kontakt sa vitalnim pulpnim i periodontalnim tkivom tokom dužeg perioda je da izazovu pozitivan odgovor i da indukuju histološke reparacije. Pojedine komponente materijala mogu delovati kao toksini i oštetiti ćelije periodoncijuma. Kao posledica toga može doći do oštećenja tkiva ili prolongiranja procesa reparacije.

Cilj ovog rada je bio da se proceni histološki odgovor periapeksnog tkiva posle aplikacije eksperimentalnog nanostrukturnog cementa na bazi kalcijum-aluminata (ALBO-HA) u kanale korena zuba ovaca.

MATERIJAL I METODE

Dozvola za sprovođenje istraživanja dobijena je od Etičkog komiteta Medicinskog fakulteta u Foči. Istraživanje je sprovedeno u saradnji sa Veterinarskim fakultetom Univerziteta u Beogradu. Eksperiment je sproveden u skladu sa međunarodnim standardima ISO 10993-2 i ISO 7405 [16, 17]. U studiju je uključeno 16 kanala korenova donjih sekutića kod dve ovce (ovis aries) rasa Virtemberg, starosti oko 24 meseca i prosečne težine oko 50 kg. Životinje su tokom trajanja eksperimenta bile smeštene u farmskim uslovima, u kontrolisanoj sredini, sa kontrolisanom ishranom uz svakodnevnu profesionalnu negu. Kod životinja je izvršena sedacija ksilazinom (2% Xylazin, CP, Pharma, Bergdorf, Germany) u dozi od 0,2 mg/kg telesne težine. Opšta anestezija postignuta je sa ketamin-hidrohloridom 10% u dozi od 7,5 mg/kg telesne težine, intravenski. Hirurška procedura je sprovedena u aseptičnim uslovima. Zubi su očišćeni 2% hlorheksidin-glukonatom. Okruglim dijamantskim borerom formirani su pristupni kaviteti prve klase na oralnoj površini sekutića. Sterilnim okruglim karbidnim borerom uklonjen je krov pulpe i koronarna pulpa. Korenski deo pulpe je uklonjen pulp-ekstirpatorima, a kanali obilno isprani 1% natrijum-hipohloritom (NaOCl). Kanali korena su zatim prošireni ručnim K turpijama ǂ15-40 (Dentsply Maillefer, Ballaigues, Switzerland) krunično apeksnom tehnikom (Crown-down) do apeksnog suženja, uz ispiranje rastvorom 1% NaOCl između instrumenata. Instrumentima ǂ15-25 prošireno je apeksno suženje kako bi se obezbedio kontakt materijala sa periodontalnim tkivom. Novi set endodontskih instrumenata je korišćen za svaku životinju. Posle mehaničke obrade finalna irigacija obavljena je sa 5 mL 1% NaOCl i 17% EDTA u trajanju od 1 minut, kanali su posušeni sterilnim papirnim poenima i napunjeni sveže zamešanim materijalima po uputstvu proizvođača. Eksperimentalni nanostrukturni kalcijum-aluminatni cement ALBO-HA je zamešan sa destilovanom vodom u omeru 2 : 1. Kontrolni materijal MTA (White MTA Angelus, Londrina, Brazil) zamešan je u omeru prah–tečnost 3 : 1 prema uputstvu proizvođača. Materijali su u kanale korena unešeni lentulo-spiralom. ALBO-HA je aplikovan u četiri desna mandibularna sekutića (grupa 1), dok je MTA aplikovan u četiri leva mandibularna sekutića (grupa 2) kod obe ovce. Višak materijala je uklonjen na ulazu u korenski kanal, a zatim je pasta komprimovana vertikalnom kondenzacijom pomoću endodontskog plugera. Pristupni kaviteti su zatvoreni svetlosno polimerizujućim glasjonomernim cementom (GC Fuji VIII, GC Corp, Tokyo, Japan). Posle završene hirurške procedure životinje su primale analgetik butorfanol (Butorfanol, 10 mg/ml, Richter Pharma AG Austria) u dozi od 0,1–0,2 mg/kg/tm i.m u naredna tri dana. Posle opservacionog perioda od 30 dana, životinje su eutanazirane produženom anestezijom ketaminom i.v i kalijum-hloridom intrakardijalno.

Posle uklanjanja mekih tkiva zubi su isečeni dijamantskom šajbnom i fiksirani u 10% formalinu i dekalcifikovani. Nakon toga je tkivo fiksirano u kružnom tkivnom procesoru (Leica TP 1020, Germany), a zatim kalupljeno u parafinske blokove. Iz parafinskih kalupa sečeni su serijski tkivni preseci (sa svakog uzorka po osam) debljine 5 μm. Preparati su standardno bojeni hematoksilin-eozin (HE) bojenjem. Mikroskopski preparati su analizirani optičkom mikroskopijom uz primenu programa za morfometriju Software «Cell-B» by Olympus, mikroskopom Olympus 5, na uveličanjima ×10, ×40 i ×100. Kao histološki kriterijumi za procenu reakcije periapeksnog tkiva korišćeni su: A. zapaljenje (bez zapaljenja, blago, umereno, teško); B. novostvoreno kalcifikovano tkivo (kompletno, parcijalno, tanak sloj, bez); C. širina periodontalnog ligamenta (normalna, blago proširen, umereno proširen, izrazito proširen); D. resorpcija dentina (odsutna, prisutna); E. resorpcija cementa (odsutna, prisutna); F. resorpcija kosti (odsutna, prisutna) [18].

Statistička obrada podataka urađena je u programu SPSS 20.0 (IBM Corp., Armonk, NY, USA). Za poređenje razlika u rezultatima histoloških analiza između grupa korišćen je Man–Vitnijev test.

REZULTATI

Rezultati histološke analize prikazani su u Tabeli 1. Kod šest uzoraka ispunjenih sa ALBO-HA zabeležena je blaga inflamacija u predelu apeksa, dok je kod dva uzorka uočeno umereno zapaljenje. Kod korenova ispunjenih sa MTA u pet uzoraka je uočeno blago zapaljenje, a kod tri uzorka umereno zapaljenje. Parcijalno kalcifikovano tkivo, kao i tanak sloj kalcifikovanog tkiva uočeni su u po tri uzorka grupe 1, dok je u grupi 2 kod dva uzorka uočeno formiranje parcijalnog kalcifikovanog tkiva, odnosno kod dva uzorka tanak sloj kalcifikovanog tkiva. Širina periodontalnog ligamenta bila je blago uvećana kod polovine uzoraka grupe 1, odnosno kod 75% uzoraka grupe 2. Resorpcije dentina, cementa i alveolarne kosti nisu zabeležene ni u jednom uzorku za oba ispitivana materijala. Statističkom analizom dobijenih podataka nije uočena značajna razlika između ispitivanih grupa u odnosu na posmatrane parametre.

DISKUSIJA

Za razliku od *in vitro* ispitivanja na ćelijskim kulturama, istraživanja koja se sprovode na eksperimentalnim životinjama daju bolje podatke o biokompatibilnosti materijala, kao i različitim oblicima biološkog odgovora organizma na ispitivani materijal [19]. U *in vivo* studijama proteini, tkivne tečnosti i faktori imunog sistema mogu da smanje toksični efekat materijala [20]. Histološka reakcija mekih tkiva na biomaterijal je često korišćena metoda za procenu biokompatibilnosti, kao i iritacije tkiva od strane materijala. Kao animalni model u ovom istraživanju korišćene su ovce rase Virtemberg. Prednost većih modela životinja za dentalna ispitivanja je u činjenici da mogu biti relevantniji, jer se operativni zahvati mogu sprovesti upotrebom identičnih kliničkih instrumenata koji se koriste na humanim zubima [21].

Ispitivanja anatomije zuba ovaca pokazala su da su dužina korenova, debljina dentina i dijametar apikalnog foramena uporedivi sa istim strukturama na humanim zubima. Dvogodišnja starost životinja je odabrana zbog činjenice da se u ovom uzrastu može koristiti veći broj zuba za istraživanje, kao i da prečnik apikalnog foramena širine od 1 mm i više može simulirati zube sa otvorenim apeksom [22]. MTA odlikuju visoka biokompatibilnost, osteoinduktivna svojstva, sporo oslobađanje jona Ca^{2+} i alkalni pH, zatim izuzetna hidrofilnost, koja omogućava korišćenje u kliničkim uslovima u vlažnoj sredini [1, 2]. Iz navedenih razloga, u ovoj studiji MTA je korišćen kao kontrolni materijal.

Rezultati studije pokazali su da je zapaljenska reakcija periapeksnog tkiva posle implementacije ispitivanih materijala ocenjena kao blaga u najvećem broju uzoraka obe grupe i u skladu je sa rezultatima prethodnih istraživanja, u kojima su korišćeni materijali sličnog hemijskog sastava aplikovani u korenske kanale eksperimentalnih životinja. Iako u pogledu intenziteta inflamacije nije bilo statistički značajne razlike između testiranih materijala, kalcijum-aluminat je proizveo nešto niži inflamatorni odgovor. Kontinuirano kalcifikovano tkivo nije uočeno, dok je u većini uzoraka ispitivanih materijala u predelu apeksa zuba uočeno formiranje tankog sloja diskontinuiranog kalcifikovanog tkiva sa fokusima vaskularne fibroblastne proliferacije. Pojava ovako formiranog tkiva uz blagu inflamaciju u kratkom vremenskom intervalu opservacije koji je korišćen u ovom istraživanju predstavlja pozitivan rezultat i potvrdu da ispitivani materijali poseduju induktivni potencijal. Pretpostavka je da bi tokom vremena moglo doći do dalje mineralizacije i formiranja regularnog kontinuiranog mineralizovanog tkiva uz iščezavanje fibroblastnih fokusa. Oba ispitivana materijala pripadaju grupi bioaktivnih materijala koje karakteriše oslobađanje jona kalcijuma tokom vezivanja. U procesu hidratacije kalcijum-aluminatnog cementa dolazi do stvaranja kalcijum-aluminatnog (CA) hidrata i aluminijum-hidroksid hidrata. Oslobađanje jona Ca^{2+} je rezultat razlaganja CA hidrata, čijom razgradnjom tokom hidratacionog procesa dolazi i do oslobađanja $Al(OH)_4$ i OH^- jona [14]. Kontinuirano oslobađanje ovih bioloških aktivnih jona indukuje formiranje kalcifikovanog tkiva, reguliše proliferaciju, diferencijaciju i mineralizaciju ćelija. Materijali koji oslobađaju kalcijum takođe mogu izazvati proliferaciju parodontalnih fibroblasta osteoblasta i cementoblasta [23, 24]. Zbog biološke razgradnje materijala u kontaktu sa tkivnim tečnostima oslobođeni joni stvaraju alkalno okruženje. S druge strane, u alkalnom okruženju dolazi do neutralizacije mlečne kiseline oslobođene iz osteoklasta. Na taj način je sprečeno rastvaranje mineralnih komponenata dentina. Alkalna sredina dovodi do aktiviranja alkalne fosfataze, koja ima značajnu ulogu u procesima stvaranja tvrdih zubnih tkiva. Za kalcijum-aluminatni cement je utvrđeno da stimuliše ekspresiju RUNX2, alkalne fosfataze, koštanog sijaloproteina i osteopontina, koji predstavljaju biohemijske markere mineralizacije. RUNX2 gen kodira transkripcioni faktor koji ima ključnu ulogu u diferencijaciji pluripotentnih mezenhimalnih ćelija u osteoblaste [25]. Takođe, potvrđeno je da nanostrukturna površina materijala utiče na ponašanje i aktivnost ćelija u smislu povećane osteoblastne adhezije, proliferacije i diferencijacije [26].

Rezultati istraživanja za ALBO-HA ne mogu se izravno uporediti sa onima iz drugih studija zbog nedostatka relevantne literature, jer se radi o novom materijalu čija je primena u endodonciji još na nivou pretkliničkih i *in vivo* eksperimenata na životinjama. Međutim, indukcija mineralizovanog tkiva posle aplikacije materijala u čijoj osnovi se nalazi kalcijum-aluminat na zubnu pulpu i u korenski kanal eksperimentalnih životinja u skladu je sa rezultatima drugih studija [13, 27]. Kramer i saradnici su ispitivali inflamatornu reakciju pulpe, formiranje dentinskog mosta kod pacova posle pulpotomije sa kalcijum-aluminosilikatnim cementom (Quick-Set). Kao kontrolni materijali korišćeni su ProRoot MTA i MTA Plus. Inflamatorni odgovor prekrivene pulpe meren kvantifikacijom inflamatornih citokina, interleukina IL-1α i IL-1β bio je približno isti kod sva tri tretirana materijala. Dentinski mostići uočeni su već nakon 30 dana od pulpotomije kod svih materijala, dok je vitalnost pulpe bila očuvana i nakon 60 dana [28]. Kohout i saradnici su u svojoj studiji utvrdili je da su Quick set i beli MTA posle apikotomije i aplikacije u korenove pasa rase Beagle imali sličan efekat na zarastanje tkiva pospešujući regeneraciju, formiranje periodontalnog ligamenta i depoziciju cementa na periodontalnoj strani materijala [13]. U novijoj studiji Walsh i saradnici su ispitivali dentinogeni i osteogeni potencijal modifikovanih varijanti materijala korišćenih u prethodne dve navedene studije u kontaktu sa pulpnim i periradikularnim tkivom Beagle pasa. Nakon opservacionog perioda od 90 dana, ispod oba materijala (Quick-Set 2 i NeoMTA plus) došlo je do izlečenja pulpe i periapeksnog tkiva formiranjem dentinskog mosta i depozicijom cementa [29].

Kalcijum-aluminatni cement sintetisan za primenu u endodonciji je u dostupnoj literaturi pokazao dobre rezultate u pogledu biokompatibilnosti posle supkutane i intraosealne implementacije kod eksperimentalnih životinja [10]. Moraes i saradnici su ukazali i na mogućnost primene kalcijum-aluminata kao skafolda i biomembrane u koštanoj regeneraciji [30]. Biokompatibilnost nanostrukturnog kalcijum-aluminata identičnog sastava kao i materijal korišćen u ovom istraživanju, ispitivana je posle potkožne implementacije u supkutano tkivo pacova. Nakon opservacionih perioda od 7, 15 i 30 dana posmatran je uzajamni odnos zapaljenja i debljine fibrozne kapsule. Uočeno je da sa smanjenjem zapaljenja tokom perioda opservacije dolazi do porasta debljine fibrozne kapsule oko implementiranih materijala, što ukazuje na dobru toleranciju tkiva na ove materijale [31].

ZAKLJUČAK

Primenom nanostrukturnog ALBO-HA i MTA u ovom istraživanju uočeno je da oba materijala izazivaju sličan inflamatorni efekat i sposobnost indukcije kalcifikovanog tkiva posle 30 dana na zubima ovaca. Povoljan biološki odgovor tkiva posle aplikacije eksperimentalnog kalcijum-aluminatnog cementa predstavlja dobru osnovu za njegova dalja ispitivanja u *in vivo* uslovima i eventualne modifikacije u sastavu u cilju poboljšanja fizičkih i bioloških karakteristika.

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The effect of sugar-sweetened carbonated soda and carbonated mineral water on the salivary pH value

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SUMMARY

Introduction Saliva plays an important role in maintaining oral health. Its buffer capacity helps neutralise acidic products from food, drinks and dental plaque. Saliva composition, quantitative and qualitative properties, such as acidity, are associated with the occurrence of dental caries, non-carious lesions and periodontitis. The aim of the study was to examine the change in salivary acidity after taking carbonated mineral water and sugar-sweetened carbonated soda in subjects aged 18 to 25 years.

Materials and method The study research was conducted at the Dentistry Clinic of Vojvodina on 30 adult subjects. Salivary acidity was measured with a digital pH meter before, and 5, 10 and 20 minutes after taking 200 ml of carbonated mineral water and 200 ml of sugar-sweetened carbonated soda. The obtained results were statistically processed by mixed, combined analysis of variance.

Results Consumption of carbonated mineral water and sugar-sweetened carbonated soda led to a change in salivary acidity in the examined time intervals. Carbonated mineral water reduced the salivary acidity, and after 20 minutes the acidity recovers reaching levels close to the initial pH value. After taking sugar-sweetened carbonated soda, the salivary pH value dropped. It reached the lowest mean value 5 and 10 minutes after taking the beverage, and then increased slightly without reaching the initial value. In some subjects, the minimum value of the salivary pH obtained was below the value considered critical for the occurrence of enamel and dentin demineralisation.

Conclusion Carbonated mineral water and sugar-sweetened carbonated soda affected the salivary pH value within a period of 20 minutes after consumption. Consuming sugar-sweetened carbonated soda can have adverse effects on oral health.

Keywords: saliva; pH; beverage

INTRODUCTION

Oral cavity, as the beginning of digestive tract, is in direct contact with the external environment. Saliva, which is secreted by the exocrine salivary glands, is of great importance for oral biochemistry. It is an aqueous solution secreted by large salivary glands (parotid, submandibular and sublingual), small salivary glands located in the mucous membrane of the lips, cheeks, tongue, palate and pharynx and gingival cervical fluids [1]. There is 700–800 ml of saliva secreted daily on average, which is swallowed and absorbed in the digestive tract under physiological conditions [1]. Saliva is composed of 99.5% water and 0.5% salts and proteins [2]. The most important proteins are the alkaline glycoproteins that protect tooth enamel and are responsible for the viscosity of saliva and lubrication [2]. Saliva also contains immunoglobulins and lysosomes that lyse bacteria, the enzymes alpha amylase and hyaluronidase [2]. In part of population, antigens of blood groups A and/or B are also found in saliva [2].

Saliva plays an important role in maintaining oral health. It protects and wets the oral mucosa, plays an important role in the processes of mineralisation and demineralisation of both enamel and dentin [3]. With its immunological and non-immunological components, it exhibits antimicrobial activity, enhances the taste of food and drink and initiates the process of food digestion [3]. Its buffering capacity helps neutralise acidic products from food, drinks and dental plaque [2, 3]. Disruption of homeostasis, which is maintained by saliva, leads to poor oral health [4].

The acidity of saliva, i.e., salivary pH depends on bicarbonate, phosphate and protein. Calcium and phosphate are supersaturated at physiological ("normal") pH, and the buffering effect of saliva depends mainly on bicarbonate and phosphate [3]. With sufficient salivary secretion rates (more than 1 ml per minute), the concentration of bicarbonate is 30-60 mmol/l, and the pH is 7.5-7.8 [3].

Saliva prevents damage to the mucous membranes of the mouth and teeth as well as the occurrence of dental erosions by washing away pathogenic microorganisms, breaking down food and destroying the bacteria as such, including cariogenic ones [4]. After eating and drinking, there is a drop in the salivary pH value, which can have harmful consequences, the appearance of dental caries and dental erosions in particular [5]. It is believed that any factor that can affect the change of oral microflora and local environmental conditions, such as a changed

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salivary pH value, leads to an imbalance in the biofilm and multiplication of cariogenic bacteria, which leads to the occurrence of dental caries [5]. Thus, the buffer system of saliva plays a key role in the prevention of both dental caries and dental erosions, which are dental lesions on the tooth surface caused by a multitude of factors, but without bacterial action [5].

There are numerous authors who have examined the influence of various beverages on the salivary pH. The studies have mostly been done *in vitro*, focusing on examining the buffering capacity of saliva or the ability of acidic beverages to damage the teeth enamel and dentin [6–12]. *In vivo* studies have been carried out on children and young people aged 18-25 by measuring the salivary pH value at different intervals after taking fruit juices, teas, wine or consuming certain types of sweets or foods [1, 4, 5,13–20]. *In vivo* findings on the salivary pH values in humans after taking carbonated mineral water and sugar-sweetened soda at different time intervals in the scientific literature are few.

This study was aimed at examining the influence of sugar-sweetened carbonated soda and carbonated mineral water on the salivary pH value 5, 10 and 20 minutes after consumption in subjects aged 18 to 25.

MATERIALS AND METHOD

The research was conducted at the Clinic for Dentistry of Vojvodina and was approved by the Ethics Committee of the Clinic. The sample consisted of 30 subjects, Dentistry students at the Faculty of Medicine in Novi Sad, aged 18 to 25, of both sexes. Before participating in the study, the subjects were informed about the method and objectives of the research and signed their voluntary consent. The selection was made by the method of random choice. The first 30 students who registered for the offered sessions and met the criteria for inclusion in the research were selected as subjects.

The research exclusion criteria were:

- candidates undergoing orthodontic or dental restorative treatment;
- pregnant women;
- candidates suffering from systemic diseases;
- candidates suffering from salivary gland diseases;
- candidates on medications that can affect the salivary gland function (antihistamines, anticancer drugs...) in a period of at least two months before the start of the experiment and those who had been taking antibiotics during the same period.

Saliva sampling was carried out at 9:00 a.m., and the subjects were instructed not to brush their teeth in the morning on the day samples were to be taken and not to eat or drink until the beginning of the experiment. Before the start of the experiment, the pH value of the tested beverages and the pH value of saliva of all subjects were determined. Saliva was collected by spitting into a sterile test tube through a sterile funnel. The pH value was measured with a digital pH meter (InoLab, Xylem analytics, Germany) in the biochemistry laboratory of the Faculty of Medicine in Novi Sad, which is located at the Dental Clinic of Vojvodina. Calibration of the pH meter was performed before measuring. The glass electrode was immersed in the test tube, and after each measurement, it was carefully cleaned with distilled water and dried with filter paper. The salivary pH value was determined by 3 consecutive immersions of the pH meter glass electrode in the test tube with the sample, and the mean value was taken as the obtained value. When immersing the glass electrode, the measurement was performed after 10 seconds, in order to allow the sampled liquid to stabilise.

The examination was performed on two consecutive days, on the first day for carbonated mineral water, and on the second day for sugar-sweetened carbonated soda. After the initial salivary pH determination, all subjects were given 200 ml of carbonated mineral water (bottled natural mineral water Vrnjci, Voda Vrnjci a.d., Vrnjačka Banja, Republic of Serbia) at room temperature on the first day, and 200 ml of sugar-sweetened carbonated soda (Coca Cola®, HBC-Srbija d.o.o. Beograd) at room temperature on the second day. They were instructed to drink the beverage within one minute. After that, saliva samples were taken again and its pH value was measured.

Saliva was collected 5, 10 and 20 minutes after the start of drinking the beverage, and the sample was measured 5 minutes after the sample collection. The obtained results were statistically analysed. A mixed, combined, analysis of variance: "mixed design ANOVA" was used.

RESULTS

The study included 30 subjects, of whom 70% were female, and 30% male. A total of 720 pH measurements of saliva and 18 pH measurements of beverages were made. The average pH value of carbonated mineral water was 6.32, while the pH of the sugar-sweetened soda was 2.62. The salivary pH values were influenced by two independent variables: time – when the saliva pH measurements were performed (0, 5, 10, 20 minutes after the beverage consumption) and the type of liquid that was taken – carbonated mineral water (Water Group) or sugar-sweetened carbonated soda (Soda Group).

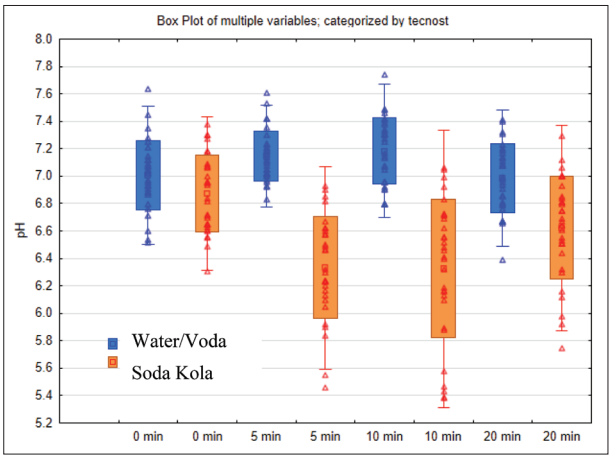
The salivary pH values for measurements before and after taking carbonated mineral water and sugar-sweetened carbonated soda are shown in Table 1. Different average pH values are observed for the two groups, as well as for different measured intervals.

The pH values for two groups (Water Group and Soda Group) for different measuring intervals are presented by a box plot in Graph 1, and the average values of this variable by a line chart in Graph 3.

There was statistically significant difference between the salivary pH value in the group that consumed carbonated mineral water and the group that consumed sugar-sweetened carbonated soda, $F(1,58)=60.02$, $p=0.00$, regardless of the measurement time intervals. For the main effect of the group, the effect size measure, the partial eta squared $\eta^2=0.51$, which is a very significant variance between the tested beverages.

Table 1. The salivary pH values in the measured intervals for Water and Soda Groups
Tabela 1. PH vrednosti pljuvačke u merenim vremenskim intervalima za grupe voda i kola

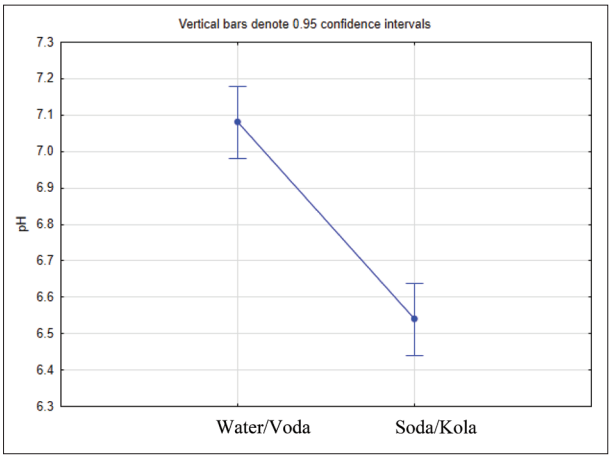
Time Vreme	Group Grupa	pH value PH vrednost						
		Number Broj	Average Srednja vrednost	95% confidence interval 95% Int. poverenja		Min	Max	Std Dev
0 min	Water Voda	30	7.01	6.91	7.10	6.52	7.64	0.25
	Soda Kola	30	6.87	6.77	6.98	6.31	7.38	0.28
5 min	Water Voda	30	7.15	7.08	7.21	6.83	7.61	0.18
	Soda Kola	30	6.33	6.19	6.47	5.46	6.93	0.37
10 min	Water Voda	30	7.18	7.09	7.28	6.80	7.74	0.24
	Soda Kola	30	6.33	6.14	6.52	5.38	7.06	0.51
20 min	Water Voda	30	6.99	6.89	7.08	6.39	7.41	0.25
	Soda Kola	30	6.62	6.48	6.76	5.75	7.29	0.37



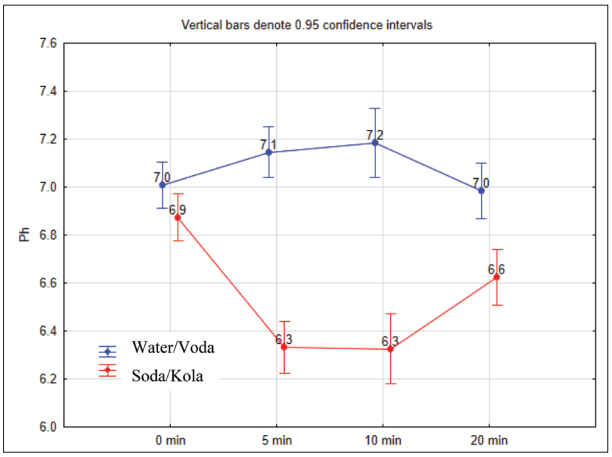
Graph 1. Box plot for salivary pH values during different time intervals for Water Group and Soda Group
Grafikon 1. Boks dijagram za vrednosti pH pljuvačke tokom različitih vremenskih intervala za grupe voda i grupe kola

The change in the pH value over time was significantly different in both subjects who took water and those who took soda (Graph 3). For the interaction of group and time, the effect size measure partial eta squared is η^2=0.443, which is a medium effect size.

When the differences between the groups were observed, by *post hoc* analysis, Tukey's test can be used to determine which average values are statistically significantly different. It is found that in the intervals of 5 min., 10 min. and 20 min., the average salivary pH values in the Water Group were significantly higher than the corresponding average salivary pH values in the Soda Group. The first measurement of the salivary pH value, before consumption of beverages, the average showed no difference in values. The results are presented in Table 2.



Graph 2. Linear chart for average salivary pH values for Water Group and Soda Group, regardless of the time elapsed since the consumption of beverages, with corresponding 95% confidence intervals
Grafikon 2. Linijski dijagram za prosečne vrednosti pH pljuvačke za grupe voda i grupe kola, bez obzira na vreme proteklo od momenta konzumiranja napitaka, sa odgovarajućim 95% intervalima poverenja



Graph 3. Linear chart for average pH values over time for Water Group and Soda Group, with corresponding 95% confidence intervals
Grafikon 3. Linijski dijagram za prosečne vrednosti pH tokom vremena za grupu koja je konzumirala vodu i grupu koja je konzumirala kola napitak, sa odgovarajućim 95% intervalima poverenja

Table 2. Results of Tukey's *post hoc* test for comparison of average salivary pH values between the Water Group and Soda Group
Tabela 2. Rezultati Takijevog post hoc testa za poređenje prosečnih pH vrednosti pljuvačke između grupe voda i kola

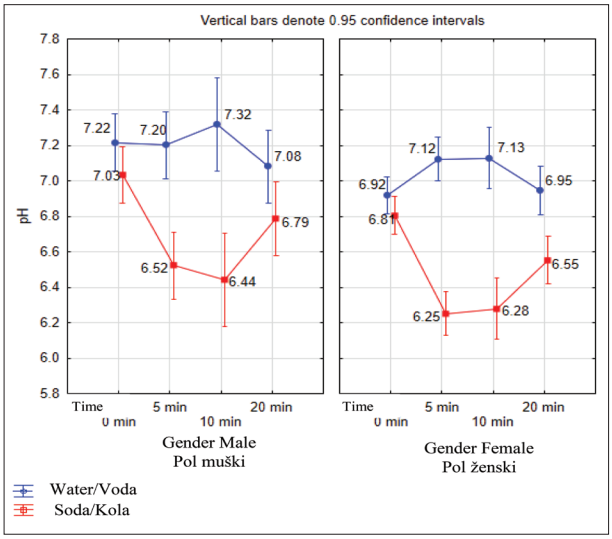
	Water average Voda – srednja vrednost	Soda average Kola – srednja vrednost	p-value p-vrednost
0 min	7.01	6.87	0.74224
5 min	7.15	6.33	0.00012
10 min	7.18	6.33	0.00012
20 min	6.99	6.62	0.00088

Table 3 shows which average values in Water Group and Soda Group differ in which measurement interval.

Analysis of Variance shows that there is no statistically significant correlation of the beverage consumed (soda, water), gender (male, female) and time (0, 5, 10, 20 min) in which the salivary pH is measured. The change in the salivary pH value over time is not statistically different for

Table 3. Results of Tukey's post hoc test for comparison of average salivary pH values in different measurement intervals within one group
Tabela 3. Rezultati Takijevog post hoc testa za poređenje prosečnih vrednosti pH pljuvačke u različitim intervalima merenja u okviru grupe

		Average Srednja vrednost		p-values P-vrednost
Water Voda	0 min. vs. 5 min.	7.01	7.15	0.1327
	5 min. vs. 10 min.	7.15	7.18	0.9955
	10 min. vs. 20 min.	7.18	6.99	0.0031
Soda Kola	0 min. vs. 5 min.	6.87	6.33	0.00032
	5 min. vs. 10 min.	6.33	6.33	1.000
	10 min. vs. 20 min.	6.33	6.62	0.00032



Graph 4. Linear chart for average pH values over time for soda and water, for men and women, with corresponding 95% confidence intervals
Grafik 4. Linijski dijagram za prosečne vrednosti pH tokom vremena za kolu i vodu, za muškarce i žene sa odgovarajućim 95% intervalima poverenja

men and women, if the beverage consumed is taken into account (Graph 4). For the interaction of gender, beverage and time, the effect size measure, the partial eta squared is η^2=0.019, which is a small effect size. Thus, the pH values for men and women change similarly over time, if the type of beverage is taken into account.

DISCUSSION

The pH value is the negative decimal logarithm of the hydrogen ion concentration in the solution. The pH values of solutions can be measured using several methods: electrochemical method, optical method (indicator colour and optical fibre pH sensor), indicator strips and pH meters [21]. A digital pH meter is an electronic device used to measure the pH value of a liquid and consists of an electrode and an electronic part of the device that measures and displays the pH value [21]. Due to its user-friendliness, availability and accuracy, it is used in recent scientific research where the salivary pH value is determined [12–15]. The use of pH indicator strips requires additional costs for test strips and is considered a convenient but less accurate method compared to a digital pH meter [21]. A digital pH meter with a glass electrode was chosen for measuring the salivary pH value in the presented research due to the accuracy, precision and simplicity of the method.

The pH of saliva can be influenced by individual factors, such as the salivary secretion rate and buffering capacity [4]. The influence of individual factors was not examined in the presented research. The salivary pH is also affected by external factors such as time of day when the experiment is performed, food and drink intake, the quantity of the beverage taken, its temperature, and taking medications in a 6-month period before the start of the experiment [4]. In order to minimise the influence of external factors, all subjects were instructed not to eat, drink or brush their teeth in the morning on the day of the experiment until it is completed, the experiment started at the same time of day and the same quantity and temperature of the experimental beverages were defined. By observing the experimental protocol and the study exclusion criteria, the influence of external factors that were not the subject of the study was minimised to the greatest extent possible.

The findings about salivary pH value after taking carbonated mineral water in the scientific literature are very few. The results of the present research can only be compared with the findings of Uma et al. from 2018 [4]. They recorded an increase, but no statistically significant difference was found in the pH value of saliva 5, 10 and 15 minutes after consuming mineral water, in contrast to the presented findings, where the pH value increased significantly after 5 and 10 minutes (Table 3). After 20 minutes, the salivary pH dropped to the level of the initial values measured before the drink had been taken, which matches the findings of Uma et al. [4]. The presented findings can be explained by a low buffering capacity of mineral water and the gustatory stimulation of salivary secretion. However, it must be taken into account that the pH value of the mineral water used in the research by Uma et al. had a pH of 7.02, while the pH of the mineral water in the present research was 6.32, thus slightly more acidic, which could have had an impact on differences in findings after 5 and 10 minutes.

In contrast to the findings of the salivary pH obtained after consuming carbonated mineral water, when taking sugar-sweetened carbonated soda with the average pH value of 2.62, the salivary pH decreased after 5 and 10 minutes, and after 20 minutes it increased, but predominantly failed to reach the initial pH value before the beverage had been taken. The lowest average pH value was determined 5 and 10 minutes after taking the sugar-sweetened soda and was pH= 6.33, which is 0.6 lower than the average initial pH value (Table 1). The findings of the authors who examined the change in the salivary pH after consuming fruit, chocolate and sweetened beverages also indicate a drop in the pH value in the time intervals examined [4, 12, 19]. In the findings of Almenara et al. from 2016, a drop in the salivary pH value was determined 5, 10 and 15 minutes after taking soda, but the research did not include a time interval of 20 minutes [19].

In vitro studies have proven the correlation between taking acidic beverages and the occurrence of dental erosions [13, 14]. The critical pH value for the appearance of enamel demineralisation is considered to be pH≤5.5, and pH≤6.5 for dentin [19]. Although in the present research the lowest mean pH value was 6.33, in some subjects the pH value below the critical was measured 5 and 10 minutes after taking soda. The minimum value 5 minutes after taking soda was pH 5.46, and after 10 minutes it was pH 5.38. The results of the present research indicate that in some subjects the salivary pH value dropped below the critical value and that taking sugar-sweetened soda can affect the occurrence of enamel demineralisation, while the mean values are indicative of the possibility of dentin demineralisation.

The question arises as to whether the lowered salivary pH value was due to the acidity of the soda as such (pH=2.62) or the decomposition of sucrose and the creation of acidic products by the microorganisms of the oral cavity had already occurred, to which it is not possible to answer based on the present research. In any case, the pH value decrease to 6.33 on average with minimum values of 5.38 and 5.46 in some subjects is a very unfavourable environment for the preservation of oral health and increases the risk of the occurrence of hard dental tissue demineralisation, the occurrence of dental caries, soft tissue diseases and the appearance of periodontitis. The presented research results indicate that the consumption of a sugar-sweetened carbonated soda can lead to a drop in the salivary pH value below the critical value for the occurrence of enamel and dentin demineralisation, which persists even 10 minutes after its consumption.

CONCLUSION

The type of beverage taken affects the salivary pH value 5, 10 and 20 minutes after consumption. After taking carbonated mineral water, the pH value of saliva rises, and after 20 minutes it drops to a value close to the value before measuring. After taking sugar-sweetened carbonated soda, there is a drop in salivary pH value. It reaches the lowest mean value 5 and 10 minutes after taking the beverage, and then increases slightly without reaching the initial value. In some subjects, a minimum pH value below the value considered critical for the occurrence of enamel demineralisation was measured, while the mean values of the pH drop indicate the possibility of dentin demineralisation. Consuming sugar-sweetened carbonated soda can have adverse effects on oral health.

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Uticaj zaslađenog napitka kola i mineralne gazirane vode na pH vrednost pljuvačke

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KRATAK SADRŽAJ

Uvod Pljuvačka ima značajnu ulogu u održavanju oralnog zdravlja. Njen puferski kapacitet pomaže u neutralizaciji kiselih produkata iz hrane, pića i dentalnog plaka. Sastav pljuvačke, kvantitativne i kvalitativne osobine, kao što je aciditet, povezani su sa pojavom karijesa zuba, nekarijesnih lezija i parodontopatije.

Cilj rada je bio da se ispita promena aciditeta pljuvačke posle uzimanja mineralne gazirane vode i zaslađenog gaziranog napitka kola kod ispitanika starosti 18 do 25 godina.

Materijal i metod Istraživanje je sprovedeno na Klinici za stomatologiju Vojvodine na 30 odraslih ispitanika. Aciditet pljuvačke je meren digitalnim pH metrom pre, 5, 10 i 20 minuta posle uzimanja 200 ml gazirane mineralne vode i 200 ml zaslađenog gaziranog napitka kola. Dobijeni rezultati su statistički obrađeni mešovitom, kombinovanom analizom varijanse.

Rezultati Konzumiranje mineralne gazirane vode i zaslađenog napitka kola dovelo je do promene aciditeta pljučke u ispitivanim vremenskim intervalima. Mineralna gazirana voda smanjuje aciditet pljuvačke, da bi se posle 20 minuta vratila na vrednost blisku onoj pre početka merenja. Nakon uzimanja gaziranog zaslađenog napitka kola vrednost pH pljuvačke opada. Najnižu srednju vrednost dostiže 5 i 10 minuta posle uzimanja napitka, a zatim blago raste ne dostižući početnu vrednost. Kod pojedinih ispitanika izmerena je minimalna vrednost pH pljuvačke ispod vrednosti koja se smatra kritičnom za nastanak demineralizacije gleđi i dentina.

Zaključak Konzumiranje gazirane mineralne vode i zaslađenog napitka kola utiče na promenu vrednosti pH pljuvačke u vremenskom periodu od 20 minuta posle konzumiranja. Konzumiranje zaslađenog gaziranog napitka kola može imati štetne posledice po oralno zdravlje.

Ključne reči: pljuvačka; pH; napitak

UVOD

Usna duplja, kao početak digestivnog trakta, u neposrednom je kontaktu sa spoljašnjom sredinom. Za oralnu biohemiju pljuvačka, koju luče egzokrine pljuvačne žlezde, ima veliki značaj. Ona je vodeni rastvor koga sekretuju velike pljuvačne žlezde (parotidne, submandibularne i sublingvalne), male pljuvačne žlezde koje se nalaze u sluzokoži usana, obraza, jezika, nepca i ždrela i gingivalnih cervikalnih fluida [1]. Dnevno se u proseku izluči 700–800 ml pljuvačke, koja se u fiziološkim uslovima proguta i apsorbuje u digestivnom traktu [1]. U sastvav pljuvačke ulazi voda, koja čini 99,5%, a 0,5% čine soli i proteini [2]. Od proteina najznačajni su bazni glikoproteini, koji štite gleđ zuba i odgovorni su za viskozitet pljuvačke i lubrikaciju [2]. U pljuvački se nalaze još i imunoglobulini i lizozomi, koji liziraju bakterije, enzimi alfa-amilaza i hijaluronidaza [2]. U jednom delu populacije u pljuvački se nalaze i antigeni krvnih grupa A i/ili B [2].

Pljuvačka ima značajnu ulogu u održavanju oralnog zdravlja. Ona štiti i vlaži oralnu sluzokožu, igra važnu ulogu u procesima mineralizacije i demineralizacije i gleđi i dentina [3]. Svojim imunološkim i neimunološkim komponentama ispoljava antimikrobnu aktivnost, pojačava ukus hrane i pića i započinje proces varenja hrane [3]. Njen puferski kapacitet pomaže u neutralizaciji kiselih produkata iz hrane, pića i dentalnog plaka [2, 3]. Poremećaj homeostaze, koja se održava pomoću pljuvačke, dovodi do lošeg oralnog zdravlja [4].

Aciditet, tj. pH pljuvačke, zavisi od bikarbonata, fosfata i proteina. Kalcijum i fosfat su prezasićeni pri fiziološkom („normalnom“) pH, a pufersko dejstvo pljuvačke zavisi uglavnom od bikarbonata i fosfata [3]. Pri dovoljno brzom lučenju pljuvačke (više od 1 ml po minutu) koncentracija bikarbonata je 30–60 mmol/l, a pH je 7,5–7,8 [3].

Pljuvačka sprečava proces oštećenja sluzokože usta, zuba, kao i nastanak dentalnih erozija spirajući patogene mikroorganizme, razgrađujući hranu i uništavajući same bakterije, uključujući i one kariogene [4]. Nakon uzimanja hrane i pića dolazi do pada vrednosti pH pljuvačke koji može imati štetne posledice, naročito na nastanak karijesa zuba i dentalnih erozija [5]. Smatra se da bilo koji faktor koji može da utiče na promenu oralne mikroflore i lokalnih uslova sredine, kao što je promena pH pljuvačke, dovodi do disbalansa u biofilmu i porasta broja kariogenih bakterija, što dovodi do nastanka dentalnog karijesa [5]. Time puferski sistem pljuvačke igra ključnu ulogu u prevenciji i dentalnog karijesa i dentalnih erozija, koje predstavljaju dentalne lezije na površini zuba uzrokovane mnoštvom faktora, ali bez učešća bakterija [5].

Brojni autori su ispitivali uticaj uzimanja različitih napitaka na pH pljuvačke. Istraživanja su mahom rađena *in vitro*, gde je ispitivan puferski kapacitet pljuvačke ili sposobnost kiselih napitaka da oštete gleđ i dentin zuba [6–12]. *In vivo* istraživanja su vršena na ispitanicima dečjeg uzrasta i na mladima 18–25 godina starosti, merenjem vrednosti pH pljuvačke u različitim intervalima posle uzimanja voćnih sokova, čajeva, vina ili konzumiranja određene vrste poslastica ili hrane [1, 4–5, 13–20]. *In vivo* nalazi o vrednostima pH pljuvačke kod čoveka posle uzimanja gazirane mineralne vode i zaslađenog napitka kola u različitim vremenskim intervalima u naučnoj literaturi su veoma oskudni.

Cilj rada je bio da se ispita uticaj zaslađenog gaziranog napitka kola i mineralne gazirane vode na vrednost pH pljuvačke 5, 10 i 20 minuta nakon konzumiranja kod ispitanika starosti 18 do 25 godina života.

MATERIJAL I METOD RADA

Istraživanje je sprovedeno u Klinici za stomatologiju Vojvodine i odobreno je od strane Etičkog odbora Klinike. Uzorak je činilo 30 ispitanika, studenata stomatologije Medicinskog fakulteta u Novom Sadu starosti 18 do 25 godina oba pola. Ispitanici su pre uključivanja u studiju bili informisani o načinu i ciljevima istraživanja i potpisali su svoj dobrovoljni pristanak. Odabir je vršen metodom slučajnog izbora. Prvih 30 studenata koji su se javili u ponuđene termine a zadovoljavali su kriterijume za uključivanje u studiju bili su izabrani kao ispitanici.

Kriterijumi za isključivanje iz studije su bili:

– ispitanici kojima je u toku ortodontski tretman i izrada zubnih nadoknada;
– trudnice;
– ispitanici koji boluju od sistemskih bolesti;
– ispitanici koji imaju oboljenja pljuvačnih žlezda;
– ispitanici koji uzimaju lekove koji mogu imati uticaja na funkciju pljuvačnih žlezda (antihistaminici, antikancerski lekovi...) u periodu od najmanje dva meseca pre početka eksperimenta i oni koji su u ovom periodu uzimali antibiotike.

Uzimanje uzoraka pljuvačke vršeno je u 9 sati ujutru, a ispitanicima je naloženo da tog jutra ne peru zube i ne uzimaju hranu ni piće do početka eksperimenta. Pre početka eksperimenta određena je vrednost pH ispitivanih napitaka i vrednost pH pljuvačke svih ispitanika. Sakupljanje pljuvačke vršeno je ispljuvavanjem u sterilnu epruvetu kroz sterilni levak. Merenje vrednosti pH je vršeno digitalnim pH metrom (InoLab, Xylem analytics, Germany) u laboratoriji za biohemiju Medicinskog fakulteta u Novom Sadu, koja se nalazi na Klinici za stomatologiju Vojvodine. Kalibracija pH metra je vršena pre početka merenja. Staklena elektroda je uranjana u test epruvetu, a nakon svakog merenja pažljivo je očišćena destilovanom vodom i osušena filter-papirom. Vrednost pH pljuvačke određivana je sa tri uzastopna uranjanja staklene elektrode pH metra u epruvetu sa uzorkom, a srednja vrednost se uzimala kao dobijena vrednost. Prilikom uranjanja staklene elektrode merenje je vršeno nakon 10 sekundi, da bi se stabilizovala uzorkovana tečnost.

Ispitivanje je vršeno u dva uzastopna dana, prvog za gaziranu mineralnu vodu, a drugog za gazirani zaslađeni napitak kola. Posle početnog određivanja pH pljuvačke svim ispitanicima je prvog dana dato 200 ml mineralne gazirane vode (flaširana gazirana prirodna mineralna voda Vrnjci, Voda Vrnjci a.d., Vrnjačka Banja, Republika Srbija), a drugog dana 200 ml zaslađenog gaziranog napitka kola (Coca Cola®, HBC-Srbija d.o.o. Beograd) na sobnoj temperaturi. Naloženo im je da napitak popiju u roku od jednog minuta. Nakon toga ponovo su uzimani uzorci pljuvačke i merena je njena vrednost pH.

Pljuvačka je sakupljana 5, 10 i 20 minuta od početka konzumiranja napitka, a merenje je izvršeno u roku od 5 minuta od uzimanja uzorka.

Dobijeni rezultati su statistički obrađeni. Korišćena je mešovita, kombinovana, analiza varijanse: „mixed design ANOVA" (engl. prim. autora).

REZULTATI

U ispitivanje je bilo uključeno 30 ispitanika. Ženski ispitanici su činili 70% uzorka, dok su muški ispitanici činili 30% uzorka.

Ukupno je načinjeno 720 merenja pH pljuvačke i 18 merenja pH napitaka.

Prosečna vrednost pH gazirane mineralne vode iznosila je 6,32, dok je pH zaslađenog napitka kola bila 2,62.

Na vrednosti pH pljuvačke uticale su dve nezavisne promenljive: vreme – momenti u kojima su izvršena merenja pH pljuvačke (0, 5, 10, 20 minuta posle uzimanja napitka) i vrsta tečnosti koja je uzimana – mineralna gazirana voda (grupa voda) ili zaslađeni gazirani napitak kola (grupa kola).

Vrednosti pH pljuvačke za merenja pre i posle uzimanja gazirane mineralne vode i zaslađenog gaziranog napitka kola prikazani su u Tabeli 1. Uočavaju se različite prosečne vrednosti pH za dve grupe, kao i za različite momente merenja.

Vrednosti pH za dve grupe (grupa voda i grupa kola) za različite momente merenja predstavljene su boks dijagramom na Grafikonu 1, a prosečne vrednosti ove promenljive linijskim dijagramom na Grafikonu 3.

Analizom varijanse utvrđeno je da postoji statistički značajan glavni efekat grupe, odnosno da postoji statistički značajna razlika između vrednosti pH pljuvačke u grupi koja je konzumirala gaziranu mineralnu vodu i grupe koja je konzumirala zaslađeni gazirani napitak kola, $F(1,58) = 60,02$, $p = 0,00$, bez obzira na vremenske intervale merenja. Za glavni efekat grupe, mera veličine efekta, parcijalni eta kvadrat η^2 iznosi 0,51, što predstavlja veoma značajnu razliku između ispitivanih napitaka.

Promena vrednosti pH tokom vremena statistički se značajno razlikuje i kod ispitanika koji su uzimali vodu i kod onih koji su uzimali kolu (Grafikon 3). Za interakciju grupe i vremena, mera veličine efekta, parcijalni eta kvadrat je $\eta^2 = 0,443$, što predstavlja srednju veličinu efekta.

Ako se gledaju razlike između grupa, *post hoc* analizom, Takijevim testom, može se utvrditi koje prosečne vrednosti se statistički značajno razlikuju. Dobija se da su u intervalima 5 min., 10 min. i 20 min. prosečne vrednosti pH pljuvačke u grupi voda statistički značajno veće od odgovarajućih prosečnih vrednosti pH pljuvačke u grupi kola. Prilikom prvog merenja vrednosti pH pljuvačke, pre uzimanja napitaka, prosečne vrednosti se nisu razlikovale. Rezultati su prikazani u Tabeli 2.

U Tabeli 3 prikazano je koje se prosečne vrednosti u grupi voda i grupi kola razlikuju u kom intervalu merenja.

Analiza varijanse pokazuje da ne postoji statistički značajna interakcija tečnosti koja se pije (kola, voda), pola (muško, žensko) i vremena (0, 5, 10, 20 min.) u kojima se meri pH pljuvačke. Promena vrednosti pH pljuvačke tokom vremena statistički se ne razlikuje za muškarce i žene, ako se uzima u obzir tečnost koja se pije (Grafikon 4). Za interakciju pola, tečnosti i vremena, mera veličine efekta, parcijalni eta kvadrat, jeste $\eta^2 = 0,019$, što predstavlja malu veličinu efekta. Dakle, vrednosti pH se i za muškarce i žene slično menjaju tokom vremena, ako se uzima u obzir vrsta napitka.

DISKUSIJA

Vrednost pH predstavlja negativan dekadni logaritam koncentracije jona vodonika u rastvoru. Vrednosti pH rastvora mogu se meriti na više načina: elektrohemijskom metodom, optičkom metodom (indikatorske boje i pH sonde od optičkih vlakana), indikatorskim trakama i pomoću pH metara [21]. Digitalni pH metar je elektronski uređaj koji se koristi za merenje vrednosti

pH tečnosti i sastoji se od elektrode i elektronskog dela uređaja koji meri i prikazuje vrednost pH [21]. Zbog svoje jednostavnosti pri radu, dostupnosti i tačnosti koristi se u savremenim naučnim istraživanjima u kojima se određuje vrednost pH pljuvačke [12–15]. Upotreba pH indikatorskih traka iziskuje dodatne troškove za merne trake i smatra se pogodnom ali manje tačnom metodom u odnosu na digitalni pH metar [21]. Za merenje vrednosti pH pljuvačke u prezentovanom istraživanju izabran je digitalni pH metar sa staklenom elektrodom zbog tačnosti, preciznosti i jednostavnosti metode.

Na pH pljuvačke mogu uticati individualni faktori, kao što su brzina lučenja pljuvačke i njen puferski kapacitet [4]. Uticaj individualnih faktora nije bio predmet ispitivanja u prezentovanom istraživanju. Na pH pljuvačke utiču i spoljašnji faktori, kao što su uzimanje hrane i pića, doba dana u kom se vrši eksperiment, količina uzetog napitka, njegova temperatura i uzimanje lekova u periodu od šest meseci pre započinjanja eksperimenta [4]. Da bi se isključio uticaj spoljašnjih faktora, svim ispitanicima je naloženo da ne uzimaju hranu, piće, niti da peru zube ujutru na dan izvođenja eksperimenta do njegovog završetka, eksperiment je započinjao u isto vreme i definisana je jednaka količina i temperatura eksperimentalnih napitaka. Poštovanjem eksperimentalnog protokola i kriterijuma za isključivanje iz studije u najvećoj mogućoj meri je isključen uticaj spoljašnjih faktora koji nisu bili predmet istraživanja.

Nalazi o stanju vrednosti pH pljuvačke posle uzimanja gazirane mineralne vode u naučnoj literaturi su veoma oskudni. Rezultati prezentovanog istraživanja mogu se uporediti samo sa nalazom Uma i saradnika iz 2018 [4]. Zabeležili su porast, ali nije pronađena statistički značajna razlika u vrednosti pH pljuvačke 5, 10 i 15 minuta posle konzumiranja mineralne vode, za razliku od prezentovanih nalaza gde je vrednost pH značajno porasla posle 5 i 10 minuta (Tabela 3). Nakon 20 minuta vrednost pH pljuvačke je opala na nivo početne vrednosti pre uzimanja napitka, što se slaže sa nalazom Uma i saradnika [4]. Prezentovani nalazi se mogu objasniti niskim puferskim kapacitetom mineralne vode i gustativnim stimulisanjem lučenja pljuvačke. Mora se uzeti u obzir i činjenica da je vrednost pH mineralne vode koja je korišćena u istraživanju Uma i saradnika bila 7,02, dok je pH mineralne vode u prezentovanom istraživanju bila 6,32, dakle nešto kiselija, što je moglo imati uticaja na razliku u nalazima posle 5 i 10 minuta.

Za razliku od nalaza pH pljuvačke dobijenog posle uzimanja mineralne gazirane vode, pri uzimanju zaslađenog napitka kola, čija je prosečna vrednost pH bila 2,62, pH pljuvačke opada posle 5 i 10 minuta, da bi se posle 20 minuta povećala, ali u najvećem broju slučajeva ne dostiže početnu vrednost pH od pre uzimanja napitka. Najniža prosečna vrednost pH utvrđena je 5 i 10 minuta posle uzimanja zaslađenog kola napitka i iznosila je 6,33, što je za 0,6 manje od srednje početne vrednosti pH (Tabela 1). Nalazi autora koji su ispitivali promenu pH pljuvačke posle uzimanja voćnih, čokoladnih i zaslađenih napitaka takođe ukazuju na pad pH u ispitivanim vremenskim intervalima [4, 12, 19]. U nalazima Almenare i saradnika iz 2016. utvrđen je pad vrednosti pH pljuvačke 5, 10 i 15 minuta posle uzimanja napitka kola, ali istraživanje nije obuhvatilo vremenski interval od 20 minuta [19].

In vitro studije su dokazale vezu između uzimanja kiselih napitaka i pojave dentalnih erozija [13, 14]. Kao kritična vrednost za pojavu demineralizacije gleđi navodi se vrednost od pH ≤ 5,5, dok je za dentin pH ≤ 6,5 [19]. Iako je u prezentovanom istraživanju najniža srednja vrednost pH bila 6,33, kod pojedinih ispitanika izmerena je vrednost pH ispod kritične vrednosti 5 i 10 minuta posle uzimanja napitka kola. Minimalna vrednost 5 minuta posle uzimanja kola napitka je bila pH 5,46, a posle 10 minuta pH 5,38. Rezultati prezentovanog istraživanja ukazuju na to da se kod pojedinih ispitanika vrednost pH pljuvačke spustila ispod kritične vrednosti i da uzimanje zaslađenog napitka kola može uticati na pojavu demineralizacije gleđi, dok srednje vrednosti čak ukazuju na mogućnost demineralizacije dentina.

Postavlja se pitanje da li snižena vrednost pH pljuvačke potiče od kiselosti samog napitka kola (pH = 2,62) ili je već došlo do razgradnje saharoze i stvaranja kiselih produkata od strane mikroorganizama usne duplje, na koje na osnovu prezentovanog istraživanja nije moguće dati odgovor. U svakom slučaju sniženje pH na 6,33 u proseku sa minimalnim vrednostima od 5,38 i 5,46 kod pojedinih ispitanika predstavlja vrlo nepovoljnu sredinu za očuvanje oralnog zdravlja i povećava rizik za pojavu demineralizacije tvrdih zubnih tkiva, pojavu karijesa zuba, za oboljenja mekih tkiva i pojavu parodontopatije. Rezultati prezentovanog istraživanja ukazuju na to da konzumiranje zaslađenog gaziranog napitka kola može dovesti do pada vrednosti pH pljuvačke ispod kritične vrednosti za pojavu demineralizacije gleđi i dentina, koja perzistira i 10 minuta posle njegovog konzumiranja.

ZAKLJUČAK

Vrsta uzetog napitka utiče na vrednost pH pljuvačke 5, 10 i 20 minuta posle konzumiranja. Nakon uzimanja gazirane mineralne vode vrednost pH pljuvačke raste, da bi posle 20 minuta opala na vrednost blisku vrednosti pre početka merenja. Posle uzimanja gaziranog zaslađenog napitka kola vrednost pH pljuvačke opada. Najnižu srednju vrednost dostiže 5 i 10 minuta posle uzimanja napitka, a zatim blago raste ne dostižući početnu vrednost. Kod pojedinih ispitanika izmerena je minimalna vrednost pH ispod vrednosti koja se smatra kritičnom za nastanak demineralizacije gleđi, dok srednje vrednosti pada pH ukazuju na mogućnost pojave demineralizacije dentina. Konzumiranje zaslađenog gaziranog kola napitka može imati štetne posledice po oralno zdravlje.

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Stability and solubility test of endodontic materials

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SUMMARY

Introduction Good physicochemical properties of endodontic materials are one of the main preconditions for successful endodontic treatment. Modern endodontic materials are expected to have good adhesiveness, stability and low solubility in order to enable high-quality and permanent obturation of the root canal.

The aim of this study was to test *in vitro* the stability and degree of solubility of two endodontic materials: Mineral Trioxide Aggregate (MTA) and Gutta Flow.

Materials and methods The solubility of endodontic materials Mineral Trioxide Aggregate - MTA (Angelus) and Gutta Flow (Colthane) was tested by the aging method using artificial saliva according to the prescription of Ira and Shannon. Twelve samples of single-rooted teeth (6 MTA, 6 Gutta Flow) were used. The samples were analyzed after 7, 14, 21, 28 and 35 days. After obturation, the samples were longitudinally cut and filled with auto-polymerizing acrylate and stored in artificial saliva at a temperature of 37° ± 2° C.

Results The results of the analysis of the longitudinal sections of the roots through MTA and Gutta Flow showed the absence of damage to both endodontic materials after 14 days of exposure to the artificial saliva. The appearance of the first morphological damage, as well as the weakening of the bonding with dentin wall, were observed on the 21st day with Gutta Flow, and on the 28th day with MTA from the beginning of the experiment. After a period of 35 days, both materials showed increased porosity, solubility and breaking of the bond with dentin wall of the root canal.

Conclusion Based on the obtained results, it can be concluded that MTA showed lower solubility and better adhesiveness with dentin wall of the tooth root canal than Gutta Flow.

Keywords: endodontic material; Mineral Trioxide Aggregate (MTA); Gutta Flow; artificial aging

INTRODUCTION

Filling the root canals represents the final stage of endodontic treatment, the main task of which is to enable high-quality apical and lateral obturation of the endodontic space, as well as to adequately close the entrance to the root canal of the tooth. Complex anatomical and morphological structure of root canals, their irregularity, inaccessibility, as well as impossibility of establishing absolutely dry field of work in the area of apical ramifications, makes the obturation phase very complex endodontic procedure. Numerous studies have confirmed that successful outcome of endodontic treatment depends precisely on the tightness of the obturation of the root canals, especially its apical third [1, 2].

Scientific and technological achievements of recent decades have offered dental practice numerous endodontic materials of different compositions and characteristics. Modern requirements of endodontics go exclusively in the direction of applying biocompatible, adhesive and physico-chemically stable endodontic materials [3, 4]. Adequate endodontic materials should enable permanent, hermetic and three-dimensional filling of the tooth root canal [5, 6]. From all of the above, the need arises that materials for definitive obturation must have good physical and chemical properties, that is, insolubility, adhesiveness and dimensional stability.

The aim of this work was to test the stability and degree of solubility of two modern endodontic materials *in vitro* using artificial aging methodology.

MATERIAL AND METHOD

The experimental test was set up in such a way that, based on induced and forced changes in the system, the properties of the tested materials were analyzed in *in vitro* conditions. In this work, the degree of solubility was tested on two endodontic materials - Mineral Trioxide Aggregate (MTA - Angelus) and Gutta Flow (Colthane), where artificial saliva was used as a solution according to the classic prescription of Ira and Shannon [7]. Twelve samples of single-rooted teeth were used during this test. Of these, six samples were filled with Mineral Trioxide Aggregate (MTA), and the remaining six were obturated using Gutta Flow and gutta-percha points. The samples of the material and the corresponding tooth were kept in a solution of artificial saliva, at a temperature of 37° ± 2°C, which corresponds to the conditions of the oral cavity. Prepared material and tooth samples were taken out for analysis of changes every seven days (7, 14, 21, 28 and 35 days) from the beginning of the experiment. The total duration of the experiment was 35 days. During the exposure of the samples to the effect of artificial saliva,

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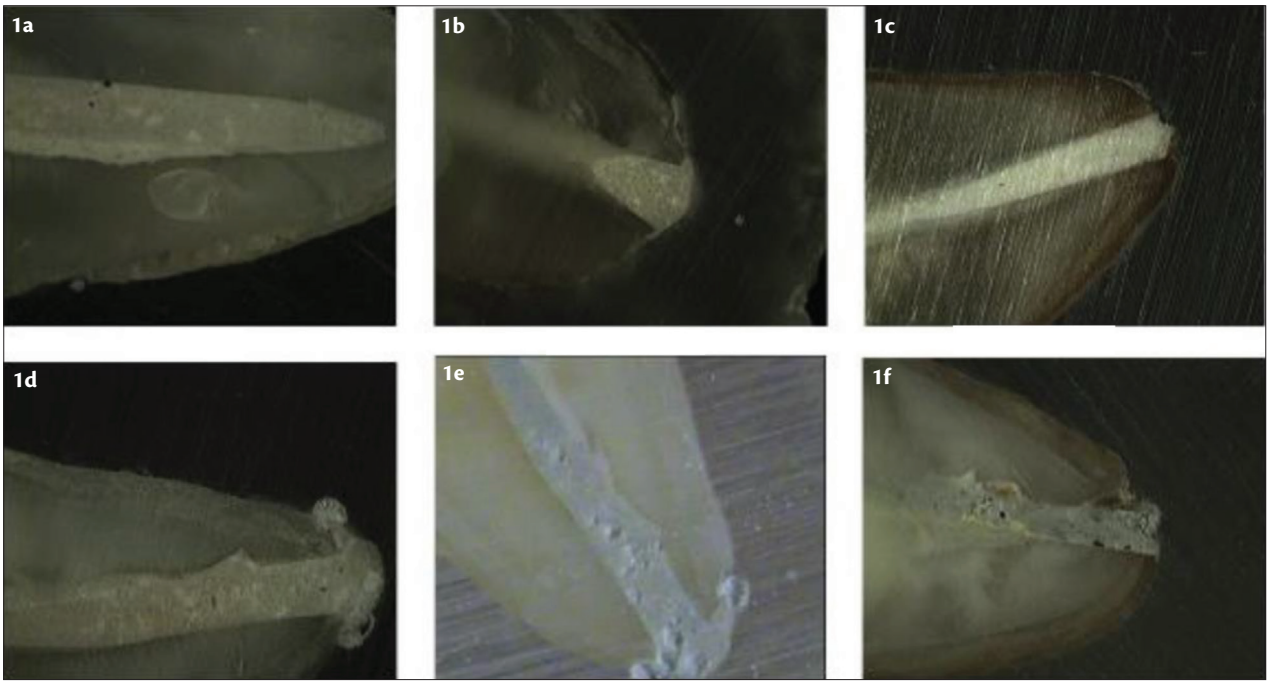

Figure 1. Longitudinal sections of root canals of teeth obturated with MTA paste
1a) Persistence and high-quality connection of MTA and dentin at the beginning of the test (0 day) is observed.
1b) After 7 days, the stability of the connection between MTA and hard dental tissue is observed, as well as a high-quality apical sealing of the root canal.
1c) After 14 days of standing in the artificial saliva solution, no damage or visible changes are observed on the contact surface of MTA and hard dental tissue.
1d) After 21 days, the appearance of minor morphological changes in the material itself is observed, whereby the bond between MTA and hard tooth tissue is completely preserved.
1e) After 28 days, the appearance of damage and visible morphological changes in the material is observed, but the bond with the dentin is mostly compact and preserved.
1f) After 35 days, increased porosity of the material as well as partial damage and disconnection of the MTA and hard dental tissue is observed.

Slika 1. Uzdužni preseci kanala korena zuba opturisanih pastom MTA
1a) Uočava se postojanost i kvalitetna veza MTA-a i dentina na početku ispitivanja (0 dan).
1b) Nakon 7 dana uočava se postojanost veze MTA i tvrdog zubnog tkiva kao i kvalitetno apikalno zaptivanje kanala korena.
1c) Posle 14 dana stajanja u rastvoru veštačke pljuvačke ne uočavaju se oštećenja ni vidljive promene na dodirnoj površini MTA-a i tvrdog zubnog tkiva.
1d) Nakon 21 dana uočava se pojava manjih morfoloških promena u samom materijalu, pri čemu je veza MTA i tvrdog zubnog tkiva potpuno očuvana.
1e) Posle 28 dana uočava se pojava oštećenja i vidljivih morfoloških promena u materijalu, ali je veza sa dentinom uglavnom kompaktna i očuvana.
1f) Posle 35 dana uočava se povećana poroznost materijala kao i delimično oštećenje i prekid veze MTA i tvrdog zubnog tkiva.

changes in the temperature and pH value of the solution were monitored. Corresponding samples of treated tooth roots removed from the solution were cut longitudinally and filled with auto-polymerizing acrylate. The surface of the longitudinal section was polished to obtain a quality tooth surface for further analysis. Determining the degree of solubility and morphological changes on the examined materials was performed using the information quantification system - Vegacam.

RESULTS

The results of the artificial aging of endodontic materials are shown in Figures 1 and 2.

A comparative analysis of the aging of MTA and Gutta Flow revealed that both materials presented persistence and stability after 14 days of the experiment. The first morphological changes with Gutta Flow were observed after 21 days of artificial saliva, while with MTA such changes occurred after 28 days. After 35 days of artificial aging, there was an increased solubility and more serious damage to the connection between MTA and hard dental tissues, while with Gutta Flow, complete disruption of the connection and disappearance of material from the apical part of the canal was observed.

DISCUSSION

All reactions between hard dental tissue (dentin, cementum) and filling material of the root canal take place at the border of their contact, the so-called interface. This generally known fact initiated the definition of the characteristics of the mentioned contact in the first phase, because these characteristics also show the quality of bonding between endodontic materials and hard tooth tissue.

In this study, a combined methodology was used to quantify the quality of the bond between endodontic materials and root canal wall. The method is based on

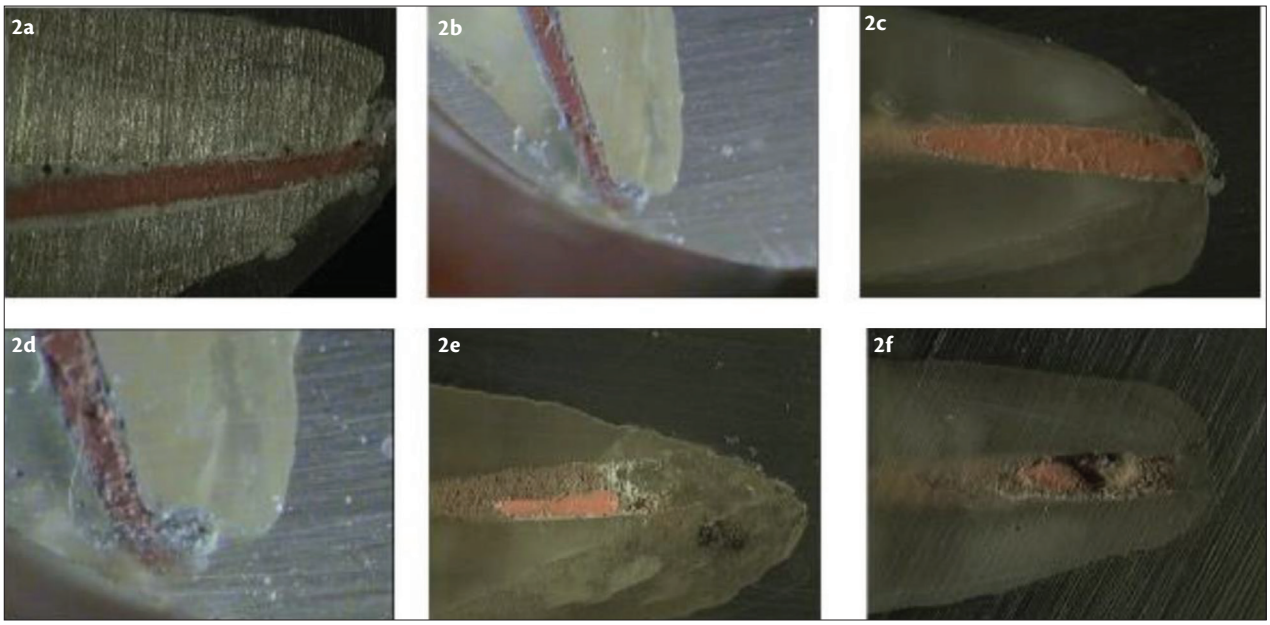

Figure 2. Longitudinal sections of root canals of teeth obturated using Gutta Flow
2a) Visible stability and quality bond between Gutta Flow and dentin at the beginning of the test (0 day) is observed.
2b) After 7 days of artificial saliva, there is no visible morphological damage to the material, nor is there a break in the connection with the dentine wall.
2c) After 14 days, slight morphological changes in the material are observed, as well as a partial loosening of the bond with the hard dental tissue.
2d) After 21 days, an increase in the porosity of the material and a weakening of the continuity of the bond in some places with the dentine wall are observed.
2e) After 28 days, visible damage and partial disappearance of the paste from the apical part of the tooth root canal are observed.
2f) After 35 days, the paste completely disappears from the apical part of the canal and the connection between the material and the hard dental tissue is broken.

Slika 2. Uzdužni preseci kanala korena zuba opturisanih pomoću Gutta Flow-a
2a) Uočava se vidljiva postojanost i kvalitetna veza između Gutta Flow-a i dentina na početku ispitivanja (0 dan).
2b) Nakon 7 dana dejstva veštačke pljuvačke ne uočava se vidljivo morfološko oštećenje materijala, niti prekid veze sa dentinskim zidom.
2c) Posle 14 dana uočavaju se blage morfološke promene u materijalu, kao i delimično popuštanje veze sa tvrdim zubnim tkivom.
2d) Nakon 21 dana primećuje se povećanje poroznosti materijala i slabljenje kontinuiteta veze na pojedinim mestima sa dentinskim zidom.
2e) Posle 28 dana uočavaju se vidljiva oštećenja i delimično nestajanje paste sa apikalnog dela kanala korena zuba.
2f) Nakon 35 dana uočava se potpuno nestajanje paste iz apikalnog dela kanala i narušavanje veze između materijala i tvrdog zubnog tkiva.

artificially causing changes in the quality of the contact surface with different agents. In the research practice of material testing, such a methodology is called the method of accelerated (artificial) aging. It is a fact that every material loses its initial, basic properties during its lifetime due to the action of external factors [5, 6, 8]. Testing the bond quality reduction can be done by artificially causing changes in the characteristics of the contact surface using a solution of artificial saliva and quantifying the quality of the connection using the described methods in certain time intervals. The results showed the expected progressive deterioration of the quality of the bond between the investigated endodontic materials and the hard dental tissue over time.

Optical analysis of the bond between MTA and hard dental tissue revealed that after 28 days of exposure to artificial saliva solution, the appearance of interface damage occured, which can be called punctate, while after a period of 35 days of "artificial aging" the appearance of more serious linear damage of the MTA connection system - hard tooth tissue was found. MTA is an endodontic cement composed of hydroxyl particles of several oxides, where the main component of the powder consists of: CaO, SiO2, Al2O3 and Bi2O3 [9, 10]. Torabinejad et al. [11] concluded that low solubility and good adhesiveness of MTA originate from its hydrophilic nature, which causes expansion of the material during curing in a moist environment. These findings were confirmed by the research of Urban et al. [12] who stated that liquid absorption in MTA leads to its dimensional stability. The good adhesiveness is attributed to the expansion of MTA in the first hours of setting. Due to the sudden expansion and low surface pressure, MTA easily penetrates into unevenness, lateral canals and ramifications, which achieves a good bond with the hard dental tissues [13]. Based on these findings, Lopes et al. [14] after 30 days of exposure of different endodontic materials to the action of distilled water, observed a volume reduction in all materials as the solubility of the materials was greater than their water absorption. The environment in which the endodontic materials were tested, in this case artificial saliva, contains various ions, cations and organic substances that cause gradual deterioration of the material. As pointed out by Pilipenko et al., the degradation of endodontic materials is actually a chemical decomposition that leads to changes in the physical and mechanical characteristics of the material [9, 15].

Gutta Flow is a new generation material based on polydimethyl-silicone and gutta-percha in the form of

particles less than 30 μm in size. The innovative composition of this sealer based on artificial resin, its consistency and method of application enable exceptional sealing power [16, 17]. The good bond with gutta-percha is reinforced by the characteristics of the sealer composition itself, which contains gutta-percha powder particles that represent the second component of the paste-paste system. In this study, Gutta Flow showed slightly higher solubility than MTA. The loss of connection between Gutta Flow and dentin wall of the tooth root canal occurred after 21 days of being in artificial saliva, while after 35 days the connection was completely broken and Gutta Flow disappeared from the apical part of the canal. These findings are consistent with the research results of Marciano et al. [13], as well as Tanomaru et al. [2] who found lower solubility of MTA than Gutta Flow. As a material based on artificial resin, Gutta Flow should have a homogeneous structure, good adhesiveness and stability, which enables hermetic obturation of tooth root canals [4, 18]. This is supported by the results of a twelve-month study by Kontakiotis et al. in which Gutta Flow showed the lowest solubility and the best adhesiveness of all tested materials [19].

However, it should be noted that each methodology has its own flaws. Despite the clear findings, the optical analysis of the interface is not quite sufficient to make the final judgment about the quality of the connection material - hard tooth tissue. The shortcoming of this method is the possibility of analyzing the quality of the connection in only one plane, that is, one section of the total contact surface of the material and the hard dental tissue, and this is obviously not enough to characterize the entire contact surface with certainty. In order to complete this research methodology, the standards for testing the solubility of endodontic materials were introduced - ISO 6876:2012, which are based on determining the difference in mass and volume of samples before and after exposure to different solutions. Although the results of all *in vitro* tests should be accepted with a certain amount of caution, it must be emphasized that they can always serve as a good basis for further clinical research.

CONCLUSION

Based on the obtained results, it can be concluded that MTA showed lower solubility and better adhesiveness with dentin wall of the tooth root canal than Gutta Flow.

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Ispitivanje postojanosti i stepena rastvorljivosti endodontskih materijala

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KRATAK SADRŽAJ

Uvod Dobra fizičko-hemijska svojstva endodontskih materijala jedan su od glavnih preduslova za uspešnu endodontsku terapiju. Od savremenih endodontskih materijala očekuje se da poseduju dobru adhezivnost, postojanost i malu rastvorljivost kako bi se omogućila kvalitetna i trajna opturacija kanala korena zuba.

Cilj ovog rada je bio da se u *in vitro* uslovima ispitaju postojanost i stepen rastvorljivosti dva endodontska materijala: mineralnog trioksidnog agregata (MTA) i Gutta Flow-a.

Materijal i metod Rastvorljivost endodontskih materijala MTA (Angelus) i Gutta Flow-a (Colthane) ispitivana je metodom starenja primenom veštačke pljuvačke po preskripciji Ire i Šanona. Korišćeno je 12 uzoraka jednokorenih zuba (6 MTA, 6 Gutta Flow). Uzorci su analizirani posle 7, 14, 21, 28 i 35 dana. Nakon opturacije uzorci su uzdužno sečeni i zaliveni autopolimerizujućim akrilatom i čuvani u veštačkoj pljuvački na temperaturi od 37° ± 2° C.

Rezultati Rezultati analize uzdužnih preseka korena zuba kroz MTA i Gutta Flow su pokazala odsustvo oštećenja na oba endodontska materijala nakon 14 dana izlaganja rastvoru veštačke pljuvačke. Pojava prvih morfoloških oštećenja, kao i slabljenje veze sa dentinskim zidom, uočeni su 21. dana kod Gutta Flow-a, a kod MTA 28. dana od početka eksperimenta. Nakon perioda od 35 dana oba materijala su pokazala povećanu poroznost, rastvorljivost i prekid veze sa dentinskim zidom kanala korena zuba.

Zaključak Na osnovu dobijenih rezultata može se zaključiti da je MTA pokazao manju rastvorljivost i bolju adhezivnost sa dentinskim zidom kanala korena zuba od Gutta Flow-a.

Ključne reči: endodontski materijal; mineralni trioksidni agregat (MTA); Gutta Flow; veštačko starenje

UVOD

Punjenje kanala korena zuba predstavlja završnu fazu endodontske terapije, čiji je osnovni zadatak da omogući kvalitetnu apikalnu i bočnu opturaciju endodontskog prostora, kao i da izvrši adekvatno zatvaranje ulaza u radiksni kanal zuba. Složena anatomsko-morfološka građa kanala korena zuba, njihova iregularnost, nepristupačnost, kao i nemogućnost uspostavljanja apsolutno suvog polja rada u predelu apikalnih ramifikacija, čine fazu opturacije veoma složenom endodontskom procedurom. Mnogobrojna istraživanja su potvrdila da uspešan ishod endodontskog lečenja zavisi upravo od hermetičnosti opturacije korenskih kanala, a posebno njegove apikalne trećine [1, 2].

Naučna i tehnološka dostignuća poslednjih decenija ponudila su stomatološkoj praksi mnogobrojne endodontske materijale, različitih sastava i karakteristika. Savremeni zahtevi endodoncije idu isključivo u pravcu primene biokompatibilnih, adhezivnih i fizičko-hemijski stabilnih endodontskih materijala [3, 4]. Adekvatni endodontski materijali morali bi da omoguće postojano, hermetično i trodimenzionalno punjenje kanala korena zuba [5, 6]. Iz svega navedenog nameće se i potreba da materijali za definitivnu opturaciju moraju da poseduju dobra fizičko-hemijska svojstva, odnosno nerastvorljivost, adhezivnost i dimenzionalnu stabilnost.

Cilj ovoga rada je bio da se u *in vitro* uslovima metodologijom veštačkog starenja ispitaju postojanost i stepen rastvorljivosti dva savremena endodontska materijala.

MATERIJAL I METOD

Eksperimentalno ispitivanje je postavljeno tako da se na osnovu indukovanih i forsiranih promena u sistemu analiziraju svojstva ispitivanih materijala u *in vitro* uslovima. U ovom radu ispitivanje stepena rastvorljivosti obavljeno je na dva endodontska materijala – mineralni trioksidni agregat (MTA – Angelus) i Gutta Flow (Colthane), pri čemu je kao rastvor upotrebljena veštačka pljuvačka po klasičnoj preskripciji Ire i Šanona [7]. Tokom ovog ispitivanja upotrebljeno je dvanaest uzoraka jednokorenih zuba. Od toga šest uzoraka je napunjeno MTA, a preostalih šest je opturisano pomoću Gutta Flow-a i gutaperka poena. Uzorci materijala i odgovarajućeg zuba držani su u rastvoru arteficijalne pljuvačke na temperaturi od 37° ± 2° C, što odgovara uslovima usne duplje. Pripremljeni uzorci materijala i zuba vađeni su radi analize promena svakih sedam dana (7, 14, 21, 28 i 35 dana) od početka eksperimenta. Ukupno trajanje eksperimenta bilo je 35 dana. Tokom izlaganja uzoraka dejstvu veštačke pljuvačke praćene su promene temperature i pH vrednosti rastvora tokom ispitivanja. Odgovarajući uzorci tretiranih korena zuba izvađenih iz rastvora sečeni su u longitudinalnom pravcu i zalivani autopolimerizujućim akrilatom. Površina uzdužnog preseka je polirana kako bi se dobila kvalitetna površina zuba za dalju analizu. Određivanje stepena rastvorljivosti i morfoloških promena na ispitivanim materijalima izvršeno je pomoću sistema za kvantifikaciju informacija – Vegacam.

REZULTATI

Rezultati ispitivanja veštačkog starenja endodontskih materijala prikazani su na slikama 1 i 2.

Uporednom analizom starenja MTA i Gutta Flow-a uočava se da su oba materijala pokazala postojanost i stabilnost 14 dana posle eksperimenta. Prve morfološke promene kod Gutta Flow-a zapažaju se posle 21 dana dejstva veštačke pljuvačke, dok kod MTA do takvih promena dolazi posle 28 dana. Nakon 35 dana veštačkog starenja dolazi do povećane rastvorljivosti i ozbiljnijih oštećenja veze MTA – tvrda zubna tkiva, dok se

kod Gutta Flow-a uočava potpuno narušavanje veze i nestajanje materijala iz apikalnog dela kanala.

DISKUSIJA

Sve reakcije između tvrdog zubnog tkiva (dentin, cement) i materijala za punjenje kanala korena zuba se odigravaju na granici njihovog dodira, tzv. interfejs. Ova opštepoznata činjenica je inicirala da se u prvoj fazi definišu karakteristike pomenute granice dodira, jer te karakteristike ujedno pokazuju i kvalitet veze između endodontskih materijala i tvrdog zubnog tkiva.

U ovom ispitivanju korišćena je kombinovana metodologija za kvantifikaciju kvaliteta veze između endodontskih materijala i kanala korena zuba. Metoda je bazirana na veštačkom izazivanju promena kvaliteta dodirne površine različitim agensima. U istraživačkoj praksi ispitivanja materijala takva metodologija naziva se metoda ubrzanog (veštačkog) starenja. Činjenica je da svaki materijal tokom svog veka korišćenja, usled delovanja spoljašnjih faktora, gubi svoja početna, osnovna svojstva [5, 6, 8]. Ispitivanje kvaliteta veze se svodilo na veštačko izazivanje promena karakteristika dodirne površine korišćenjem rastvora veštačke pljuvačke i kvantifikacijom kvaliteta veze opisanim metodama u određenim vremenskim intervalima. Rezultati su pokazali očekivano progresivno oštećenje kvaliteta veze između ispitivanih endodontskih materijala i tvrdog zubnog tkiva tokom vremena.

Optičkom analizom veze između MTA i tvrdog zubnog tkiva utvrđeno je da 28 dana posle početka izlaganja dejstvu rastvora veštačke pljuvačke dolazi do pojave oštećenja interfejsa koja se mogu nazvati tačkastim, dok nakon perioda od 35 dana „veštačkog starenja" dolazi do pojave ozbiljnijih linijskih oštećenja sistema veze MTA – tvrdo zubno tkivo. MTA je endodontski cement sastavljen od hidroksilnih čestica više oksida, pri čemu glavnu komponentu praha čine CaO, SiO_2, Al_2O_3 i Bi_2O_3 [9, 10] . Torabinejad i sar. [11] zaključuju da mala rastvorljivost i dobra adhezivnost MTA potiču od njegove hidrofilne prirode, zbog čega dolazi do ekspanzije materijala prilikom stvrdnjavanja u vlažnoj sredini. Ove nalaze potvrđuju istraživanja Urbana i sar. [12], koji konstatuju da apsorpcija tečnosti kod MTA dovodi do njegove dimenzionalne stabilnosti. Dobra adhezivnost se pripisuje ekspanziji MTA u prvim satima vezivanja. Zbog nagle ekspanzije i niskog površinskog pritiska, MTA lako prodire u neravnine, lateralne kanale i ramifikacije, čime se ostvaruje dobra veza sa tvrdim zubnim tkivima [13]. Bazirajući se na ovim nalazima, Lopes i sar. [14], nakon 30 dana izlaganja različitih endodontskih materijala dejstvu destilovane vode, primećuju zapreminsku redukciju kod svih materijala, zato što je rastvorljivost materijala bila veća nego što je njihova apsorpcija vode. Sredina u kojoj su ispitivani endodontski materijali, u ovom slučaju veštačka pljuvačka, sadrži različite ajone, katjone i organske supstance koji izazivaju postepeno propadanje materijala. Kako ističu Pilipenko i saradnici, degradacija endodontskih materijala je zapravo hemijska razgradnja koja dovodi do promena fizičkih i mehaničkih karakteristika materijala [9, 15].

Gutta Flow je materijal nove generacije na bazi polidimetilsilikona i gutaperke u vidu partikula veličine manje od 30 μm. Inovirani sastav ovog silera na bazi veštačke smole, njegova konzistencija i način aplikacije omogućavaju izuzetnu moć zaptivanja [16, 17]. Dobra veza sa gutaperkom pojačana je karakteristikama samog sastava silera, koji u sebi sadrži gutaperka čestice u prahu, koje predstavljaju drugu komponentu sistema pasta-pasta. U ovom istraživanju Gutta Flow je pokazao nešto veću rastvorljivost od MTA. Do gubitka veze između Gutta Flow-a i dentinskog zida kanala korena zuba dolazi nakon 21 dana dejstva veštačke pljuvačke, dok posle 35 dana dolazi do potpunog narušavanja veze i nestajanja Gutta Flow-a iz apikalnog dela kanala. Ovi nalazi su u skladu sa rezultatima istraživanja Marčana i sar. [13], kao i Tanomarua i sar. [2], koji govore u prilog manje rastvorljivosti MTA od Gutta Flow-a. Kao materijal na bazi veštačke smole Gutta Flow treba da poseduje homogenu strukturu, dobru adhezivnost i stabilnost koje mu omogućavaju hermetičnu opturaciju kanala korena zuba [4, 18]. U prilog tome idu rezultati dvanaestomesečne studije Kontakiotisa i sar., u kojima je Gutta Flow pokazao najmanju rastvorljivost i najbolju adhezivnost od svih ispitivanih materijala [19].

Ipak treba napomenuti da svaka metodologija ima i svoje mane. I pored jasnih nalaza, optička analiza interfejsa nije sasvim dovoljna za donošenje konačnog suda o kvalitetu veze materijal – tvrdo zubno tkivo. Nedostatak ove metode je mogućnost analiziranja kvaliteta veze u samo jednoj ravni, odnosno jednom preseku ukupne površine dodira materijala i tvrdog zubnog tkiva, a to očigledno nije sasvim dovoljno da bi se sa sigurnošću okarakterisala celokupna površina dodira. Da bi se ovakva metodologija istraživanja upotpunila, uvedeni su i standardi ispitivanja rastvorljivosti endodontskih materijala – ISO 6876:2012, koji se baziraju na određivanju razlike u masi i zapremini uzoraka pre i posle izlaganja različitim rastvorima. Iako rezultate svih *in vitro* ispitivanja treba prihvatiti sa određenom dozom opreza, mora se istaći da oni uvek mogu da posluže kao dobra osnova za dalja klinička istraživanja.

ZAKLJUČAK

Na osnovu dobijenih rezultata može se zaključiti da je MTA pokazao manju rastvorljivost i bolju adhezivnost sa dentinskim zidom kanala korena zuba od Gutta Flow-a.

CASE REPORT
PRIKAZ BOLESNIKA

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Mandibular overdenture retained with precision balls and bar attachment

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SUMMARY

Introduction Milled precision bar with the lateral additions of two precision attachments could significantly contribute to the primary and secondary retention of partial denture and overdenture.
This clinical case demonstrates stability of mandibular overdenture using milled precision bar and two coronally positioned precision attachments.

Case report A sixty-five years old male patient had two preserved canine roots in lower jaw. Semicircular metal-ceramic (PFM) bridge was previously fabricated for upper teeth. Decision for fabrication of milled bar and metal framework of overdenture was established due to the presence of PFM bridge in the upper jaw. The root canals of the two remaining mandibular canines were prepared for posts. After final mandibular impression using A-silicone in a custom tray, master cast with prepared canals of roots of canines was provided. Two posts connected with milled precision bar were designed. Coronal attachments-patrixs were positioned onto the tip of each coronal part of the construction with axial direction of precision attachments towards root canals. The construction was invested and casted. Metal framework of overdenture was designed and casted. After interocclusal record, the artificial anatomic teeth were selected and waxed model of overdenture with matrixes was provided for try-in clinical phase. Finally, the overdenture was flasked and polished. Metal construction of two posts and milled bar were cemented simultaneously with overdenture, using self-adhesive resin cement.

Conclusion Milled bar improves retention and stability of metal framework of overdenture. Coronally positioned patrix of attachment provides redirection of occlusal and other functional forces towards apical root parts.

Keywords: overdenture; mandible; precision attachment

INTRODUCTION

Different retention systems have been shown successful in treating subtotal edentulism (partially edentulous jaw) in cases where few retained teeth or roots were preserved while implant has not been an option. Some systems mentioned in the literature represent simpler structural solutions [1–5], while other systems, however, have more complex components in the composition of denture construction [5–8].

Very important approach in solving the problem of retention and stabilization of dentures in partially edentulous-maximally edentulous patients is evaluation and assessment of systems of precise connecting elements that will contribute the most to primary retention and secondary retention-stabilization.

The aim of this work was to present a case report from our clinical practice and possibility of improving stability of supra-dental mandibular denture, in which two precise connecting ball elements and one milled bar are primarily placed as the prosthesis bearers.

CASE REPORT

Male patient SD, 65 years old, had two endodontically treated lower canine roots. Partially edentulous upper jaw was restored with semicircular porcelain fused to metal (PFM) bridge. Endodontically treated roots of the two remaining canines in the lower jaw were prepared for prosthetic restoration by removing 2/3 of the length of one root canal filling material and removing 1/3 of the root canal material of the opposite canine. After definitive impression of the mandible and the remaining roots in the mandible with A-silicone, the master cast made of hard plaster (Elite-master with resin, type IV, Zhermack, Italy) was done. In the next procedure, wax models were shaped using modeling wax - corresponding to the shapes of the prepared space in the root canals of the remaining canines, and then wax copings (caps) were modeled over the remaining crown surfaces of the canines. Between the copings, an individualized milled bar (Bredent, VSP-FS/GS, Germany) was formed, and on the top of the wax forms of the covering copings, one patrix of a precise connecting element was placed on each side (Bredent VKS-uni 1.7 mm, Germany). Then the model of an overall construction consisting of two stakes with copings connected by a milled crossbar were inserted into a cylinder

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Figure 1. Master cast and casted framework on the overall construction consisting of two dedicated copings with ball attachments and a crossbar in the middle between the copings
Slika 1. Radni model i izliven skelet na sveukupnoj konstrukciji sačinjenoj od dve namenske kapice sa kugličastim atečmenima i prečkom u sredini između kapica

Figure 2. Master cast of the maximally edentulous mandible and a cast retention structure made of custom dedicated copings, ball-attachments on the top of custom copings and a bar in the middle, together with a hard plaster cast of antagonists
a) frontal perspective view; b) distal-posterior view
Slika 2. Radni model maksimalno krezube donje vilice pacijenta i izlivena retenciona konstrukcija sačinjena od namenskih kapica, patrica atečmena na vrhovima namenskih kapica i prečkom u sredini, i model antagonista od tvrdog gipsa
a) pogled iz prednje perspektive; b) pogled iz distalne-zadnje projekcije

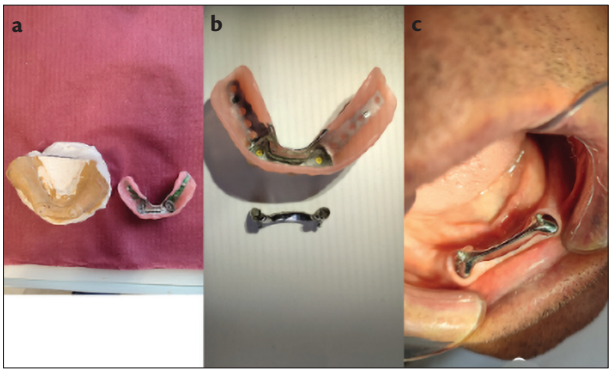

Figure 3. Casted overall retentive construction
a) in the appropriate position in the overdenture, separated from the master cast; b) separated from the supradental prosthesis; c) correctly placed on supporting tissues of the patient's mandible
Slika 3. Izliven metalni sveukupni retencioni oblik
a) na odgovarajućoj poziciji u prekrivnoj protezi, odvojen od radnog modela; b) razdvojen od supradentalne proteze; c) pravilno postavljen na odgovarajuće mesto u donjoj vilici pacijenta

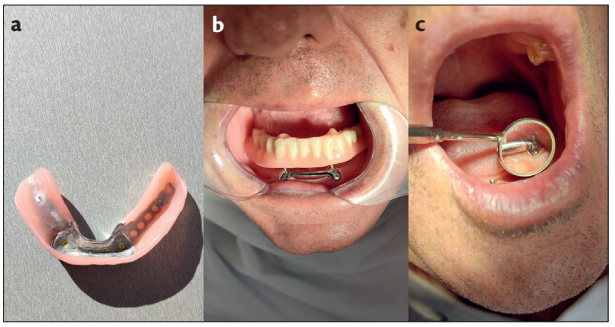

Figure 4. a) Completed lower supradental prosthesis-overdenture immediately before placement in the mouth of the SD patient;
b) Retention structure in place in the mouth and the lower overdenture above it;
c) Surface of the metal protective coping in the mouth- oral view
Slika 4. a) Završena donja supradentalna prekrivna proteza neposredno pre postavljanja u usta pacijenta SD;
b) Retenciona konstrukcija na mestu u ustima i donja supradentalna proteza iznad nje;
c) Površina metalne zaštitne kapice u ustima, posmatrana sa oralne strane.

Figure 5. Lower supradental prosthesis in the patient's mouth
Slika 5. Donja supradentalna proteza u zagrižaju u ustima pacijenta

with investment mass and casted with an alloy of specific metals (Wironit® Bego, USA).

In the next procedure, the framework of the base of the future lower supra-dental prosthesis was shaped using wax profiles, which was inserted and casted of Co-Cr-Mo alloy (Remanium GM 800, Dentaurum, Germany) (Figure 1). Using the master cast of the lower jaw waxed occlusal rim was formed, including the casted framework as the base of the covering-supra-dental prosthesis. After the clinical phase of determining the jaw relationships, a selection of anatomically shaped artificial teeth was made. In the next procedure, the wax model of supra-dental prosthesis for the lower jaw with the matrices of precise connecting elements and artificial teeth arrangement was performed. At the end, the model of the lower covering prosthesis was inserted, polymerized and the prosthesis was definitively processed and polished (Figure 2). The metal construction made of two pins under the covering caps with the pins of precise connecting elements on

the tops of the copings connected by a milled bar was cemented using self-binding adhesive cement (Totalcen, dual-cure, Itena Clinical, France) (Figures 3-5).

DISCUSSION

The retention of natural teeth or their roots is considered a biological concept that can significantly contribute to the preservation of the level of the remaining alveolar ridge in the jaws, and serve as retention of supra-dental prostheses [1, 3, 4, 5, 9, 10]. On the other hand, an increasing number of articles suggests extraction of the remaining teeth and placement of at least two (or four) implants as the best solution in treating edentulism: using supra-dental covering prosthesis [8, 11–14].

With regards to therapeutic approach in the repair and rehabilitation of the edentulous lower jaw in our patient, there were certain doubts regarding the solution and placement of the final prosthetic construction. When planning the definitive structure, the most important thing was to ensure axial transmission via precise connecting element-attachment towards the remaining roots. The decision to make a metal cast form of a milled bar as a definitive construction, and later an overdenture with a base reinforced with a metal framework, was conditioned by the presence of a metal-ceramic semicircular bridge in the upper jaw. The milled individual bar improves both retention and stability of the overdenture. Coronally placed attachment patrix ensures redistribution of occlusal and other forces that may occur in the function of the oro-facial system, towards the apical surfaces of the retained roots of the remaining supporting teeth [5, 9].

One of the possible solutions was to make cast extensions on the remaining roots, and telescope-double crowns with retentive extension bars for the retention in casted partial denture [9, 15, 16]. However, double telescopic crowns imposed the problem of over-dimensioning and aesthetically unsatisfactory effect as they were located in a visible sector of the mouth. The next possibility was the insertion of two or more implants – left and right, that is, distally in the edentulous ridge of the lower jaw. A decision for this solution was not made in the first place for financial reasons, and partly due to the poor bone quality of the edentulous ridge in our patient.

In our clinical case, a structure consisting of two dedicated copings (caps) with retention stakes in the prepared root canals was used. Between the dedicated copings was a milled crossbar [13]. In order to improve retention and stabilization of the covering supra-dental prosthesis on the basic metal structure with a bar, one dedicated coping could have been added distally, both left and right and one precise attachment pad in the shape of ring, regardless of the already existing ball-shaped attachment-patrix on top of each dedicated coping [16]. This solution was not applied in our case because the dedicated copings on the roots of the remaining canines were not massive enough, i.e. the area was not large enough to additionally accept the ring on the lateral surface of the coping (such construction would be too bulky, and in addition there would

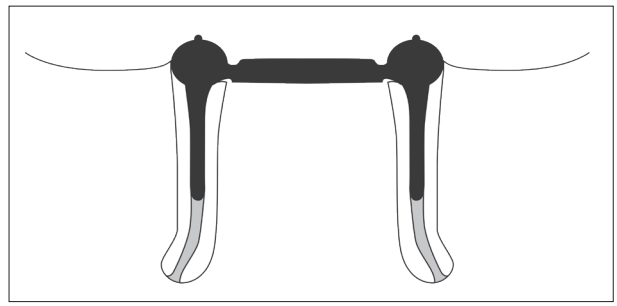

Figure 6. The roots of the canines in the parallel position and the possibility to remove up to 2/3 of the definitive endodontic filling from the root canal
Slika 6. Korenovi očnjaka u paralelnom položaju i mogućnost da se iz kanala korenova ukloni do 2/3 definitvnog endodontskog punjenja

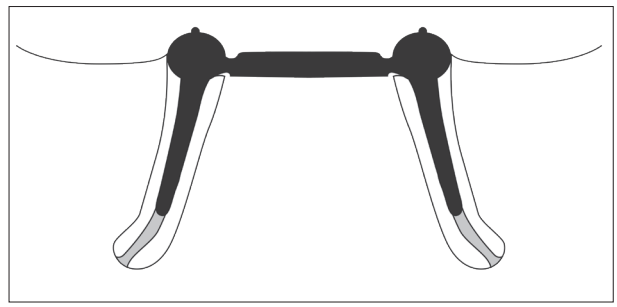

Figure 7. Divergently placed canine roots in the lower jaw-diagram illustrating the posts placed in the depressions after removal of up-to 2/3 of the length of the definitive endodontic filling in the canals of the left and right roots, after which it would not be possible to place the construction on the supporting tissues and the casted posts in the root canals.
Slika 7. Divergentno postavljeni korenovi očnjaka u donjoj vilici – dijagram ilustruje kočiće postavljene u udubljenja posle uklanjanja 2/3 dužine kanala i levog i desnog korena, posle čega ne bi bilo moguće postaviti konstrukciju na noseća tkiva i kočiće u kanale korenova.

be a problem of difficult or too intense separation and parting of the matrices from the abutments in the overall construction, which after some time could have caused the bonding cement to crack and the overall milled metal construction to separate from the roots together with the supra-dental prosthesis.

Since the roots of the remaining teeth have been endodontically treated, it was necessary to include cast metal posts in the definitive construction. Therefore, the root canal filling material was removed at least in the amount of ½ the length of the canal, or the best in the amount of 2/3 of the total length of the root canal (Figure 6). Difficulties, however, arise if the roots of the remaining teeth in the jaw are not parallel (Figures 7, 8). The dis-parallelism of the two remaining tooth roots can be overcome by calculating the permissible deviation and, accordingly, the value of the angle between the two not-parallel posts that still allow the placement of the supporting metal structure in one manual manipulation by the therapist. Good approach would also be to remove up to 2/3 of the length of the root canal from one remaining root, and from the other one to remove about 1/3 or possibly up to ½ of the filling, and then make (waxed) models of retentive posts (Figure 9, 10). However, the difference in convergence of the apical segments of the roots towards the medial line

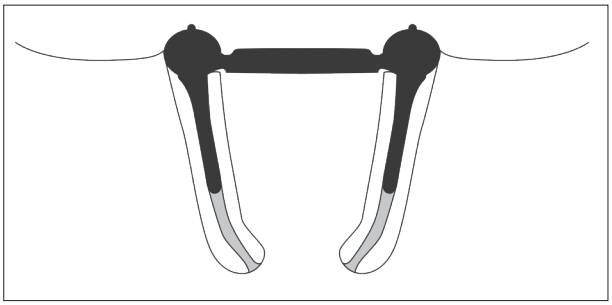

Figure 8. Not-parallel and convergent roots of canines (tips of the roots are located significantly closer to the reference medial line)
Slika 8. Disparalitet i konvergentnost korenova očnjaka (vrhovi korenova su locirani značajno bliže referentnoj medijalnoj liniji)

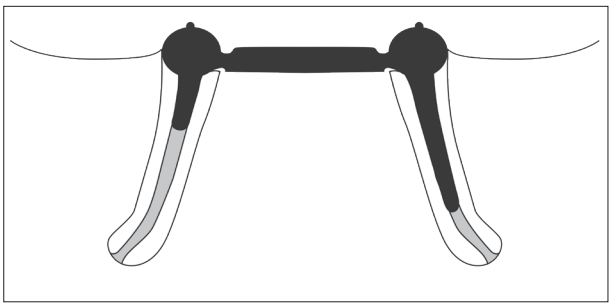

Figure 9. The drawing illustrates the situation when a definitive endodontic filling in the amount of 2/3 of the length of the root canal was prepared and removed in the right root canal, while a maximum of 1/3 of the root canal length (or even less) was removed in the left root which created favorable conditions for simultaneous manual cementation of the retention structure in both root canals.
Slika 9. Crtež ilustruje situaciju kada je u desnom kanalu korena preparirano i uklonjeno definitivno endodontsko punjenje u iznosu od 2/3 dužine kanala korena, dok je iz levog kanala korena ekstrahovano najviše do 1/3 dužine kanala korena (ili čak i manje), čime su stvoreni povoljni uslovi za jednovremeno manuelno cementiranje retencione konstrukcije u oba korenska kanala.

(Figure 8) could not be solved by the construction shown in our paper - in such cases the construction with two retention casted posts could not be placed in the roots of supporting teeth. Likewise, parallel roots of the remaining roots could be the problem too. In such cases, it would actually not be a good idea to form posts up to ½ the length of the root canal. Rather, it would be necessary to prepare deeper, and remove the canal filling before making the post model at least from 2/3 of the canal length of each canine root (Figure 6). Anatomically parallel root canals of the canines in the lower jaw represent a difficulty and a weakly resistant surface of the supra-structure could be easily removed from the root canal, as they are parallel between them as well as with separating, parting and removal of the prosthesis (Figure 6).

Regarding the shape of the dedicated copings over the surfaces of the remaining roots, three approaches could be considered in choosing the shape of the coping: 1) the first approach would imply that the copings are made symmetrically (like a hemisphere); 2) in the second approach, copings would be shaped as oval (more or less elongated, i.e. ellipsoidal) forms and 3) for dedicated covering copings to be additionally milled. According to the authors, the first approach is the most favorable in achieving the

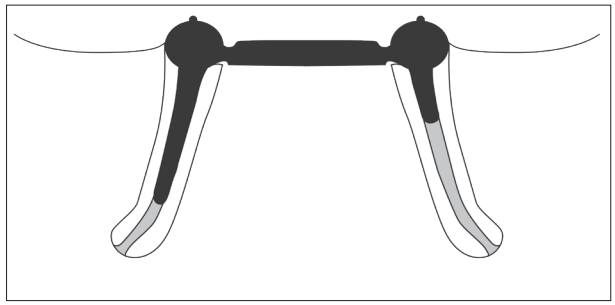

Figure 10. The drawing illustrates the situation when a definitive endodontic filling in the amount of 2/3 of the root canal length was prepared and removed in the left root canal, while in the right root canal only 1/3 of the root canal length (or even less) was removed, which created favorable conditions for simultaneous manual cementation of the retention structure in both root canals.
Slika 10. Crtež ilustruje situaciju kada je u levom kanalu korena preparirano i uklonjeno definitivno endodontsko punjenje u iznosu od 2/3 dužine kanala korena, dok je iz desnog kanala korena ekstrahovano najviše do 1/3 dužine kanala korena (ili čak i manje), čime su stvoreni povoljni uslovi za jednovremeno manuelno cementiranje retencione konstrukcije u oba korenska kanala.

best results due to the fact that only the hemispherical shape allows centric-axial loading on the top of the hemispherical surface (which is significant in this clinical case due to the placement of the supplementary connecting element-patrix on the surface of the hemisphere), and it also enables more favorable redistribution of the forces acting on the surface of the coping during the functions of the oro-facial (stomatognathic) system [9]. The second approach - which involves designing a dedicated ovoid, i.e. oval-shaped coping in this case could not be recommended, both because of the impossibility of directing the occlusal and all other forces in the function of the oro-facial system in axial direction, as well as because of the difficulties in determining the exact position of supplementary precise connecting element-attachment on the top of the dedicated coping. The third possibility, which refers to the milling of the copings, could not be applied in our case, as milled surface, although it significantly contributes to the primary and secondary retention of the dedicated coping in general [7], would not achieve either sufficient or significantly large surface of the prosthesis resting on the milled surfaces, and therefore secondary retention-stabilization would not be significantly improved.

Special protective coping needs to be designed to protect the tooth structure of the remaining carrier teeth and prevent loosening and falling the roots of retained carrier teeth in the jaw [11]. Protective copings are considered as a very necessary ones, even in cases where the remaining last teeth are planned to be extracted and be replaced with implants as a supporting structure [13].

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Terapija donje vilice supradentalnom prekrivnom protezom retiniranom prečkom i preciznim kugličastim veznim elementima

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KRATAK SADRŽAJ

Uvod Frezovana prečka sa dodatkom dva precizna atečmena lateralno levo i desno na krajevima fiksne konstrukcije može značajno doprineti poboljšanju primarne i sekundarne retencije ne samo parcijalne proteze već i prekrivne proteze.

Cilj rada je da na osnovu prikaza slučaja iz kliničke prakse ukaže na mogućnost poboljšanja stabilnosti prekrivne proteze u donjoj vilici u kojoj su postavljena dva precizna vezna elementa i jedna frezovana prečka.

Prikaz slučaja Pacijent muškog pola star 65 godina imao je dva endodontski sanirana korena očnjaka sa desne i sa leve strane u donjoj vilici. Krezubost u gornjoj vilici je zbrinuta postavljanjem semicirkularnog mosta. Odluka da kao definitivna konstrukcija bude izrađena metalna frezovana prečka i kasnije i prekrivna proteza sa bazom ojačanom metalnim skeletom je bila uslovljena prisustvom metalokeramičkog semicirkularnog mosta u gornjoj vilici. Endodontski lečeni i zbrinuti kanali korenova dva preostala očnjaka u donjoj vilici su preparirani za postavljanje livenih kočića. Posle definitivnog otiskivanja donje vilice i preostalih korenova u donjoj vilici A-silikonom u individualnoj kašici, izliven je radni model od tvrdog gipsa sa reprodukcijama prepariranih kanala korenova očnjaka. Zatim su izlivena dva metalna kočića i kapice povezane frezovanom prečkom. Patrice preciznih veznih elemenata su zatim postavljene na vrhove prekrivnih kapica u sveukupnoj protetskoj konstrukciji vodeći pri tome računa da bude ostvaren aksijalni prenos preko preciznog veznog elementa prema korenu kanala očnjaka na desnoj i na levoj strani vilice. Model protetske konstrukcije je zatim odvojen od radnog modela donje vilice i uložen i izliven. U sledećem postupku je oblikovan skelet baze buduće donje prekrivne proteze koji je uložen i izliven. Posle faze određivanja međuviličnih odnosa izvršen je izbor anatomski oblikovanih akrilatnih veštačkih zuba. U sledećem postupku je u ustima obavljena proba voštanog modela donje prekrivne proteze sa postavljenim matricama preciznih veznih elemenata. Na kraju je model prekrivne proteze uložen, polimerizovan i proteza je difinitivno obrađena i ispolirana. Metalna konstrukcija sačinjena od dva kočića ispod prekrivnih kapica sa patricama preciznih veznih elemenata na vrhovima kapica povezanih frezovanom prečkom cementirana je pomoću samovezujućeg adhezivog cementa istovremeno sa postavljanjem prekrivne proteze na noseća tkiva.

Zaključak Frezovana individualizovana prečka poboljšava i retenciju i stabilnost prekrivne proteze. Koronarno postavljena patrica atečmena obezbeđuje preraspodelu okluzionih i drugih sila koje se mogu javiti u funkciji orofacijalnog sistema, prema apikalnim površinama korenova preostalih zuba nosača.

Ključne reči: supradentalna proteza; donja vilica; precizni vezni element

UVOD

U domaćoj i inostranoj literaturi iz stomatološke protetike postoji čitav niz navoda i prikaza različitih retencionih sistema koji mogu biti primenjeni u rešavanju suptotalne krezubosti, u slučajevima kada u ustima pacijenta još uvek postoji nekoliko zadržanih zuba, ili korenova zuba i kada još uvek nije postignut konsenzus oko ugradnje implanta.

Pojedini, u literaturi pominjani, sistemi predstavljaju jednostavnija konstrukciona rešenja. [1–5]. Drugi sistemi, međutim, imaju složenije komponente u sastavu dentalne protetske konstrukcije [5–8].

Uzimajući u obzir čitav spektar različitih retencionih sistema koji danas postoje na dentalnom tržištu, vrlo važan pristup u rešavanju problema retencije i stabilizacije proteza kod pacijenata sa suptotalnom krezubošću čine sagledavanje i procena takvog sistema preciznih veznih elemenata koji će za dati tip krezubosti najviše doprineti primarnoj retenciji i sekundarnoj retenciji – stabilizaciji.

Cilj ovog rada je da na osnovu prikaza slučaja iz kliničke prakse ukaže na mogućnost poboljšanja stabilnosti prekrivne proteze u donjoj vilici u kojoj su primarno postavljena dva precizna vezna elementa i jedna frezovana prečka kao nosioci proteze.

PRIKAZ SLUČAJA

Pacijent muškog pola SD, star 65 godina, imao je dva endodontski sanirana korena očnjaka sa desne i sa leve strane u donjoj vilici. Krezubost u gornjoj vilici je zbrinuta postavljanjem semicirkularnog mosta. Endodontski lečeni i zbrinuti kanali disparalelnih korenova dva preostala očnjaka u donjoj vilici su preparirani i pripremljeni za protetsku sanaciju uklanjanjem 2/3 dužine jednog kanalnog punjenja i uklanjanjem 1/3 dužine kanala korena suprotnog preostalog očnjaka. Posle definitivnog otiskivanja donje vilice i preostalih korenova u donjoj vilici A-silikonom u individualnoj kašici je izliven radni model od tvrdog gipsa (Elite-master sa smolom, tip IV, Zhermack, Italy) sa reprodukovanim konično oblikovanim udubljenjima u prepariranim kanalima korenova očnjaka. U sledećem postupku, pomoću voska za modelaciju oblikovani su voštani kočići odgovarajući oblicima prepariranih udubljenja u kanalima korenova preostalih očnjaka, a zatim su modelovane kapice od voska nad preostalim kruničnim površinama očnjaka. Između kapica je oblikovana individualizovana frezovana prečka (Bredent, VSP-FS/GS, Germany), a na vrhovima voštanih oblika prekrivnih kapica je postavljena sa svake strane po jedna patrica preciznog veznog elementa (Bredent VKS-uni 1.7 mm, Germany). Zatim je model sveukupne konstrukcije koja se sastojala od dva kočića sa kapicama povezanim frezovanom prečkom uložen u cilindar sa masom za ulaganje i izliven legurom specifičnih metala (Wironit® Bego, USA).

U sledećem postupku je korišćenjem voštanih profila oblikovan skelet baze buduće donje prekrivne supradentalne proteze, koji je uložen i izliven od Co-Cr-Mo legure (Remanium GM 800, Dentaurum, Germany) (Slika 1). Na radnom modelu krezube vilice oblikovani su voštani bedem i zagrižajna šablona, u čijem sastavu se nalazio i izliven skelet baze prekrivne supradentalne proteze. Posle faze određivanja međuviličnih odnosa izvršen je izbor anatomski oblikovanih veštačkih zuba. U sledećem postupku je obavljena proba voštanog modela donje prekrivne proteze sa postavljenim matricama preciznih veznih elemenata. Na kraju je model donje prekrivne proteze uložen, polimerizovan i proteza je definitivno obrađena i ispolirana (Slika 2). Metalna konstrukcija sačinjena od dva kočića ispod prekrivnih kapica sa patricama preciznih veznih elemenata na vrhovima kapica povezanih frezovanom prečkom cementirana je pomoću samovezujućeg adhezivog cementa (Totalcen, dual-cure, Itena Clinical, France) istovremeno sa postavljanjem prekrivne proteze na noseća tkiva (slike 3, 4, 5).

DISKUSIJA

Zadržavanje preostalih zuba, odnosno korenova zuba u vilicama, još uvek se smatra biološkim konceptom koji može značajno doprineti očuvanju nivoa preostalog alveolarnog grebena u vilicama i poslužiti za prihvatanje prekrivne supradentalne proteze [1, 3, 4, 5, 9, 10]. Sa druge strane, u stručnoj, posebno inostranoj literaturi, može se naći sve veći broj radova koji navode podatak da je upravo ekstrakcija dva ili jednog preostalog zuba u vilici i postavljanje najmanje dva, odnosno četiri implanta najboje rešenje u primenjenoj terapiji uslovne krezubosti, odnosno bezubosti supradentalnom prekrivnom protezom [8, 11–14].

U pogledu terapijskog pristupa u saniranju i rehabilitovanju krezube donje vilice, kod ovog pacijenta je bilo izvesnih nedoumica u pogledu rešenja i postavljanja konačne protetske konstrukcije. Pri planiranju definitivne konstrukcije najviše se vodilo računa o tome da obavezno bude ostvaren aksijalni prenos preko preciznog veznog elementa prema korenu kanala očnjaka na desnoj i na levoj strani vilice. Odluka da kao definitivna konstrukcija bude izrađena metalna livena forma frezovane prečke, a kasnije i prekrivna proteza sa bazom ojačanom metalnim skeletom bila je uslovljena prisustvom metalokeramičkog semicirkularnog mosta u gornjoj vilici. Frezovana individualizovana prečka poboljšava i retenciju i stabilnost prekrivne proteze. Koronarno postavljena patrica atečmena obezbeđuje preraspodelu okluzionih i drugih sila koje se mogu javiti u funkciji orofacijalnog sistema, prema apikalnim površinama zadržanih korenova preostalih zuba nosača [5, 9].

Inače, prema mogućnostima koje bi bile na raspolaganju na osnovu prikaza sličnih slučajeva iz domaće, a takođe i iz strane literature, jedan od mogućih pristupa je bio da na preostalim korenovima budu napravljene livene nadogradnje, i zatim teleskop-dvostruke krune sa retencionim produžecima za skeletiranu parcijalnu protezu [9, 15, 16]. U tom smislu odmah su nametnuti i problem predimenzioniranosti i problem estetski nezadovoljavajućeg efekta dvostrukih teleskopskih kruna na očnjacima, koji se zapravo nalaze u veoma vidljivom sektoru u ustima, tako da svako, makar i diskretno, povećanje dimenzija fasete ili spoljašnje krune u celini narušava spontanost i harmoniju u estetskom i fizičkom izgledu pacijenta. Sledeća mogućnost u terapijskom pristupanju sanacije krezubosti donje vilice pacijenta je bila ugradnja dva ili više implantata – levo i desno, odnosno distalno u bezubi greben donje vilice. Za ovakvo rešenje nije doneta odluka u prvom redu iz finansijskih razloga, a delimično i stoga što je kvalitet kosti bezubog grebena na jednoj strani donje vilice bio unekoliko sporan i oslabljen.

U pogledu razmatranja dizajna konstrukcije koja je izabrana kao rešenje u zbrinjavanju krezubosti i protetskoj rehabilitaciji pacijenta u ovom kliničkom slučaju je primenjena konstrukcija koja se sastoji od dve namenske kapice sa kočićima za retencije u prepariranim kanalima korenova. Između namenskih kapica se nalazi frezovana prečka [13]. Jedna od mogućnosti je bila i da se, u cilju poboljšanja retencije i stabilizacije prekrivne proteze na osnovnoj metalnoj konstrukciji sa prečkom dodatno distalno, na lateralnoj distalnoj strani desne namenske kapice i na lateralnoj distalnoj strani leve namenske kapice doda po jedna patrica preciznog atečmena u obliku prstena, bez obzira na već postojeću patricu atečmena kugličastog oblika na vrhu svake namenske kapice [16]. Ovakvo rešenje nije primenjeno u ovom slučaju iz razloga što namenske kapice na korenovima preostalih očnjaka nisu bile dovoljno masivne, odnosno po površini velike da dodatno prihvate i prsten na lateralnoj površini kapice (takva konstrukcija bi bila preglomazna, a pored toga bi postojao i problem otežanog ili previše intenzivnog odvajanja i razdvajanja matrica od patrica u sveukupnoj konstrukciji, što bi posle izvesnog vremena moglo uzrokovati pucanje vezujućeg cementa i odvajanje sveukupne frezovane metalne konstrukcije od korenova zajedno sa supradentalnom protezom).

Ukoliko su korenovi preostalih zuba endodontski tretirani, neophodno je u definitivnu konstrukciju uključiti izlivene metalne kočiće. U tom smislu punjenje iz kanala korena treba ukloniti bar u iznosu od 1/2 dužine kanala, a najbolje bi bilo ukoliko bi punjenje bilo uklonjeno u iznosu od 2/3 od ukupne dužine kanala korena (Slika 6). Teškoće, međutim, nastaju ukoliko su korenovi preostalih zuba u vilici disparalelni. Što je disparalelitet veći, problem je izraženiji (slike 7 i 8) Disparalelitet dva preostala korena zuba može se prevazići izračunavanjem dozvoljenog odstupanja i shodno tome vrednosti ugla između dva disparalelna kočića koji još uvek dopuštaju postavljanje noseće metalne konstrukcije u jednoj manuelnoj manipulaciji terapeuta. U tom smislu, takođe je dobar pristup ukloniti do 2/3 dužine kanala korena iz jednog preostalog nosača, a iz drugog ukloniti oko 1/3 ili eventualno najviše do 1/2 punjenja, i zatim napraviti modele retencionih kočića (slike 9 i 10). Međutim, disparalelitet u smislu konvergencije apikalnih segmenata korenova prema medijalnoj liniji (Slika 8) ne može se rešiti konstrukcijom prikazanom u ovom radu – u takvim slučajevima konstrukcija sa dva retenciona izlivena kočića ne bi mogla biti postavljena u korenove zuba nosača. Isto tako, prilično izražen problem mogu predstavljati i paralelno postavljeni korenovi preostalih očnjaka u kosti. U takvim slučajevima zapravo ne bi bilo dobro oblikovati kočiće u dužini do 1/2 kanala korena, već bi bilo potrebno preparirati dublje, i kanalno punjenje pre izrade modela kočića ukloniti bar iz 2/3 dužine kanala svakog korena očnjaka (Slika 6). Anatomski paralelno postavljeni kanali korenova očnjaka u donjoj vilici predstavljaju teškoću i slabo otpornu površinu konstrukcije, koja može biti lako izvađena iz kanala korenova, s obzirom na činjenicu da se nalazi u istom pravcu koji je ujedno i pravac odvajanja, iznošenja i vađenja proteze (Slika 6).

U pogledu oblika namenskih kapica nad površinama preostale zubne supstance levog i desnog očnjaka mogla bi se

razmatrati tri pristupa u oblikovanju kapice: 1) prvi pristup bi podrazumevao da kapice budu napravljene simetrično (kao polulopta); 2) u drugom pristupu bi trebalo uzeti u obzir i mogućnost da kapice budu oblikovane kao ovalne (manje-više izdužene, odnosno elipsoidne) forme i 3) da namenske prekrivne kapice budu dodatno frezovane. Prema mišljenju autora, prvi pristup najviše pogoduje u ostvarenju najboljeg rezultata u terapiji krezubosti donje vilice iz razloga što samo poluloptasti oblik dozvoljava centrično-aksijalno opterećenje na vrhu poluloptaste površine (što je u ovom kliničkom slučaju značajno zbog postavljanja dopunskog veznog elementa – patrice na površinu polulopte), a takođe i omogućava povoljniju preraspodelu sila koje deluju na površinu kapice tokom funkcija orofacijalnog, (stomatognatog) sistema [9]. Drugi pristup, gde se podrazumeva oblikovanje namenske kapice ovoidnog, odnosno ovalnog oblika, u ovom slučaju ne bi mogao biti preporuka, kako zbog nemogućnosti usmeravanja okluzionih i svih drugih sila u funkciji orofacijalnog sistema u aksijalnom pravcu, tako i zbog teškoća u određivanju tačnog položaja dopunskog preciznog veznog elementa na vrhu namenske kapice. Treća mogućnost, koja se odnosi na frezovanje kapica, takođe ne bi mogla doći u obzir da bude primenjena u ovom radu, iz razloga što frezovana površina, iako značajno doprinosi primarnoj i sekundarnoj retenciji namenske kapice uopšte [7], ne bi ostvarila ni dovoljnu, niti značajno veliku površinu naleganja proteze na frezovane površine, pa samim tim ni sekundarna retencija– stabilizacija ne bi bila značajno poboljšana.

Zaštitne namenske kapice je potrebno oblikovati da bi se zaštitila zubna supstanca preostalih zuba nosača i preveniralo labavljenje i ispadanje korenova zadržanih zuba nosača u vilici [11]. Zaštitne kapice se smatraju veoma potrebnim čak i u slučajevima kada je planirano da i poslednji zubi budu izvađeni i da na njihovom mestu budu ugrađeni implantati kao nosači konstrukcije [13].

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Serbian Dental Journal, vol. 69, N° 4, 2022 | 183

CASE REPORT
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Root Canal Treatment of an Extensive Periapical Lesion

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SUMMARY

Chronic apical periodontitis (CAP) is one of the most common endodontic diagnosis caused by microbial infection within the root canal system of the affected tooth. Endodontic therapy is one of the possible treatment modalities for CAP, but the prognosis depends on numerous factors. The size of the periapical lesion is always singled out as one of the most significant, as its increase drastically decreases the degree of success of endodontic therapy. Certain periapex radiographic indices (PAI, CBCT-PAI, PESS) are used to evaluate the size and characteristics of the periapical lesion, as well as to monitor the outcome of the implemented therapy. A 30-year-old patient presented with pain caused by an acute exacerbation of CAP on tooth 37. Radiographic analysis revealed the presence of an extensive, diffuse radiolucency in the area of tooth 37. A complete endodontic procedure was performed. One year after, there were clear, radiographic signs of the reduction of the lesion. Findings of periapical radiographic indices indicated the success of therapy as well. The aim of this paper was to present, on one case from clinical practice, complete endodontic therapy protocol of an extensive periapical lesion with symptoms of exacerbation.

Keywords: apical periodontitis; apical cyst; endodontic treatment; periapical index; PAI; CBCT-PAI

INTRODUCTION

Chronic apical periodontitis (CAP) develops as a result of microbial infection within the root canal system of the affected tooth. It represents an important defense mechanism against bacterial penetration into the alveolar bone and other nearby or distant structures. In the essence of this condition lies chronic inflammation followed by periapical bone resorption, which is why the characteristic radiographic image shows radiolucency in the periapical area of affected tooth. CAP is most often asymptomatic in nature and usually does not show clinical symptoms such as pain or swelling except in possible phases of exacerbation of the disease. Therefore, the diagnosis of this condition is based on clinical findings and additional radiographic analyses. Tibúrcio-Machado et al. found that the prevalence of CAP when using orthopantomography, retroalveolar radiography, and cone beam computed tomography (CBCT) was 46%, 56%, and 70%, respectively [1].

According to the results of recent literature reviews and meta-analyses, the estimated prevalence of this disease in the world is 52% [1, 2], which means that more than half of the world's population has at least one tooth with CAP. A study conducted by Ilić et al. [3] on the part of urban population in Serbia showed that 51.8% of the treated teeth had radiographic signs of CAP, with the frequency being significantly higher in teeth with inadequate compared to those with adequate root canal filling (72.2% and 25.9%, respectively). In support to the existence of a connection between CAP and general health, it should be mentioned that a significant difference of about 15% was observed in the frequency of CAP between healthy people and people suffering from some chronic disease [1], where it is most often registered in diabetics [4, 5], cardiovascular patients [6, 7] and smokers [8, 9]. In addition, it was shown that CAP is significantly more often described around the roots of teeth that have been previously endodontically treated (39% - 41% of all treated teeth), compared to teeth that have not been previously treated (3%), which further complicates the performance of endodontic therapy and reduces degree of success of CAP treatment [1, 2, 3].

Endodontic therapy in cases of CAP gives a success rate of 53.6% to 87.8% [10, 11, 12]. Studies have shown [13] that increasing lesion size directly increases the failure rate of non-surgical endodontic therapy for CAP. Therefore, although it is not a contraindication for orthograde endodontic treatment, the size of the periapical lesion, its borders, as well as the relationship with the tooth roots and surrounding important anatomical structures must always be taken into account. In addition to this parameter, Ng et al. [14] state pain, presence of swelling or fistula, deep periodontal defects, achievement and preservation of apical patency, non-transfer of septic material through the apex, absence of exacerbations during therapy as significant pre-, intra- and postoperative prognostic factors, the elapsed time until the placement of definitive restoration and the quality of the crown seal.

Due to objective impossibility of histopathological analysis of each lesion, the definitive diagnosis of CAP is established by radiographic findings. Certain radiographic indices are available to clinicians in order to, in combination with clinical findings, evaluate the possibility of success of planned endodontic therapy. The PAI index (periapical index) [15] is a scoring system that evaluates the condition of

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Figure 1. Retroalveolar radiograph done at first visit presenting previously treated lower, left second molar and an extensive radiolucency around both roots
Slika 1. Retroalveolarni radiogram sa početka terapije na kome se uočava prethodno lečen zub 37 sa ekstenzivnim rasvetljenjem oko oba korena

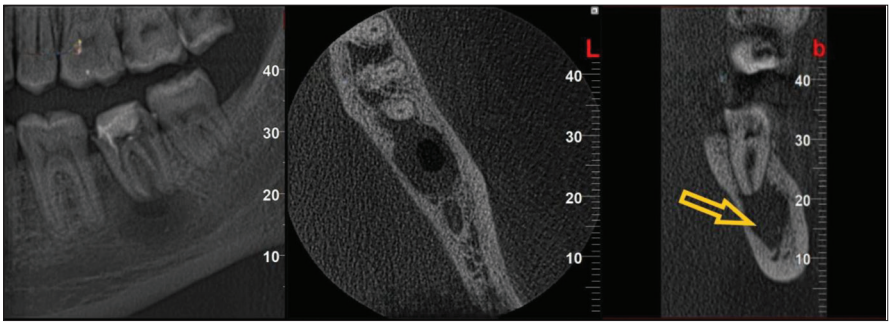

Figure 2. Representative sections from CBCT made right after the first visit: (a) coronal plane; (b) axial plane presenting well-defined radiolucency inside the bigger, diffuse radiolucency; (c) sagital plane presenting breakdown of the roof of the mandibular canal
Slika 2. Reprezentativni preseci CBCT snimka načinjenog nakon dezopturacije i uspostavljanja transkanalne drenaže: (a) koronalni presek i (b) aksijalni presek, na kojima se uočava jasno ograničeno rasvetljenje unutar većeg difuznog; (c) sagitalni presek, na kome se uočava oštećenje krova mandibularnog kanala

the periapical bone on a retroalveolar radiograph, with the lowest score of 1 being assigned to a healthy apical periodontium, and the highest score being 5 to diffuse periapical radiolucency. CBCT-PAI (CBCT – periapex index) [16] is a scoring system for 3D radiographic findings obtained by CBCT, scores from 0 to 5, whereby the size of the lesion is determined linearly in three dimensions (buccal-oral, mesio-distal and diagonal), and the lesion is evaluated with the highest score. Radiolucencies smaller than 1 mm receive a score of 1, while the highest score of 5 is given to lesions that are larger than 8 mm in at least one dimension. The CBCT-PAI index, in addition to the grade, may also contain the letters E or D, which describe the expansion and destruction of the cortical bone, respectively. PESS (Periapical and Endodontic Status Scale) is a hybrid index [17] and differs from the previously described indices in that it not only evaluates the radiological characteristics of CAP, but also the quality of endodontic treatment. It consists of two indices (COPI and ETTI). COPI (Complex Periapical Index) evaluates CAP threefold, according to: the size of the lesion, its relationship with the root, i.e. the roots of the teeth, and the location of CAP in relation to important anatomical structures. ETTI (Endodontically Treated Tooth Index) evaluates the quality of endodontic treatment by analyzing: length of filling, homogeneity of filling, quality of crown sealing and possible presence of errors or complications (such as perforations, resorption, untreated canals, etc.).

The aim of this work is to present the effects of endodontic therapy of large periapical lesions on one case from clinical practice.

CASE REPORT

A 30-year-old male patient came to the Clinic of Restorative Odontology and Endodontics due to pain and swelling in the area of tooth 37. He did not report in his medical history any chronic disease and denied taking any medications. The patient stated that tooth 37 was primarily endodontically treated more than 10 years ago, and that in the past 7 years, several exacerbations occurred during which he took antibiotics, without dental interventions.

The patient described the pain as unbearable, non responsive to analgesic therapy. It lasted for hours, constantly and extended over the entire left half of the face towards the ear and temple region. He stated that the swelling appeared one day before reporting to this institution. Clinical examination revealed submandibular extraoral and intraoral swelling in the area of the tooth 37, that had a metal-ceramic crown and with exceptional sensitivity to percussion. Analysis of the retroalveolar image (Figure 1) revealed a diffuse, ellipsoidal extensive radiolucency, approximately 10 × 12 mm around both roots of the tooth 37. It was assigned a score of 5 according to the PAI index (diffuse radiolucency). A shadow corresponding to a metal intracanal post was observed in distal canal.

In order to relieve pain, the metal-ceramic crown and the intracanal post were removed in the same visit. Root canal filling material was removed from canals and transcanal drainage was established in each canal to the size of the apex of K#40 master file. Abundant purulent content was obtained, and the tooth was allowed to drain spontaneously. Antibiotic therapy was prescribed (Amoxiclav tab. 1.0) and advice was given on cold compresses. The patient was referred for a small-field CBCT scan of the region of the tooth 37. Analysis of the CBCT scan (Figure 2) described a diffuse change of grade 5 according to the CBCT-PAI index (dimensions 13.5×10×9.3 mm), within which a clear limited radiolucency was described. (dimension 4×4×5.5 mm). On the COPI scale, the change is graded S3 (the highest grade that refers to the size of the lesion and which is used to evaluate changes greater than 5mm in one of its dimensions), R2 (the grade that describes the relationship of the change to the roots of the teeth and is assigned to lesions that are in contact with more than one root, while not affecting the area of furcation) and D2 since the roof of the mandibular canal was damaged (a score that describes the localization of the lesion in the bone and which indicates lesions that communicate with important anatomical structures, but did not lead to destruction of cortical jaw bones). In addition, significant thinning of the lingual lamella of the

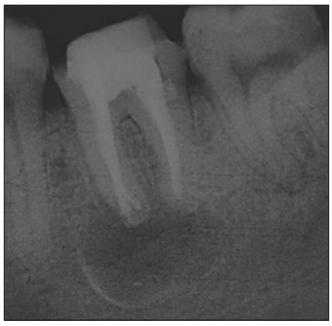

Figure 3. Retroalveolar radiograph done three months after therapy presenting healing of radiolucency and appearance of thin calcification of the central lesion wall
Slika 3. Retroalveolarni radiogram načinjen tri meseca posle početka terapije, na kome se uočava smanjenje veličine rasvetljenja, kao i formiranje tankog zasenčenja zida centralne promene

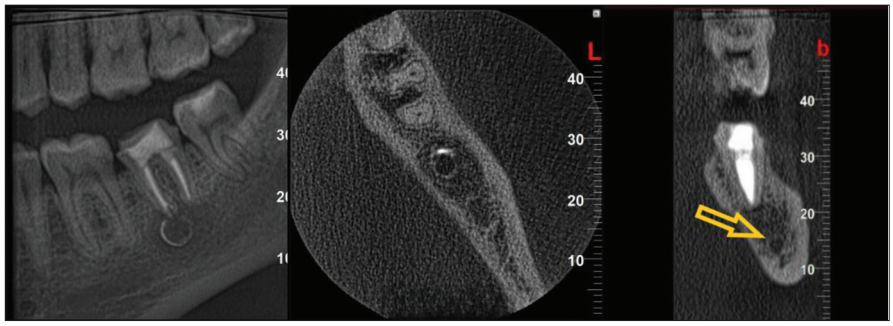

Figure 4. Representative sections from CBCT made one year after therapy: (a) coronal and (b) axial plane presenting reduction of diffuse lesion as well as calcification of the wall of central radiolucent lesion; (c) sagital plane presenting newly formed mandibular canal roof
Slika 4. Reprezentativni preseci CBCT snimka godinu dana posle terapije: (a) koronalni presek i (b) aksijalni presek, na kojima se uočava smanjenje dimenzija difuzne promene, kao i kalcifikacija zida jasno ograničene promene sa početka; (c) sagitalni presek, na kome se uočava ponovno formiranje krova mandibularnog kanala

cortical jaw bone was also described. Since the tooth was de-opturated before the CBCT image was taken, it was not possible to evaluate the primary endodontic treatment with the three-dimensional ETTI scale. However, the analysis of the two-dimensional retroalveolar radiogram describes a homogeneous obturation of adequate length, as well as the presence of an adequate coronary restoration that appears radiographically intact. The presence of endodontic complications such as perforations, root resorption, forgotten and untreated canals was not observed.

After complete relief of symptoms, which occurred a few days after the emergency treatment, the endodontic therapy continued. The canals were prepared using the double cone technique. Apex preparation was completed with a K#60 instrument in both mesial canals and a K#80 in the distal canal. For irrigation, the following were used: 0.5% NaOCl, 10% citric acid, saline and 2% CHX with ultrasonic activation. In the course of further therapy in the third visit, about 5 ml of serous content was obtained from the mesial canals by transcanal aspiration with a standard syringe and a 27G needle. Fresh Ca(OH)2 paste was used as an intracanal medication, which was applied three times for 7 days. One month after the start of therapy, in the absence of symptoms and clinical signs of infection, tooth 37 was definitively filled with AH plus endodontic paste (Dentsply Sirona, Tulsa, Oklahoma, USA) and gutta-percha points using the cold lateral compaction method. The tooth was closed with a temporary material based on resin-reinforced glass ionomer cement Fuji II (GC Europe, Louvain, Belgium), and after 7 days a temporary acrylic crown was placed.

At the first check-up, after 3 months, the patient was without symptoms, and a comparative analysis of new (Figure 3) and the primary retroalveolar radiograph (Figure 1) showed a decrease in the size of the radiolucency, as well as formation of a thin shadowing of the wall of the central change. Radiolucency still remains in the domain of two-dimensional assessment PAI 5. At the next check-up, after one year, a small-field control CBCT was performed (Figures 4), which showed a decrease in the size of CAP in all three dimensions (11.4×7.5×7.6 mm). However, the lesion still remains in CBCT-PAI grade zone 5. Also, the thickening of the lingual lamella and formation of the roof of the mandibular canal, as well as semicircular linear light corresponding to the hypercalcified bone in the central zone are observed. On the COPI scale, although the lesion has decreased, it still remains in the domain of S3 and R2, while in relation to important anatomical structures it receives a lower value of D1. The ETTI index is now L0, H1, CS2 and CF0, which indicates adequate length (L0) and homogeneity of filling (H1), as well as the absence of visible errors and complications (CF0). A temporary crown remained on the tooth even during this check-up, with the patient's explanation that time constraints prevented a visit to the prosthodontist and definitive treatment with a new crown. Therefore, coronary restoration was assessed as inadequate (CS2).

DISCUSSION

Currently available evidence does not provide clinicians with reliable and clear guidelines for the management of extensive periapical lesions. There is no evidence of superiority of surgical compared to non-surgical approach to the treatment of CAP after one year, nor after 4 and 10 years [18]. For the treatment of primary lesions, clinicians generally opt for an endodontic approach, while for the treatment of secondary lesions, they more often opt for a surgical approach [19, 20]. However, in the era of endodontic microscopes, ultrasound preparation and irrigation, as well as better instrumentation that ensures a more certain retreatment outcome, the need for primary surgical therapy is decreasing [21, 22].

In the tooth shown, the presence of clearly limited radiolucency within the larger periapical diffused lesion indicates the existence of a cystic formation within the granuloma, which is consistent with clear, serous content

obtained by transcanal aspiration. Transcanal aspiration was performed after it was noticed that the root canals of the teeth were intensively filled with clear content and that it was not possible to dry them in the initial stages of therapy. Since the apical preparation was done with #60 and #80 canal files, it was possible to pass the needle (27G) passively over the tip of the root of the tooth and aspirate contents without further dentin removal. Transcanal aspiration is not part of the usual endodontic protocol in the treatment of CAP, but decompression achieved this way has been suggested as a method that can sometimes give success [23]. This way, with the synergistic effect of decompression of the cyst walls and an adequate antimicrobial protocol enhanced by the activation of irrigants, the prerequisites for healing of periapical lesion were created.

Complete calcification of the walls of the cystic lesion, clearly visible on the control CBCT image, may be a consequence of the collapse of the epithelial cover of the cyst and its demarcation by a defensive osteogenic reaction. We interpret this as a sign of arresting the pathological process, while monitoring the condition of the bone in the following years is of course necessary. Large periapical lesions that clinically and radiographically correspond to apical cysts with transcanal drainage and full mechanical-drug root canal treatment may respond well to non-surgical endodontic therapy [24].

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Endodontska terapija velike periapeksne lezije

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KRATAK SADRŽAJ

Hronični apeksni periodontitis predstavlja jedno od najrasprostranjenijih endodontskih oboljenja, a razvija se kao posledica infekcije u kanalu korena zuba. Endodontska terapija jedan je od mogućih modaliteta lečenja hroničnog apeksnog periodontitisa, a prognoza uspeha zavisi od brojnih faktora. Kao jedan od najznačajnijih uvek se izdvaja veličina periapeksne lezije, sa čijim povećanjem drastično opada stepen uspeha endodontske terapije. Za evaluaciju veličine i karakteristika periapeksne lezije, kao i praćenje ishoda sprovedene terapije koriste se određeni periapeksni radiografski indeksi (PAI, CBCT-PAI, PESS). Pacijent starosti 30 godina javio se zbog bolova uzrokovanih akutnom egzarcerbacijom hroničnog apeksnog periodontitisa na zubu 37. Radiografska analiza pokazala je postojanje velikog difuznog rasvetljenja u predelu zuba 37. Realizovana je kompletna endodontska intervencija i nakon godinu dana uočavaju se radiografski znaci smanjenja lezije, a nalazi periapeksnih radiografskih indeksa ukazuju na uspeh terapije. Cilj ovog rada je bio da se na jednom slučaju iz kliničke prakse prikaže postupak ortogradne endodontske terapije velike periapeksne lezije sa simptomima egzacerbacije.

Ključne reči: hronični apeksni periodontitis; apikalna cista; endodontska terapija; periapeksni indeks; PAI; CBCT-PAI

UVOD

Hronični apeksni periodontitis (HAP) razvija se kao posledica infekcije u kanalu korena i predstavlja važan odbrambeni odgovor organizma na prodor mikroorganizama u alveolarnu kost i druge, bliske ili udaljene strukture. Patološki supstrat ove promene je hronična inflamacija praćena resorpcijom periapeksne kosti, zbog čega je i karakteristična radiografska slika prisustvo rasvetljenja u zoni vrha korena obolelog zuba. Hronični apeksni periodontitis je najčešće asimptomatske prirode i obično ne pokazuje kliničke simptome poput bola ili otoka, osim u mogućim fazama egzarcebacije bolesti. Stoga se dijagnoza ovog stanja postavlja na osnovu kliničkog nalaza i dodatnih radiografskih analiza. Tibúrcio-Machado i sar. su utvrdili da je prevalenca HAP-a kada je korišćena ortopantomografija, retroalveolarna radiografija i kompjuterizovana tomografija konusnog snopa (CBCT) redom bila 46%, 56% i 70% [1].

Prema rezultatima skorašnjih pregleda literature i metaanaliza procenjena prevalenca ovog oboljenja u svetu je 52% [1, 2], što znači da više od polovine svetske populacije ima makar jedan zub sa HAP-om. Studija koju su sproveli Ilić i sar. [3] na delu urbane populacije Srbije pokazala je da je 51,8% lečenih zuba imalo radiografske znake HAP-a, pri čemu je učestalost bila značajno veća kod zuba s neodgovarajućim u odnosu na one s odgovarajućim punjenjem kanala korena (72,2% i 25,9%, redom). U prilog postojanju veze između HAP-a i opšteg zdravlja treba pomenuti da je primećena značajna razlika, od oko 15%, u učestalosti HAP-a između zdravih osoba i osoba koje boluju od neke hronične bolesti [1], pri čemu je najčešće registrovana kod dijabetičara [4, 5], kardiovaskularnih pacijenata [6, 7] i pušača [8, 9]. Dodatno, pokazano je da se HAP značajno češće opisuje oko korenova zuba koji su prethodno endodontski lečeni (39–41% svih lečenih zuba) u odnosu na zube koji nisu prethodno zbrinjavani (3%), što dodatno otežava izvođenje endodontske terapije i smanjuje stepen uspeha lečenja HAP-a [1, 2, 3].

Endodontska terapija u slučajevima HAP-a daje stepen uspeha od 53,6% do 87,8% [10, 11, 12]. Studije su pokazale [13] da se povećanjem veličine lezije direktno povećava stepen neuspeha nehirurške endodontske terapije HAP-a. Stoga, iako ne predstavlja kontraindikaciju za ortogradni endodontski tretman, veličina periapeksne lezije, njene granice, kao i odnos sa korenovima zuba i okolnim važnim anatomskim strukturama uvek se moraju uzeti u obzir. Pored ovog parametra, Ng i saradnici [14] kao značajne preoperativne, intraoperativne i postoperativne prognostičke faktore navode bol, postojanje otoka ili fistule, duboke periodontalne defekte, postizanje i očuvanje apikalne prohodnosti, neprebacivanje septičnog materijala preko apeksa, odsustvo egzarcebacija u toku terapije, proteklo vreme do postavljanja definitivne restauracije i kvalitet kruničnog zaptivanja.

Budući da se, zbog objektivne nemogućnosti histopatološke analize svake lezije, definitivna dijagnozu HAP-a postavlja radiografskim nalazom, kliničarima su dostupni određeni radiografski indeksi kako bi, u kombinaciji sa kliničkim nalazom, procenili mogućnost uspeha planirane endodontske terapije. PAI indeks (periapikalni indeks) [15] je sistem bodovanja kojim se ocenjuje stanje periapeksne kosti na retroalveolarnom radiogramu, pri čemu se najniža ocena – 1 dodeljuje zdravom apeksnom parodoncijumu, a najviša ocena – 5 difuznom periapeksnom rasvetljenju. CBCT-PAI (CBCT – periapeksni indeks) [16] predstavlja sistem bodovanja 3D radiografskog nalaza dobijenog primenom CBCT-a, ocenama od 0 do 5, pri čemu se veličina lezije linearno određuje u tri dimenzije (bukooralnoj, meziodistalnoj i dijagonalnoj), a lezija se ocenjuje najvećom ocenom. Rasvetljenja manja od 1mm dobijaju ocenu 1, dok najveću ocenu – 5 dobijaju lezije koje su veće od 8 mm u makar jednoj dimenziji. CBCT-PAI pored ocene može sadržati i slova E ili D, koja opisuju redom ekspanziju, odnosno destrukciju kortikalne kosti. PESS (Periapical and Endodontic Status Scale) hibridni je indeks [17] i razlikuje se od prethodno opisanih indeksa po tome što ne ocenjuje samo radiološke karakteristike HAP-a već i kvalitet endodontskog lečenja. Sastoji se iz dva indeksa (COPI i ETTI). COPI (Complex Periapical Index) trostruko ocenjuje HAP, i to prema veličini lezije, njenom odnosu sa korenom, odnosno korenovima zuba, i lokacijom HAP-a u odnosu na značajne anatomske strukture. ETTI (Endodontically Treated Tooth Index) ocenjuje kvalitet endodontskog lečenja analizirajući dužinu punjenja, homogenost punjenja, kvalitet kruničnog zaptivanja i eventualno

prisustvo grešaka ili komplikacija (poput perforacija, resorpcija, neobrađenih kanala itd.).

Cilj ovog rada je da se na jednom slučaju iz kliničke prakse prikažu efekti endodontske terapije velikih periapeksnih lezija.

PRIKAZ SLUČAJA

Pacijent muškog pola, starosti 30 godina, javio se na Kliniku za bolesti zuba zbog bola i otoka u predelu zuba 37. U anamnezi navodi da ne boluje od hroničnih bolesti i negira uzimanje ikakvih lekova. Pacijent je naveo da je zub 37 primarno endodontski lečen pre više od 10 godina, kao i da su se u proteklih sedam godina nekoliko puta javljale egzarcebacije, u toku kojih je uzimao antibiotike, bez stomatoloških intervencija.

Pacijent je opisivao bol kao neizdrživ, koji nije prolazio na analgetsku terapiju, koji je trajao satima, konstantno i pružao se celom levom polovinom lica ka uhu i slepoočnici. Naveo je da se otok pojavio jedan dan pre javljanja u ovu ustanovu. Kliničkim pregledom uočen je submandibularni ekstraoralni, kao i intraoralni otok u predelu zuba 37, koji je bio zbrinut metalokeramičkom krunom i sa izuzetnom osetljivošću na perkusiju. Analizom retroalveolarnog snimka (Slika 1) uočeno je difuzno, elipsoidno ekstenzivno rasvetljenje, približnih dimenzija 10 × 12 mm oko oba korena zuba 37. Dodeljena mu je ocena 5 prema PAI indeksu (difuzno rasvetljenje). U distalnom kanalu se uočava senka koja odgovara metalnom intrakanalnom kočiću.

U cilju pružanja prve pomoći, u istoj poseti uklonjena je metalokeramička kruna, kao i intrakanalni kočić. Svi kanali su dezopturisani i u svakom je uspostavljena transkanalna drenaža do veličine apeksne master turpije K#40. Dobijen je obilan gnojni sadržaj, a zub je ostavljen da se spontano drenira. Ordinirana je antibiotska terapija (Amoksiklav tabl. 1,0) i dat savet o hladnim oblogama. Pacijent je upućen da uradi CBCT snimak malog polja regije zuba 37. Analizom CBCT snimka (Slika 2) opisuje se difuzna promena ocene 5 prema CBCT-PAI indeksu (dimenzija 13,5 × 10 × 9,3 mm) unutar koje se opisuje jasno ograničeno rasvetljenje (dimenzija 4 × 4 × 5,5 mm). Na COPI skali promena dobija ocene S3 (najveća ocena koja se odnosi na veličinu lezije i kojom se ocenjuju promene veće od 5 mm u jednoj od svojih dimenzija), R2 (ocena kojom se opisuje odnos promene s korenovima zuba i koja se dodeljuje lezijama koje su u kontaktu sa više od jednog korena, a pri tome nisu zahvatile predeo furkacije) i D2, budući da je narušen krov mandibularnog kanala (ocena kojom se opisuje lokalizacija lezije u kosti i kojom se označavaju lezije koje komuniciraju sa važnim anatomskim strukturama, a nisu dovele do destrukcije kortikalne kosti vilice). Pored toga, opisuje se i značajno istanjenje lingvalne lamele kortikalne kosti vilice. Budući da je zub dezopturisan pre nego što je načinjen CBCT snimak, nije bilo moguće primarno endodontsko lečenje oceniti trodimenzionalnom ETTI skalom. Međutim, analizom dvodimenzionalnog retroalveolarnog radiograma opisuje se homogena opturacija adekvatne dužine, kao i prisustvo adekvatne koronarne restauracije koja radiografski deluje intaktno. Ne uočava se prisustvo endodontskih komplikacija poput perforacija, resorpcija korena, zaboravljenih i netretiranih kanala i slično.

Nakon potpunog smirivanja simptoma, koje se javilo nekoliko dana nakon urgentnog tretmana, endodontska terapija je nastavljena. Kanali su preparisani tehnikom dvostrukog konusa. Apeksna preparacija završena je instrumentom K#60 u oba mezijalna kanala i K#80 u distalnom kanalu. U irigaciji su korišćeni 0,5% NaOCl, 10% limunska kiselina, fiziološki rastvor i 2% CHX uz ultrazvučnu aktivaciju. U toku dalje terapije u trećoj poseti, transkanalnom aspiracijom učinjenom standardnom brizgalicom i iglom promera 27G iz mezijalnih kanala dobijeno je oko 5 ml seroznog sadržaja. Kao intrakanalni medikament korišćena je sveža pasta $Ca(OH)_2$, koja je postavljana tri puta na po sedam dana. Nakon mesec dana od početka terapije, u odsustvu simptoma i kliničkih znakova infekcije, zub 37 je definitivno opturisan AHplus endodontskom pastom (Dentsply Sirona, Tulsa, Oklahoma, SAD) i gutaperka poenima metodom hladne lateralne kompaktaže. Zub je zatvoren privremenim materijalom na bazi smolom ojačanog glasjonomernog cementa Fuji II (GC Europe, Luven, Belgija), a posle sedam dana postavljena je privremena akrilatna kruna.

Na prvoj kontroli, nakon tri meseca, pacijent je bio bez simptoma, a uporednom analizom novog (Slika 3) i primarnog retroalveolarnog radiograma (Slika 1) uočava se smanjenje veličine rasvetljenja, kao i formiranje tankog zasenčenja zida centralne promene. Rasvetljenje još uvek ostaje u domenu dvodimenzionalne ocene PAI 5. Na sledećoj kontroli, nakon godinu dana, načinjen je kontrolni CBCT malog polja (Slika 4), na kome se uočava smanjenje veličine HAP-a u sve tri dimenzije (11,4 × 7,5 × 7,6 mm). Međutim, lezija i dalje ostaje u zoni ocene 5 CBCT-PAI. Takođe, uočava se zadebljanje lingvalne lamele i formiranje krova mandibularnog kanala, ali i polukružna linijska svetlina koja odgovara hiperkalcifikovanoj kosti u centralnoj zoni kao i na početku terapije. Na COPI skali, iako je došlo do smanjenja lezije, ona ipak ostaje u domenu S3 i R2, dok u odnosu prema važnim anatomskim strukturama dobija manju vrednost D1. ETTI indeks je sada L0, H1, CS2 i CF0, što govori o adekvatnoj dužini (L0) i homogenosti punjenja (H1), kao i o nepostojanju vidljivih grešaka i komplikacija (CF0). Na zubu je i tokom ove kontrole ostala privremena kruna sa pacijentovim obrazloženjem da su vremenska ograničenja onemogućavala posetu protetičaru i definitvno zbrinjavanje novom krunom. Stoga je koronarna restauracija ocenjena kao neadekvatna (CS2).

DISKUSIJA

Trenutno dostupni dokazi ne pružaju kliničarima pouzdane i jasne smernice za lečenje ekstenzivnih periapeksnih lezija. Ne postoje dokazi o superiornosti hirurškog u odnosu na nehirurški pristup lečenju HAP-a posle godinu dana, kao ni posle 4 i 10 godina [18]. Kliničari se za lečenje primarnih lezija uglavnom odlučuju za endodontski pristup, dok se za lečenje sekundarnih lezija češće odlučuju za hirurški pristup [19, 20]. Međutim, sa pojavom endodontskih mikroskopa, ultrazvučne preparacije i irigacije, kao i boljeg instrumentarijuma koji obezbeđuje izvesniji ishod retretmana, potrebe za primarnom hirurškom terapijom se smanjuju [21, 22].

Kod prikazanog zuba prisustvo jasno ograničenog rasvetljenja unutar veće periapeksne difuzne lezije ukazuje na postojanje cistične tvorevine unutar granuloma u skladu sa čime je i bistar, serozni sadržaj dobijen transkanalnom aspiracijom. Transkalana aspiracija je načinjena nakon što je primećeno da se kanali korena zuba intenzivno ispunjavaju bistrim sadržajem i da ih nije moguće posušiti u početnim fazama terapije. Budući

da je apikalna preparacija urađena kanalnim turpijama broj #60 i #80, bilo je moguće bez daljeg uklanjanja dentina pasivno preći iglom (27G) preko vrha korena zuba i aspirirati prisutan sadržaj. Transkanalna aspiracija nije deo uobičajenog endodontskog protokola u terapiji HAP-a, ali dekompresija postignuta na ovaj način predložena je kao metoda koja nekada može dati uspeh [23]. Na taj način, sinergičnim uticajem dekompresije zidova ciste i adekvatnog antimikrobnog protokola pospešenog aktivacijom irigansa stvoreni su preduslovi za izlečenje periapeksne lezije.

Potpuna kalcifikacija zidova cistične promene, koja je jasno uočljiva na kontrolnom CBCT snimku, može biti posledica kolapsa epitelnog pokrova ciste i njegove demarkacije odbrambenom osteogenom reakcijom. Ovo tumačimo kao znak zaustavljanja patološkog procesa, dok je praćenje stanja kosti narednih godina naravno neophodno. Velike periapeksne lezije koje klinički i radiografski odgovaraju apikalnim cistama uz transkanalnu drenažu i potpuno mehaničko-medikamentoznu obradu kanala korena zuba mogu dobro reagovati na nehiruršku endodontsku terapiju [24].

Da li ste pažljivo čitali radove?

1. Promena aciditeta pljuvačke je ispitivana kod:
   a) dece
   b) odraslih od 18 do 25 god.
   c) odraslih od 18 do 45 god.

2. ALBO-HA je nanostrukturni cement na bazi:
   a) kalcijum-aluminata
   b) kalcijum-fosfata
   c) kalcijum-silikata

3. Soli i proteini čine:
   a) 0,5% pljuvačke
   b) 1,5% pljuvačke
   c) 2,5% pljuvačke

4. Postojanost i stepen rastvorljivosti endodonskih materijala je proveravana kod:
   a) fosfatnog cementa
   b) samo kod MTA
   c) kod MTA i GUTTA FLOW

5. Terapija bezubosti je rešavana:
   a) supradentalnom protezom
   b) totalnom protezom
   c) parcijalnom protezom

6. Kao alternativa MTA korišćen je nanostrukturni cement:
   a) ALBO-OS
   b) ACBO-OS
   c) ALBO-HA

7. Promena aciditeta pljuvačke je ispitivana posle:
   a) uzimanja zaslađenog napitka kola
   b) uzimanja zaslađene vode
   c) uzimanja voćnog soka

8. Rastvorljivost endodonskih materijala je proverava:
   a) metodom starenja u veštačkoj pljuvački
   b) praćenjem kliničkog ishoda lečenja
   c) praćenjem rendgenološkog ishoda lečenja

9. Poboljšanje stabilnosti prekrivne proteze je rešavano:
   a) samo sa dva precizna vezna elementa
   b) samo sa jednom frezovanom prečkom
   c) sa dva precizna vezna elementa i jednom prečkom

10. ALBO-HA je proveravan:
    a) posle direktnog prekrivanja pulpe
    b) posle implantacije u interradiksne perforacije
    c) posle aplikacije u kanale korena

11. Širina periodontalnog ligamenta posle implantacije ALBO-HA i MTA u kanale korena je bila:
    a) slična
    b) različita
    c) značajno veća kod ALBO-HA

12. U fiziološkim uslovima dnevno se izluči:
    a) 300–400 ml pljuvačke
    b) 500–600 ml pljuvačke
    c) 700–800 ml pljuvačke

13. Voda čini:
    a) 89,5% pljuvačke
    b) 99,5% pljuvačke
    c) 95,5% pljuvačke

14. Pacijent kod koga je proveravana mogućnost poboljšanja stabilnosti prekrivne proteze je bio:
    a) uzrasta 65 godina
    b) uzrasta 45 godina
    c) uzrasta 35 godina

15. Cement ALBO-HA je implantiran u:
    a) kanale korenova kunića
    b) kanale korenova pacova
    c) kanale korenova ovaca

16. Konzumiranje zaslađenog napitka utiče na promenu pH pljuvačke:
    a) posle 5 minuta
    b) posle 10 minuta
    c) posle 20 minuta

17. ALBO-HA i MTA su u eksperimentu na ovcama pokazali:
    a) različitost u formiranju kalcifikovanog apikalnog tkiva
    b) sličnost u formiranju kalcifikovanog apikalnog tkiva
    c) neefikasnost u formiranju kalcifikovanog apikalnog tkiva

18. Postojanost i stepen rastvorljivosti endodonskih materijala je proveravana kod:
    a) 12 jednokorenskih zuba
    b) 12 dvokorenskih zuba
    c) 12 višekorenskih zuba

19. Pacijent sa supradentalnom protezom je imao:
    a) dva endodonski sanirana očnjaka
    b) dva endodonski sanirana premolara
    c) dva endodonski sanirana molara

20. Nakon implantacije ALBO-HA u kanale korena procenjivana je:
    a) histološka reakcija pulpe
    b) histološka reakcija cementa
    c) histološka reakcija PA tkiva

21. Najniža vrednost pH pljuvačke posle uzimanja zaslađenog napitka se dostiže:
    a) posle 5 i 10 minuta
    b) posle 5 i 10 sati
    c) posle 5 i 10 dana

22. Istraživanje o uticaju zaslađenog kola napitka na aciditet pljuvačke je sprovedeno:
    a) na Klinici za stomatologiju Vojvodine
    b) na Klinici za stomatologiju Niš
    c) na Stomatološkom fakultetu u Beogradu

23. Koncentracija bikarbonata u pljuvački iznosi:
    a) 20 mmol/l
    b) 10 mmol/l
    c) 30–60 mmol/l

24. Izlečeni korenovi očnjaka kod pacijenta sa supradentalnom protezom su bili:
    a) sa desne i sa leve strane u donjoj vilici
    b) sa desne i sa leve strane u gornjoj vilici
    c) sa desne strane u gornjoj i sa leve strane u donjoj vilici

25. Histološka reakcija PA tkiva realizovana je kod:
    a) 16 mandibularnih sekutića
    b) 16 maksilarnih sekutića
    c) 16 mandibularnih i maksilarnih sekutića

26. ALBO-HA i MTA su u eksperimentu na ovcama pokazali:
    a) sličnost u analizi pojave inflamacije
    b) ALBO-HA je uzrokovao veću inflamaciju
    c) MTA je uzrokovao veću inflamaciju

27. Rastvorljivost i postojanost endodonskih materijala je analizirana:
    a) posle 7, 14 i 28 dana
    b) posle 14, 21 i 35 dana
    c) posle 7, 14, 21, 28 i 35 dana

28. Nakon žrtvovanja životinja histološkim nalazom je praćena:
    a) resorpcija samo dentina
    b) resorpcija samo cementa
    c) resorpcija dentina, cementa i kosti

29. Mineralna gazirana voda:
    a) smanjuje aciditet pljuvačke
    b) povećava aciditet pljuvačke
    c) ne utiče na aciditet pljuvačke

30. Uzroci uzdužno presečenih zuba su čuvani u veštačkoj pljuvački na temperaturi:
    a) 32 stepena C
    b) 35 stepeni C
    c) 37 stepeni C

31. Kod pacijenta sa supradentalnom protezom je postojao:
    a) pun zubni niz prirodnih zuba
    b) cirkularni metalokeramički most
    c) semicirkularni most

32. U studiji gde je proveravan cement ALBO-HA korišćeno je:
    a) 16 sekutića
    b) 16 premolara
    c) 16 molara

33. Posle uzimanja zaslađenog napitka:
    a) pH pljuvačke raste
    b) pH pljuvačke opada
    c) pH pljuvačke ostaje isti

34. Zaslađeni napitak kola je uziman u količini od:
    a) 100 ml
    b) 200 ml
    c) 300 ml

35. Manju rastvorljivost i bolju adhezivnost u veštačkoj pljuvački je pokazao:
    a) MTA
    b) GUTTA FLOW
    c) MTA samo posle 7 dana

36. Uzimanje zaslađenog napitka:
    a) dovodi do promene aciditeta pljuvačke
    b) ne dovodi do promene aciditeta pljuvačke
    c) dovodi do promene aciditeta pljuvačke samo u prvom satu nakon uzimanja

37. Pojava prvih morfoloških oštećenja kod materijala GUTTA FLOW je uočena:
    a) 21. dana
    b) 28. dana
    c) 35. dana

38. Zaslađena gazirana mineralna voda je uzimana u količini od:
    a) 100 ml
    b) 200 ml
    c) 150 ml

39. Histološkim nalazom PA tkiva posle implantacije ALBO-HA praćen je:
    a) intenzitet inflamacije u periapeksu
    b) intenzitet inflamacije u gingivi
    c) intenzitet inflamacije u pulpi

40. Povećana poroznost kod oba ispitivana materijala je uočena:
    a) 21. dana
    b) 28. dana
    c) 35. dana

41. Aciditet pluvačke je meren:
    a) pre i posle uzimanja napitaka
    b) samo pre uzimanja napitaka
    c) samo posle uzimanja napitaka

42. Resorpcija dentina, cementa i kosti posle implantacije ALBO-HA u kanale korena uočena je:
    a) u jednom uzorku
    b) u tri uzorka
    c) ni u jednom uzorku

43. Aciditet pljuvačke je meren:
    a) digitalnim pH metrom
    b) lakmus-papirom
    c) specijalnim aparatom

44. Blaga zapaljenska reakcija PA tkiva uočena je kod:
    a) 75% uzoraka I grupe
    b) 55% uzoraka I grupe
    c) 35% uzoraka I grupe

45. Pojava prvih morfoloških oštećenja kod materijala MTA je uočena:
    a) 21. dana
    b) 28. dana
    c) 35. dana

46. Diskontinuirano kalcifikovano tkivo u periapeksu uočeno je:
    a) kod 75% uzoraka II grupe
    b) kod 62,5% uzoraka II grupe
    c) 87,5% uzoraka II grupe

47. Diskontinuirano kalcifikovano tkivo u periapeksu uočeno je:
    a) kod 55% uzoraka I grupe
    b) kod 62,5% uzoraka I grupe
    c) kod 75% uzoraka I grupe

48. Blaga zapaljenska reakcija PA tkiva uočena je kod:
    a) 62,5% uzoraka II grupe
    b) 52,5% uzoraka II grupe
    c) 45,5% uzoraka II grupe

49. Nakon punjenja kanala cementom ALBO-HA životinje su žrtvovane:
    a) posle 7 dana
    b) posle 21 dan
    c) posle 28 dana

50. U predelu apeksa uočeno je:
    a) kalcifikovano tkivo
    b) nekrotično tkivo
    c) inficirano tkivo

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