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Terapija ozonom inicijalnih karijesnih lezija u fisurama

Primary Fissure Carious Lesion Reversal Using Ozone

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Sažetak
Minimalno invazivna stomatologija ima sve važnije mjesto u terapiji karijesne lezije. Primjena laserske fluorescencije kao dijagnostičkog postupka te ozona kao terapijskog sredstva, sve se češće primjenjuje kako u preventivnoj tako i u kurativnoj stomatologiji. Uređaj DIAGNOdent (KaVo, Njemačka) radi na principu laserske fluorescencije te omogućuje ranu dijagnostiku i praćenje razvoja karijesne lezije, a primjena ozona pomoću uređaja HealOzone (KaVo, Njemačka) bezbolnu terapiju. Iako za primjenu ozona u stomatologiji postoji niz indikacija, najvažnije mjesto ima u terapiji karijesnih lezija. Svrha ovog rada bila je ispitati učinak ozona primijenjenog uz pomoć uređaja HealOzone na ukupno 70 lezija fisurnog sustava dijagnosticiranih uređajem DIAGNOdent te ustanoviti padaju li vrijednosti demineralizacije lezije između prvog posjeta, te prve i druge kontrole provedene nakon mjesec dana i dva mjeseca. Rezultati su pokazali statistički znatne razlike u vrijednostima demineralizacije očitanih na ljestvici DIAGNOdenta između prvog posjeta i svake ponovljene kontrole ($p<0,001$).

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Uvod

Zadaća moderne stomatologije trebala bi se temeljiti na preventivnom pristupu umjesto na invazivnom tretmanu karijesne lezije. Na osnovi trenutačnog koncepta o razvoju karijesne bolesti, detekciji lezije i ranoj intervenciji, primarni cilj modernoga kliničkog pristupa karijesu jest: inhibicija inicijacije nove lezije, zaustavljanje napretka postojeće te poboljšanje prirodnog procesa cijeljenja lezije postupkom remineralizacije (1).

Najčešće rabljene konvencionalne metode u dijagnosticiranju karijesa, poput sondiranja i rendgenograma, primarno se temelje na subjektivnoj procjeni što može rezultirati velikim razlikama u dijagnozi među različitim terapeutima. Te metode imaju kva-

Introduction

The aim of modern dentistry should be preventive approach rather than invasive repair of the caries disease. On the basis of the current concept of the process of the caries disease, lesion detection and early intervention, the primary goals of modern clinical management of caries are: to inhibit the initiation of new lesions, to arrest the progression of established lesions and to enhance the natural process of lesion repair by remineralization (1).

The most often used conventional caries diagnostic methods such as probing and radiography are based primarily on subjective evaluations, which may lead to large diagnostic variations among different examiners. These methods have qualitative,

litativnu, ograničenu vrijednost u praćenju razvoja lezije te u evaluaciji učinkovitosti preventivnih postupaka. Idealna dijagnostička metoda trebala bi biti sigurna za oboje - pacijenta i terapeuta te omogućiti detekciju lezije u ranoj fazi. Također bi trebala biti objektivna, kvantitativna i neinvazivna te bi se financijski trebala isplatiti, a obavljena mjerenja moći ponoviti.(2).

Danas je jedna od najpopularnijih metoda za detekciju karijesa uređaj DIAGNOdent (Kavo, Biberach, Njemačka), a temelji se na laserskoj flourescenciji. DIAGNOdent ima ugrađenu lasersku diodu (655 nm, modulirana, 1 mW pik) kao ekscitacijski izvor svjetla i foto-diodu spojenu s filtrom (transmisija >680 nm) kao detektor. Spektroskopsko istraživanje fluorescencije pokazalo je znatan kontrast između tvrdog i karijesnog zubnog tkiva kod crvenoga svjetla - 655 nm (3), pri čemu je fluorescencija bila jače izražena u karijesnom nego u zdravom tkivu. Zbog izvrsne ponovljivosti rezultata, uređaj je koristan za dugotrajno praćenje karijesnog procesa te za procjenu rezultata preventivne intervencije (4).

Tehnološki napredak nije samo poboljšao postupak za detekciju karijesa, nego je potaknuo i razvoj ne-invazivnih, bezbolnih postupaka tretmana karijesa. Jedan od najpopularnijih je tretman ozonom. Ozon se dugo koristi u medicini, a posljednjih godina i u stomatologiji, i to najčešće u tretmanu karijesa okluzalnih i glatkih ploha. To su dvije najvažnije, ali ne i jedine kliničke situacije za uporabu ozona u stomatologiji (5).

Ozon je iznimno jak antimikrobni agens, komercijalno dostupan kao HealOzone (KaVo, Njemačka). Nedavno su Baysan i suradnici objavili da je aplikacija ozona 10 ili 20 sekundi učinkovita u uništavanju većine mikrooganizama u karijesnoj leziji (>99% uništenje mikroba nakon 10 sekundi aplikacije ozona) (6,7). Prskalo i suradnici u svojem su istraživanju također potvrdili antimikrobni učinak HealOzona na karijesnu leziju (8).

Longitudinalnim kliničkim istraživanjima dokazan je reverzibilan učinak HealOzona na primarni karijes korijena (9,10). Bysan i Lynch (9) zaključili su da aplikacija ozona 10 ili 20 sekundi znatno smanjuje količinu većine mikroorganizama u primarnim lezijama karijesa korijena bez ikakva popratnog učinka. Holmes (10) navodi da nekavitirane primarne lezije karijesa korijena mogu biti neoperativno zaustavljene uporabom ozona i proizvoda za remineralizaciju. Takav pristup je učinkovita zamjena za klasičnu preparaciju kaviteta i ispuna.

limited value for monitoring lesion development and evaluating the effectiveness of preventive procedures. The ideal diagnostic method should be safe for both patients and users, enabling lesion detection at an early stage. Also it should be objective and quantitative, non invasive and cost effective and the measurements observed with this method should be reproduciable (2).

One of the most popular methods for caries detection today is the laser fluorescence based device DIAGNOdent (Kavo, Biberach, Germany). DIAGNOdent contains a laser diode (655 nm, modulated, 1 mW peak power) as the excitation light source and a photo diode combined with a long pass filter (transmission >680 nm) as detector. Fluorescence spectroscopic investigations revealed considerable contrast between sound and carious tooth tissues when excited by red light, 655 nm (3), and fluorescence was found to be more intense in carious tissue than sound tooth tissue. Due to the good reproducibility, the device should be useful for longitudinal monitoring of the carious process and thus for assessing the outcome of preventive interventions (4).

Technology development has not only resulted in caries detection methods improvement, but also in non-invasive, painless caries treatment methods. One of the most popular is caries treatment with ozone. Ozone has been used for many years in medicine, and within recent years in dentistry in the management of occlusal and plain surface caries. These are only two of the clinical problems for which ozone can be used and has been used, in dentistry (5).

Ozone is a very powerful antimicrobial agent, and commercially is available as HealOzone (CuroOzone, USA and KaVo, Germany). Recently, Baysan et al. reported that ozone application either for 10 or 20 seconds was effective to kill the great majority of microorganisms in carious lesions (>99% microbial killing after 10 seconds ozone application) (6,7). Prskalo et al. also confirmed in their study the antimicrobial effect of HealOzone on carious lessions (8).

The HealOzone has been proven to reverse primary root caries in longitudinal clinical trials (9,10). Bysan and Lynch (9) found that ozone application either for 10 or 20 seconds dramatically reduced most of the micro-organisms in primary root caries lesions without any side effects. Holmes (10) concluded that non-cavitated primary root caries can be arrested non-operatively with ozone and remineralising products. This treatment regime is an effective alternative to conventional “drilling and filling”.

Baysan i Lynch (11) pokazali su da je ta jednostavna neinvazivna tehnika iznimno važna i za preventivu karijesa, jer se takav pristup karijesu vrlo lagano može koristiti u ordinacijama primarne zaštite i tijekom kućnih posjeta starijim i nepokretnim pacijentima u domovima i bolničkim ustanovama (12).

Svrha ovog pokusnog ispitivanja bila je detektirati inicijalnu karijesnu leziju uređajem za lasersku fluorescenciju te procijeniti učinak ozona u kombinaciji s pacijentovom svakodnevnom uporabom sredstava za remineralizaciju na inicijalni fisurni karijes premolara i molara.

Materijali i postupci

Populacija obuhvaćena ispitivanjem

Etički pristanak dobiven je od Etičkoga povjerenstva Stomatološkog fakulteta Sveučilišta u Zagrebu (Hrvatska). Svaki ispitanik dao je pristanak za oboje - stomatološki pregled i tretman ozonom - a obavljali su se u Zavodu za endodonciju i restaurativnu stomatologiju Stomatološkog fakulteta Sveučilišta u Zagrebu. Odabrano je ukupno 70 lezija kod 39 ispitanika obaju spolova u dobi od 22 do 60 godina.

Oprema rabljena u ispitivanju

DIAGNOdent se koristio za detekciju te procjenu napretka karijesa u fisurnoj leziji. Trenutačno očitanje pokazuje vrijednost u pravom vremenu koji vrh sonde mjeri, dok se najveća vrijednost (peak value) odnosi na najvišu vrijednost zabilježenu u leziji. Ta najviša vrijednost rabljena je u statističkoj analizi.

HealOzone – sustav oslobađanja (generiranja) ozona. HealOzone je uređaj koji omogućuje proizvodnju ozona iz zraka te se on zatim cijevima dostavlja u sterilnu kapicu za jednokratnu uporabu u koncentraciji od 2,100 ppm±10%. Ozon se u toj jednokratnoj kapici rashlađuje brzinom 615 cc/minute, mijenjajući volumen plina unutar kapice više od 300 puta u svakoj sekundi. Kapica oblikuje pečat oko tretirane lezije, tako da ozon ne može "curiti" u oralnu šupljinu.

Protokol tretmana

Nakon pregleda (Slika 1.), čišćenja zuba PROPHYflexom i utvrđivanja demineralizacijskih vrijednosti u fisurama premolara i molara uporabom DIAGNOdenta (Slika 2.) rabljen je tretman HealOzonom (Slika 3.), kao što je pokazano u Tablici 1. (13,14). Nakon tretmana ozonom aplicirano je na leziju 5 kapi

Baysan and Lynch (11) also reported that this simple and non-invasive technique may benefit many patients with root caries throughout the world since this approach to treat root caries can easily be employed in primary care clinics and in the domiciliary treatment of home-bound elderly people and immobile patients in hospices and hospitals (12).

The aim of this pilot study was to detect initial carious lesions with laser fluorescence device and to assess the effect of an ozone delivery system, combined with the daily use of a remineralizing patient kit, on the initial fissure caries in premolars and molars.

Materials and Methods

Study population

Ethical approval was obtained by the Ethics Committe of School of Dental Medicine, University of Zagreb, Croatia. Each subject had given their informed consent for both dental examination and ozone treatment to be undertaken at the Department of Endodontics and Restorative Dentistry, School of Dental Medicine, Zagreb. A total of 70 lesions in 39 subjects, males and females, aging from 22 to 60 years, have been selected.

Equipment used

The DIAGNOdent was used to detect and quantify the severity of fissure carious lesions. The instant reading indicated the real time value that the probe tip was measuring, whilst the peak value refered to the highest level scanned on the lesion. The peak value was used in statistical analyses.

HealOzone – ozone delivery system. The HealOzone is a device that takes in air and produces ozone gas which is then delivered via a hose into a disposable sterile cup at a concentration of 2,100 ppm±10%. The ozone gas is refreshed in this disposable cup at a rate of 615 cc/minute changing the volume of gas inside the cup over 300 times every second. The cup forms a seal around the lesion being treated so that ozone cannot leak into the oral cavity.

Protocol treatment

After inspection (Figure 1), tooth cleaning with PROPHYflex and recording of demineralisation values in fissures of premolars and molars using the DIAGNOdent (Figure 2), treatment with HealOzone (Figure 3) was used as shown in Table 1 (13,14). After treatment with ozone, 5 drops of a remineralizing solution containing xylitol, fluoride, calcium, phos-

Slika 1. Suspektna karijesna lezija na premolaru
Figure 1 Suspected caries lesion on premolar

Slika 2. Uporaba DIAGNOdenta za pronalaženje vrijednosti demineralizacije
Figure 2 Use of DIAGNOdent for determining demineralization value

Slika 3. Tretman karijesne lezije HealOzonom
Figure 3 Treatment of deminaralization with HealOzone

Tablica 1. Trajanje tretmana ozonom prema DIAGNOdent vrijednostima (6)
Table 1 Treatment duration with ozone according to DIAGNOdent values (6)

Vrijednosti na ljestvici DIAGNOdenta • DIAGNOdent value	Tretman HealOzone-om • Treatment with HealOzone
0~19	10 sekundi • 10 second
20~23	20 sekundi • 20 second
24~29	30 sekundi • 30 second
>30	40 sekundi / konvencionalni tretman • 40 second / conventional dental care

remineralizacijske otopine koja sadržava ksilitol, fluor, kalcij, fosfate i cink (HealOzone remineralizirajuća otopina). Svaki ispitanik dobio je detaljne upute o uporabi HealOzone remineralizirajuće zubne paste dva puta na dan i HealOzone vodice za ispiranje jedanput na dan. Ispitanici su pozvani na kontrolu jedan i dva mjeseca nakon prvog posjeta. Svaki put je ponovljen isti protokol. U statističkoj analizi rabljeni su deskriptivna statistika, t-test i Pearsonova korelacija.

Rezultati

Rezultati su predstavljeni u Tablicama 2 do 4. Kao što se iz njih vidi postoji statistički znatna razlika između prvog posjeta i prve kontrole, prvog posjeta i druge kontrole te između prve i druge kontrole - t-test je pokazao znatnu razliku između svih triju kombinacija na razini znatnosti p<0,001, a Pearsonova korelacija pokazuje pozitivnu linearnu korelaciju između parova na razini znatnosti p<0,001. Brojčane vrijednosti na ljestvici DIAGNOdenta smanjivale

phate and zinc (HealOzone remineralizing solution) was applied to the lesion. To each subject instructions were given for using the HealOzone remineralizing toothpaste twice a day, and the HealOzone mineral mouth wash once a day. Subjects were recalled at one and two months after the first visit. At each recall the same protocol was repeated.

Descriptive statistics, t-test and Pearson Correlations were used for data analyses.

Results

The results are shown in tables 2-4. As it can be seen, there was a significant difference between the first visit and the first recall, the first visit and the second recall, and between the first and the second recall: t-test revealed a signifficant difference between all three pairs (combinations) at the level of p<0.001 and Pearson's correlation exhibits positive linear correlation between observed pairs at the level of p<0.001. Numeric values on DIAGNOdent

Tablica 2. Deskriptivna statistika za ispitivane parametre
Table 2 Descriptive statistics for tested parameters

		Srednja vr. • Mean	N	Std. devijacija • Std. Deviation	Std. pogreška • Std. Error Mean
Par 1 • Pair 1	Prvi posjet • First visit	23,24	70	10,98	1,31
	Prva kontrola • First recall	20,47	70	10,40	1,24
Par 2 • Pair 2	Prvi posjet • First visit	23,24	70	10,98	1,31
	Druga kontrola • Second recall	18,03	70	9,86	1,18
Par 3 • Pair 3	Prva kontrola • First recall	20,47	70	10,40	1,24
	Druga kontrola • Second recall	18,03	70	9,86	1,18

Tablica 3. T-test za ispitivane parametre
Table 3 T-test for tested parameters

	Razlike između parova • Paired Differences					t	df	Značajnost • Sig. (2-tailed)
	Sr. vr. • Mean	Std. Dev.	Std. pog. • Std. Error Mean	95% vjerojatnosti Interval razlike • 95% Confidence Interval of the Difference				
				donji • lower	gornji • upper			
Par 1 / Prvi posjet – prva kontrola • Pair 1 / First visit – First recall	2,77	5,31	.63	1,51	4,04	4,370	69	.000
Par 2 / Prvi posjet – druga kontrola • Pair 2 / First visit – Second recall	5,21	6,89	.82	3,57	6,86	6,328	69	.000
Par 3 / Prva kontrola – druga kontrola • Pair 3 / First recall – Second recall	2,44	3,43	.41	1,62	3,26	5,953	69	.000

Tablica 4. Korelacija između ispitivanih parametara
Table 4 Correlation between tested parameters

	N	Korelacija • Correlation	St. znatnost • Sig
Par 1 / Prvi posjet – prva kontrola • Pair 1 / First visit – First recall	70	.878	.000
Par 2 / Prvi posjet – druga kontrola • Pair 2 / First visit – Second recall	70	.786	.000
Par 3 / Prva kontrola – druga kontrola • Pair 3 / First recall – Second recall	70	.944	.000

su se u prosjeku za tri jedinice nakon prve kontrole, a pet jedinica nakon druge kontrole u odnosu prema početnoj vrijednosti. Velika odstupanja rezultata od srednjih vrijednosti mogu se objasniti većim razlikama u brojčanim vrijednostima očitanima na ljestvici DIAGNOdenta tijekom dijagnostičkog tretmana između pojedinih zuba, budući da se radilo o zubima s različitim stupnjem demineralizacije. Iz Tablice 1., na kojoj su pojedini intervali brojčanih vrijednosti očitanih na DIAGNOdentu i s obzirom na to vrijeme terapije HealOzonom, vidljiv je ujedno i mogući interval ostupanja između pojedinih promatranih zuba, pa je tako na primjer vrijednost demineralizacije jednog zuba iznosila 20, a drugog 30. Uzimajući u obzir broj ispitivanih zuba, time su opravdana velika odstupanja od srednje vrijednosti.

scale increased on average three units after first recall, and five units after second recall in comparison with initial value. Large result variances from mean values can be explained by significant differences in numerical values recorded on DIAGNOdent scale during diagnostic treatment as teeth with different demineralization degree were observed. Table 1 shows numerical values recorded on DIAGNOdent scale and appropriate treatment time with HealOzone. Observed variances between teeth can also be seen, e.g. demineralization value of one tooth was 20 and of another one 30. Taking into account the number of examined teeth, large variances from mean values are justifiable.

Rasprava

Rana dijagnostika primanog karijesa fisura pomoću uređaja DIAGNOdent, temeljenog na principu laserske fluorescencije, pokazuje prednost u odnosu prema drugim dijagnostičkim postupcima (sondiranje, vizualna inspekcija, rtg) koji zbog slabe osjetljivosti postupka dijagnostike dovode do znatne pogreške tijekom dijagnostike karijesa. Visoka ponovljivost DIAGNOdenta ustanovljena je u uvjetima in vitro i in vivo (15,16). Prema tome, ta je metoda pogodna za longitudinalno praćenje karijesne lezije, a omogućuje i preventivne intervencije. Longitudinalno praćenje remineralizacije prije toga demnineralizirane lezije, od velike je važnosti u slučaju terapije ozonom.

Svrha tretmana karijesne lezije ozonom jest smanjiti mikrobne uzročnike i čimbenike rizika kako bi se zaustavio karijesni proces i stimulirala remineralizacija. Istraživanja su pokazala da ozon rastavlja kisele proizvode kariogenih bakterija, koji su važni u etiologiji nastanka karijesne lezije (14). Baysan i suradnici (5) pokazali su da aplikacija ozona 10 sekundi smanjuje Streptococcus Mutans i Streptococcus Sobrinus in vitro. Daljnja istraživanja OT Abu-Salema (17) pokazala su da se okluzalni karijes u mliječnoj denticiji može učinkovito kontrolirati ozonom. Glavni problem ne-invazivnog farmaceutskog pristupa tretmanu karijesa i remineralizaciji lezije u kliničkoj je praksi poteškoća pri supresiji ili eliminaciji mikroorganizama na dulje vrijeme koje je potrebno za remineralizaciju.

Pomak mikrobne flore, od acidogenih i acidurnih mikrooganizama prema normalnim oralnim nametnicima pod utjecajem ozona, omogućuje remineralizaciju unutar karijesnog procesa (6). Uklanjajući proteine iz karijesne lezije omogućuje ionima kalcija i fluora difuziju unutar lezije, što rezultira njezinom remineralizacijom nakon aplikacije ozona.

Ozon se često koristi u općoj stomatološkoj praksi u kombinaciji s pečaćenjem karijesnih lezija. Na sreću, dokazano je da tretman ozonom ne djeluje štetno na kvalitetu sveze. Ozon nije imao nikakav učinak na ispitivana fizikalno-kemijska svojstva cakline te nije niti poboljšao niti ugrozio mogućnost sveze (18). Prema tome, stavljanje adhezijske restoracije moguće je odmah nakon primjene ozona za dezinfekciju kaviteta (19).

U tom ispitivanju dogodio se znatan pad u DIAGNOdent vrijednostima između prvog posjeta i prve/druge kontrole. Nakon početne eliminacije mikroorganizama, njihova dekolonizacija potpomognuta je manjkom dostupnog organskog substrata

Discussion

Early diagnosis of primary fissure caries with the laser fluorescence device DIAGNOdent is of great importance because of the low sensitivity of visual, probing and bitewing examination which leads to a significant number of teeth with undetected dentinal caries. High reproducibility of DIAGNOdent has previously been reported under both in vitro and in vivo conditions (15,16). Thus, this method is suitable for longitudinal monitoring of carious lesions and also enables preventive interventions. Longitudinal monitoring of remineralization of demineralized lesions is of great importance in the case of ozone therapy.

The goal of treatment of carious lesions with ozone is to reduce the causative microbiota and contributing risk factors to halt the caries decay process and stimulate remineralization. Research has shown that ozone breaks up acid products of cariogenic bacteria, which may be important in the aetiology of the developing carious lesion (14). Research by Baysan and others (5) has shown that an application of ozone for a period of 10 seconds was capable of reducing the Streptococcus Mutans and Streptococcus Sobrinus in vitro. Further research by OT Abu-Salem (17) have shown that occlusal caries in deciduous teeth can be effectively controlled with ozone. The main problem of non-invasive pharmaceutical approaches in clinical practice for management of caries reversal and remineralization of the lesion is the difficulty in suppressing or eliminating micro-organisms for long periods of time required for remineralization.

Ozone enables the shifting of microbial flora from acidogenic and aciduric micro-organisms to normal oral commensals which will allow the remineralization to occur within the carious process (6). Ozon has the ability to remove proteins in carious lesions, and to enable calcium and phosphate ions to diffuse through the lesions, which results in remineralization of the lesion after ozone application.

Ozone is extensively used in general practice followed by sealing of the carious lesions. Fortunately this ozone treatment has been proven not to be detrimental to the bond. Ozone did not influence the studied enamel physical properties and neither enhanced nor harmed the sealing ability (18). Thus, adhesive restoration placement should be possible immediately after ozone application for cavity disinfection (19).

In this study, there were highly significant decreases in DIAGNOdent values between the first

ključnog za metabolizam kariogenih bakterija (20). Prema rezultatima ove studije može se zaključiti da uporaba ozona na primarni fisurni karijes ne samo da pridonosi čuvanju zubne strukture izbjegavajući invazivnu tehniku odstranjivanja karioznog tkiva, nego pridonosi obratu karijesnog procesa i remineralizaciji.

baseline visit and the first/second recall. After the initial elimination of microorganisms, decolonisation of microorganisms may be reinforced by lack of available organic substrate essential for the metabolism of cariogenic bacteria (20). Within the limitations of this study it can be concluded that the use of ozone in primary fissure caries not only preserves the tooth structure by avoiding the use of invasive techniques for the removal of carious tissue, but also promotes the caries reversal and tooth remineralization.

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Abstract
Minimally invasive dentistry holds an important place in the treatment of caries lesion. Introduction of laser fluorescence as a diagnostic and ozone as a therapeutic means finds more frequent usage in both preventive and curative dentistry. DIAGNOdent device (KaVo, Germany) is based on laser fluorescence which enables early diagnosis as well as monitoring the development of caries lesion while use of ozone with HealOzone device (KaVo, Germany) provides painless treatment. Even though there are number of indications for use of ozone in dentistry, most important is therapy of caries lesions. Purpose of this investigation was to observe the effect of ozone applied via HealOzone device on the total of 70 primary fissure lesions previously detected with DIAGNOdent device and to determine whether there is a decrease in lesion demineralization values between first visit, first and second recall after one and two month period. Results showed statistically significant difference in demineralization values recorded on DIAGNOdent scale between first visit and every repeated recall ($p<0,001$).

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