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Preliminarno istraživanje kretanja vode preko veze dentina i stakleno-ionomernih cemenata

A Preliminary Study of the Water Movement Across Dentin Bonded to Glass-Ionomer Cements

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Sažetak
Svrha ovog istraživanja bila je ispitati kako djeluje pomicanje vode po površini dentina vezanog za konvencionalne stakleno-ionomerne cemente. **Materijal i postupci:** Na ekstrahiranim trećim molarima bili su pripremljeni kaviteti petog razreda ispunjeni konvencionalnim stakleno-ionomernim cementom Fuji IX. Zatim je dio uzoraka bio jedan mjesec uronjen u umjetnu slinu, a dio 18 mjeseci. Nakon toga roka razrezani su longitudinalno i analizirani SEM-om (sekundarnim i „backscattered“ načinom) te EDAX-om. **Rezultati:** Nakon 18 mjeseci u materijalu su bile uočene sferične strukture kod spoja tvrdog dentina. Prazni prostori u blizini spoja tradicionalnih stakleno-ionomera i dentina uglavnom su bili u obliku „ljuske jajeta“ (iako je bilo i čvrstih). To je najvjerojatnije rezultat daljnjeg stvrdnjavanja u praznim prostorima originalnog polialkenoatnog matriksa, a događa se zbog difuzije vode iz vlažnog dentina. EDAX-ovom analizom potvrđeno je da su te formacije sastavljene od velike količine stroncija, silikata i aluminijia. **Zaključak:** Opisane sferične formacije mogle bi poboljšati kompresivne snage uočene kod starijih ispuna s konvencionalnim stakleno-ionomernim cementom.

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Uvod

Glavna je prednost stakleno-ionomernih cemenata njihova sposobnost samoadhezije na caklinu i dentin. Samoadhezija stakleno-ionomernih cemenata na strukturu zuba je dvostruka – postiže se mikromehaničkim prožimanjem i plitkom hibridizacijom kolagene fibrilne mreže obavijene hidroksilapatitom (na taj se način njihova adhezija na zub može smatrati samojetkajućim postupkom) te sekundarno pravim kemijskim vezivanjem i stvaranjem ionskih veza između karboksilnih skupina polialkenoične

Introduction

The main advantage of glass-ionomer cements is their ability to self-adhere to enamel and dentin. The auto-adhesion of glass-ionomer to tooth tissue is thought to be two-fold in nature: first, micro-mechanical interlocking by a shallow hybridization of the hydroxyapatite-coated collagen fibril network (so, their adhesion to the tooth tissue can be considered as a kind of self-etch approach); and second, true primary chemical bonding through formation of ionic bonds between the carboxyl groups of kiseline i kalcija hidroksilapatita koji je ostao nakon ogoljivanja kolagenske površine (1). Tako nastaje intermedijarna zona (sloj izmjene iona) kalcija i fosfata na spoju cementa i zuba (2,3).

Adhezija na caklinu je jednostavnija od one na dentin. Morfologija dentinskog tkiva uključuje tubule ispunjene tekućinom, pa molekule vode mogu lako doći u doticaj s materijalom. Taj fenomen lokalne prisutnosti vode osobito se zapaža kod samojetkajućih adheziva i stakleno-ionomernih cemenata modificiranih smolama (4 -15). Tako su Sano i suradnici (16) te Li i njegovi kolege (17) opisali „nanopropusnost" na temelju hibridnog sloja kod primjene dentinskih adheziva. Istaknuli su da nepotpuna penetracija adhezivnog sustava u kolagenu mrežu stvara područja demineraliziranog dentina na dnu hibridnoga sloja (16,18), pa adhezivni spoj postaje «ranjiv», jer se degradiraju kolageni fibrili koji nisu uključeni u adhezivni spoj (19,20). S druge strane, pak, samojetkajući adhezivi mnogo manje demineraliziraju dentin, ali ispitivanja nanopropusnosti potvrđuju pomicanje tekućine preko spoja adheziva i dentina (16,17).

Slično tome, kretanje vode preko veze dentina i zbog smola modificiranog stakleno-ionomernog cementa nije bilo poznato sve dok u tom području nije otkriven amorfni, nepartikulirani sloj debljine 5 do 15 mm (21-23). Nastanak toga takozvanog „apsorpcijskog sloja", pripisuje se HEMA-inoj sorpciji vode, ili difuziji HEMA-e iz matriksa smole u dentinsku površinu bogatu vodom. Zbog polimerizacije HEMA-e stvara se mekani sloj poli(HEMA) hidrogela. Stakleno-ionomerni cementi modificirani smolama sadržavaju taj apsorpcijski sloj, a pretpostavljalo se da on služi kao blokator stresa (24) te da ima funkciju sličnu onoj dentinskoga adhezivnog sloja koji smanjuje stres kod skvrčavanja tijekom polimerizacije (25).

Samo malobrojna istraživanja potvrđuju pomicanje vode kod tradicionalnih stakleno-ionomernih materijala (26-28) te onih modificiranih smolama (13) stvaranjem struktura «zarobljenih» u prazne prostore unutar matriksa.

Dosad se velika pozornost posvećivala procesima na spoju dentalnih tkiva i tih materijala, ali i u samom dentinu. Ovo istraživanje, pak, imalo je zadatak zabilježiti promjene u konvencionalnim stakleno-ionomernim cementima dok su njihove površine bile u doticaju s umjetnom slinom te zabrtvljene lakom. Zato je bila postavljena nulta hipoteza da nema razlike u mikromorfološkom izgledu stakleno-ionomernog cementa vezanog za dentin nakon različitog trajanja skladištenja.

the polyalkenoic acid and calcium of hydroxyapatite that remained around the exposed surface collagen (1). Therefore, an intermediate zone (ion-exchange layer) of calcium and phosphate formed on the interface between the cement and the tooth exists (2,3).

The adhesion to enamel is more straightforward than the adhesion to dentin. The morphology of the dentinal tissue involves presence of dentinal tubules filled with fluid, so water molecules can easily transudate through the interface with the material. This phenomenon of localized water sorption has been extensively observed in self-etch adhesives and resin-modified glass-ionomer cements (4-15). For example, Sano et al. (16) and Li et al. (17) described the appearance of "nanoleakage" at the basis of the hybrid layer when dentin adhesives are applied. They stated that the incomplete penetration of the adhesive system through the collagen network creates a region of demineralized dentin at the bottom of the hybrid layer and the adhesive union therefore becomes vulnerable, since degradation of the collagen fibrils that are not incorporated into the adhesive system appears (16, 18-20). On the other side, the self-etching adhesives demineralize the dentin in much less extent, but the nanoleakage studies confirm that the liquid still moves along the interface of the adhesive and the dentin (16,17).

Likewise, the water movement across bonded resin-modified glass ionomer cement/dentin interfaces was almost completely unknown until the detection of a 5-15 mm thick, amorphous, non-particulate zone formed in this region (21-23). The formation of this, so-called, "absorption layer" has been attributed to water sorption by HEMA, or the diffusion of HEMA from the resin matrices of the resin modified glass-ionomer cements into the water-rich dentin surface. The subsequent polymerization of the HEMA resulted in the form of a soft poly (HEMA) hydrogel layer. The resin-modified glass ionomer cement absorption layer has been thought to act as a stress-breaking layer and may provide a similar function as a dentin adhesive layer in relieving polymerization shrinkage stresses (24,25).

Only a limited number of studies confirm the water movement in traditional glass- ionomers and resin-modified glass-ionomer cements through a formation of structures entrapped into the air voids of the materials' matrix (13, 26-28).

So far, much attention has been paid to the processes that appear at the interface between the dental tissues and these materials, as well as in the dentin itself. This study was designed to witness the changes that appear into the conventional glass-ionomer cements, while the surfaces of the cement that were in contact with the artificial saliva were sealed with varnish. Therefore, the null hypothesis tested was that there is no difference in the micro-morphological appearance of the glass-ionomer cement bonded to dentin after different storage time intervals.

Materijal i postupci

1. Priprema zuba i ispuna

U ispitivanju se uporabilo 20 trajnih trećih molara ekstrahiranih iz ortodontskih razloga na Klinici za oralnu kirurgiju. Nakon toga zubi su bili odloženi u umjetnu slinu te uporabljeni za mjesec dana. Priprema je uključivala ultrazvučno čišćenje i poliranje zubnom pastom i gumicama. Kruna je nakon toga separirana od korijena dijamantnim svrdlom na mikromotoru s velikim brojem okretaja te hlađena vodom u razini caklinsko-cementnog spoja. Zatim su uklonjeni ostaci pulpalnog tkiva. Na vestibularnoj strani svakog zuba obavljena je preparacija 5. razreda dijamantnim svrdlom i mikromotorom s velikim brojem okretaja. Nakon toga postupka zubi su kondicionirani 10 sekundi pomoću GC Cavity Conditionera i još 10 sekundi ispirani vodom. Nakon toga je, prema uputama proizvođača, izrađen ispun od materijala Fuji IX (GC Corp., Japan, broj 000152) i premazan lakom.

Zubi su uronjeni u umjetnu slinu pripremljenu prema britanskim standardima (British Standards Institution - BS 7115, dio 2, BSI, London, 1988.), a ranije se koristila za testiranje dentalnih materijala. Sastav je prikazan u Tablici 1. Dio uzoraka analiziran je nakon mjesec dana, a dio nakon 18 mjeseci.

2. Priprema uzoraka za SEM

Nakon što je prošao određeni rok, zubi su bili prerezani longitudinalno - jedna je polovica pregledana elektroničkim (skening) mikroskopom (SEM-om) da bi se dobile sekundarne slike, a druga polovica da bi se dobile „backscattered“ snimke.

Material and method

1. Teeth preparation and restoration

Twenty permanent third molar teeth extracted due to orthodontic reasons at the Clinic for Oral Surgery were used in the examination. After the extraction, the teeth were stored in artificial saliva and used within 1 month after the extraction. The preparation involved ultrasonication and cleaning with polishing toothpaste and pumice. The crown was separated from the radices with diamond bur and high speed handpiece with water cooling at the level of the cemento-enamel junction, and afterwards the remnants of the pulp tissue were discarded. Standard Class V cavities were prepared on the vestibular side of each tooth, using diamond bur and high speed dental handpiece. After the preparation, the teeth were conditioned for 10 seconds with GC Cavity Conditioner and rinsed with water for additional 10 seconds. Then, they were restored with Fuji IX (GC Copr., Japan, batch No. 000152) according to the manufacturer's instructions, and covered with varnish.

The teeth were stored in artificial saliva prepared according to the British Standards Institution, BS 7115, part 2, BSI, London, 1988, and previously used for dental materials testing. Its composition is given in Table 1. The samples were examined after 1 month and 18 months storage period.

2. Sample preparation for SEM

After each storage time interval, the teeth samples were cut by half longitudinally; one of the halves was examined under Scanning Electron Microscope (SEM) to obtain secondary and the second one for backscattered electron images.

Tablica 1. Komponente umjetne sline
Table 1 Components of the artificial saliva

Komponenta • Component	Koncentracija • Concentration (g l^{-1})
NaCl	0.50
$NaHCO_3$	4.20
$NaNO_3$	0.03
KCl	0.20

Za SEM („backscattered" način) rezne su površine bile postavljene na dno plastičnog kalupa (Buehler®, SAD, Batch br. 20-8180) s unutarnjim promjerom od 32 mm. Kalupi su bili ispunjeni smolom (Epo-Thin, Buehler®, SAD, Batch br. 20-8140-032) i polimerizirani jedan sat u vakuumskom desikatoru.

Polimerizacija je nastavljena sljedeća 24 sata na sobnoj temperaturi. Priprema uzorka dovršena je brušenjem različitim karborundnim svrdlima do dijamantnog svrdla od 1μm. Uzorci su nakon toga presvučeni karbonom (model S105, Edwards Co., Velika Britanija) i analizirani SEM-om JEOL JSM 5310LV na povećanju od 350 puta „backscattered" načinom (20kV akcelerirajuća voltaža i 15 mm radna udaljenost). Analiza je uključivala raščlambu disperzije energije s rendgenskim zrakama (EDAX-om) na istom uređaju, na reprezentativnim točkama u istim uvjetima.

SEM analiza drugih polovica uzoraka uključivala je sušenje, sprejanje zlatom (Edwards 150B) te analizu pod visokom rezolucijom sekundarnim elektroničkim načinom (Model Cambridge Stereoscan 360 Scanning Electron Microscope, Cambridge Instruments Co., Velika Britanija).

Rezultati

Kao rezultat sušenja (dehidratacije) tijekom preparacije uzoraka zuba SEM-om, pojavila se pukotina u polialkenoatnom matriksu. Budući da je vakuum za sekundarne elektroničke snimke jači, pukotine su na tim snimkama češće i veće od onih kod „backscattered" načina.

Nakon mjesec dana u umjetnoj slini, u uzorcima s Fujem IX pronađene su mnogobrojne šupljine. Uzorci su se činili praznima, tj. oni pregledani „backscattered" načinom bili su ispunjeni samo smolom u koju su bili uronjeni (Slika 1.).

Nakon 18 mjeseci situacija je bila potpuno drugačija. Naime, bilo je mnogo sferičnih tijela u praznom prostoru polialkenoatnog matriksa (Slika 2.). Pronađena su dva oblika:

a) prazni i „slični ljuski jajeta" (Slike 3. i 4.) te
b) čvrsti (Slika 5.).

Sferična tijela mogu se lako razlikovati od angularnih komadića fluoroaminosilikatnog stakla.

Grafički prikaz dobiven EDAX-om pokazao je da su te strukture sastavljene uglavnom od stroncija, ali s velikim udjelima aluminija i silikona.

For the SEM (backscattered electron mode), the cut surfaces were placed on the bottom of plastic moulds (Buehler®, USA, Batch No. 20-8180) with 32 mm internal diameter. The moulds were filled with resin (Epo-Thin, Buehler®, USA, Batch No.20-8140-032) and cured in a vacuum-desiccator for 1 hour.

The curing process continued at room temperature for 24 hours. The sample preparation was finished by grinding with different sizes of carborundum grits down to 1μm diamond. The samples were then carbon-coated (Model S105, Edwards Co., UK) and examined with JEOL JSM 5310LV Scanning Electron Microscope at 350x magnification in backscattered electron mode (20 kV accelerating voltage and 15 mm working distance). The analysis involved Energy Dispersive Analysis with X-rays (EDAX) on JEOL JSM 5310LV, Japan on representative points of interest under the same experimental conditions.

The SEM (secondary electron mode) analysis of the other half of the samples involved desiccation, gold-sputtering (Edwards 150B) and examination under high-resolution Scanning Electron Microscope in secondary electron mode Model Cambridge Stereoscan 360 Scanning Electron Microscope, Cambridge Instruments, Co., UK.

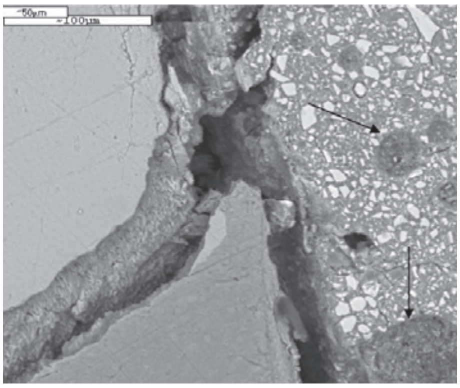
Results

As a result of the desiccation (dehydration) during the preparation of the teeth samples for the SEM, cracks appeared within the polyalkenoate matrix. Since the vacuum for the secondary electron images is higher, the cracks that can be seen at these images were more frequent and larger in comparison to the ones seen in the backscattered mode.

After one month of storage in artificial saliva, numerous air voids were found in the Fuji IX samples. The samples appeared empty, i.e. the ones visualized under backscattered electron mode were filled only with the epoxy-resin used for embedding of the samples, Fig. 1.

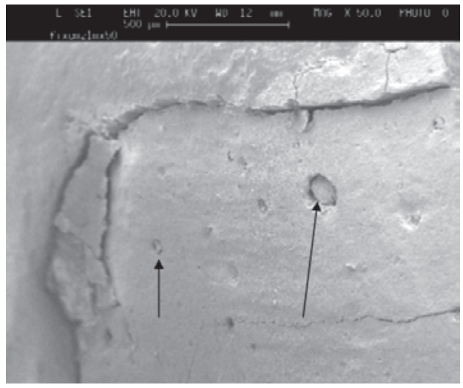
After 18 months, the situation was completely different. Namely, there was presence of numerous spherical bodies within the air-voids inside the polyalkenoate matrix, Fig. 2. Two types of spherical bodies were found: a. hollow and "egg-shell-like" , Fig. 3, Fig. 4. and b. solid ones, Fig. 5. The spherical bodies can be easily distinguished from the angular fluoroaluminosilicate glass particles.

The graph obtained by EDAX of these structures showed that they are made mainly from strontium, but quite high quantities of aluminium and silicon in their composition were also found.



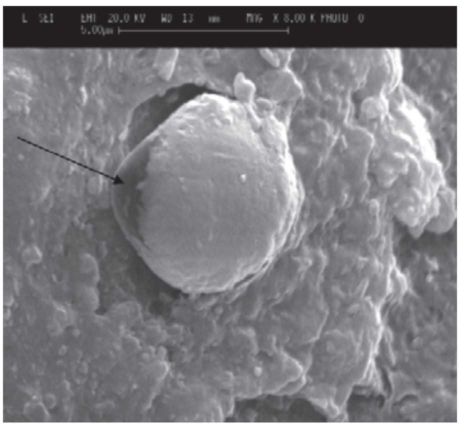
Slika 1. Reprezentativna slika konvencionalnog stakleno-ionomernog cementa Fuji IX nakon mjesec dana u umjetnoj slini – SEM („backscattered“ način) - u praznim prostorima nema ničega

Figure 1 Representative image of a conventional glass-ionomer cement Fuji IX after 1 month storage in artificial saliva –SEM (backscattered electron mode): the air voids are empty



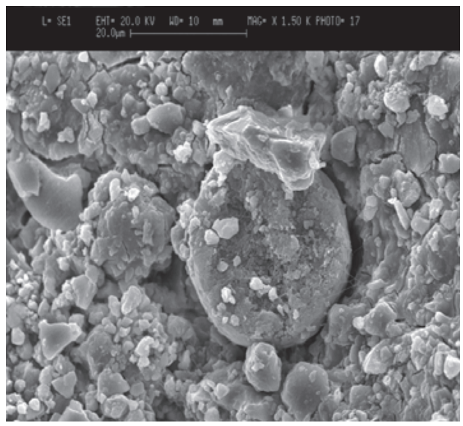
Slika 2. Reprezentativna slika konvencionalnog stakleno-ionomernog cementa Fuji IX nakon 18 mjeseci u umjetnoj slini – SEM (sekundarni elektronički način)- praznine su ispunjene sferičnim tijelima

Figure 2 Representative image of a conventional glass-ionomer cement Fuji IX after 18 month storage in artificial saliva – SEM (secondary electron mode): air voids filled with spherical bodies



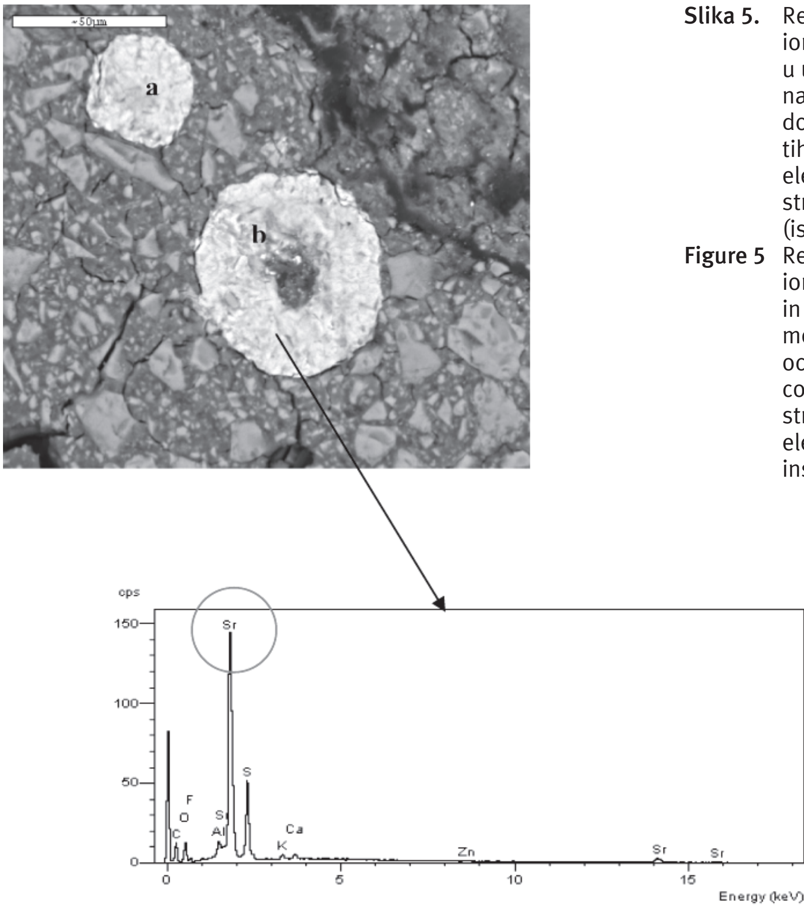
Slika 3. Reprezentativna slika konvencionalnog stakleno-ionomernog cementa Fuji IX nakon 18 mjeseci u umjetnoj slini – SEM (sekundarni elektronički način) - sferično tijelo nalik na ljusku jajeta s tankom krustom i praznom jezgrom; strelica ističe frakturu koja upućuje na praznu unutrašnjost

Figure 3 Representative image of the conventional glass-ionomer cement Fuji IX after 18 month storage in artificial saliva – SEM (secondary electron mode): “egg-shell-like” spherical body, consisted of a thin crust and an empty core; the arrow pointing towards the fracture which exposes the hollow interior



Slika 4. Reprezentativna slika konvencionalnog stakleno-ionomernog cementa Fuji IX nakon 18 mjeseci u umjetnoj slini – SEM (sekundarni elektronički način) - frakturirano sferično tijelo s čvrstim vanjskim slojem i mekanom unutrašnjosti s tendencijom punjenja; struktura se lako razlikuje od fluoroaminosilikatnih staklenih partikala.

Figure 4 Representative image of a conventional glass-ionomer cement Fuji IX after 18 month storage in artificial saliva – SEM (secondary electron mode): a fractured spherical body which has a solid peripheral outer layer, but the core is not solid and has a tendency to fill up; the structure is easily distinguished from the angular fluoroaluminosilicate glass particles



Slika 5. Reprezentativna slika konvencionalnog stakleno-ionomernog cementa Fuji IX nakon 18 mjeseci u umjetnoj slini – SEM (sekundarni elektronički način) - malo sferično tijelo potpuno je ispunjeno, dok je veće (b) prazno, a „bljeskajući“ izgled tih struktura upozorava na prisutnost „teških elemenata“ – u ovom slučaju velike količine stroncija, označenog na EDAX-ovu grafikonu (ispod).

Figure 5 Representative image of a conventional glass-ionomer cement Fuji IX after 18 month storage in artificial saliva - SEM (backscattered electron mode): the smaller spherical body is completely occluded, while the bigger one (b) has an empty core, the “sparkling” appearance of these structures indicates the presence of “heavy elements”- in this case high quantity of strontium inside, marked on the EDAX graph (below)

Rasprava

U uobičajenoj mikroskopskoj analizi opisuje se poroznost stakleno-ionomernih matriksa, a oni su slični mjerhurićima koji nastaju zbog inkluzija zraka tijekom miješanja materijala. Kada se on stvrdne, te su šupljine doslovce zarobljene u matriksu. Pojava tih struktura jedan je od razloga male kompresivne snage stakleno-ionomernih cemenata, što se smatra njihovim glavnim nedostatkom.

Nedavno je uočeno da se te šupljine ispunjavaju tijekom godina (26 - 28). Naše snimke pokazuju da su one nakon mjesec dana u vodenom mediju bile prazne. Kasnije, nakon 18 mjeseci, oblikovale su se dvije vrste tih sferičnih tijela - ona koja izvana ima omotač sličan krusti, te ona čvrsta. Zato moramo odbaciti nultu hipotezu koja je implicirala sličnost uzoraka iz različitih vremenskih intervala.

Naši su rezultati samo djelomice u skladu s onima koje su objavili Tay i suradnici (27), budući da su oni kod konvencionalnih stakleno-ionomernih cemenata u blizini dentinskih površina našli samo strukture slične ljuski jajeta. To se može pripisati kraćem stajanju u vodenom mediju. Čvrste sfe-

Discussion

Common microscopic observation is the appearance of porosities into glass-ionomer cement matrices that resemble to bubbles and are formed by inclusion of air during the mixing of the material. Once the material sets, these voids become entrapped into the matrix. The presence of these structures is one of the reasons for the low compressive strength found in glass-ionomer cements, which is considered as one of their main disadvantages.

Recently, however, it was noticed that these air voids tend to fill up in function of time (26,28). Our electron microscope images prove that after one month of storage in aqueous medium these voids were empty. Later on, after 18 months, two types of spherical bodies formed: the first ones have only an outer layer which looks like a crust, and the others are solid. Therefore, we have to reject the null hypothesis, which implied similarity between the samples in different time intervals.

These results are only partially in accordance with the results of Tay et al (27), because they found only “egg-shell-like”, hollow structures in convenrične strukture unutar praznih prostora u matriksu materijala, uočene su jedino kod stakleno-ionomernih cemenata modificiranih smolama, te samo ako su frakturirane površine bile 3 mm udaljene od spoja (26). Sumnjamo da bi se kod duljeg skladištenja stvorile i neke druge strukture. Osim toga, manje praznine ispunjavale su se brže od većih.

Vjerojatni mehanizam je inicijacija odgođenog spajanja baze i kiseline tijekom sazrijevanja stakleno-ionomernih cemenata u prazninama originalnog matriksa. Budući da je materijal bio zaštićen lakom, difuzija vode mogla je početi samo iz dentinske tekućine preko spoja, te iz dentina ispod materijala.

Tijekom EDAX-ove analize stvorenih struktura pronađen je velik udjel stroncija, što nije neobično s obzirom na sastav Fujija IX, ali naša opažanja impliciraju da postoji tendencija koncentracije tog elementa u ovim strukturama. To bi moglo pogubno utjecati na snagu materijala, jer samo male koncentracije stroncija jačaju materijal (29).

Osim stroncija, u našim se rezultatima opisuju i velike količine aluminija te silikata. U ranijim istraživanjima također se isticalo da je periferno područje takvih struktura bogato silikatima. Istaknuto je da je sastav tih prostora sličniji izvornom polialkenoatnom matriksu negoli silikatnoj fazi koja okružuje fluoroaluminosilikatne staklene partikle (27). Sekundarna faza odgovara silikatnoj uočenoj kod starenja stakleno-ionomernih cemenata (30,31).

Prisutnost tih struktura je vrlo važna, jer bi to mogao biti instrument za osnaživanje kompresivne jakosti ispuna od stakleno-ionomernih cemenata, vjerojatno kao rezultat reparacije pukotina koje se šire po matriksu i ispunjavanjem praznina odgađaju pojavu novih.

Nedostatak toga fenomena jest u tome što stakleno-ionomerni cementi mogu brzo povući vodu iz dentina, a to može završiti poslijeoperativnom preosjetljivošću (27,32). Ta bi karakteristika mogla biti objašnjenje za preporuke proizvođača da se stakleno-ionomerni materijali primjenjuju na blago vlažnom dentinu.

tional glass-ionomer cements next to dentin surfaces. This may be attributed to the shorter storage time they applied. The presence of solid spherical structures within the air-voids in the material's matrix was noted only in resin-modified glass-ionomers, and only if the fractured surfaces were on 3mm from the interface (26). We suspect that if the storage time interval is longer, more structures will be formed. Also, the smaller voids can be occluded faster than the bigger ones.

The probable mechanism is initiation of a delayed acid-base setting reaction during the maturation phase of glass-ionomer cements into the air voids of the original matrix. Since the materials were protected with varnish, the water diffusion could only result from movement of the dentinal fluid across the bonded interface from the underlying dentin.

The EDAX analysis of the formed structures found very high quantity of strontium, which is not strange, having in mind the composition of Fuji IX, but our observations imply that there is a tendency for concentration of this element in these formations. This may be detrimental for the material's strength, because only lower concentrations of strontium may lead to its increase (29).

Along with the strontium, our results found high quantity of silica and aluminium. Previous studies also witnessed the silica-rich peripheral phase of these formations. They found that the composition of these bodies is closer to the structure of the original polyalkenoate matrix than to the siliceous phase which envelopes the fluoroaluminosilicate glass particles (27). The presence of this secondary phase resembles to the silica phase that was observed following the aging of glass-ionomer cements (30,31).

The appearance of these structures is highly important, because this may be an instrument for increasing of the compressive strength found in old glass-ionomer cement restorations, probably as a result of repairing the cracks that spread throughout the matrix and postponing the appearance of new ones by the occlusion of the voids.

The shortcoming of this phenomenon is that the glass-ionomer cements may draw water from the dentin quickly, so it may result in the appearance of the post-operative sensitivity (27,32). This feature may be an explanation for the manufacturers' recommendations that glass ionomer-based materials should be used on slightly moist dentin.

Zaključci

1. Stakleno-ionomerni cementi vezani na dentin stalno «navlače» vodu iz vlažnog dentina te potiču dodatnu reakciju neutralizacije;
2. Sferična tijela upućuju na kretanje vode prema praznim prostorima preko spoja konvencionalnih stakleno-ionomernih cemenata i dentina;
3. Te se strukture uglavnom sastoje od stroncija, s malo silikata i aluminija;
4. Djelomično ili potpuno ispunjivanje praznih prostora sferičnim tijelima može se smatrati mehanizmom koji poboljšava kompresivnu jakost.

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Conclusions

1. Glass-ionomer cements bonded to dentin will persistently take-up water from the underlying moist dentin and will propagate an additional reaction of neutralization.
2. The presence of the spherical bodies indicates that movement of water into the air voids across the interface of conventional glass-ionomer cements exists.
3. These structures are mainly composed of strontium, with some silica and aluminium.
4. The partial or complete filling up of the air voids by the spherical bodies can be regarded as a mechanism which leads to improvement of the compressive strength.

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Abstract

Objectives: The purpose of this study was to examine the effects of the water movement across dentin bonded to conventional glass-ionomer cements. **Material and method:** Class V cavities were prepared on extracted permanent third molar teeth, filled with conventional glass-ionomer cement Fuji IX and stored in artificial saliva for one and 18 months. After the storage time interval, the teeth were sectioned longitudinally and examined by SEM (in secondary and backscattered electron mode) and EDAX. **Results:** Spherical structures were noted in the material adjacent to the interface with the hard dental substances after 18 months. The air voids found next to the interface between the traditional glass-ionomer cements and dentin are mainly "egg-shell-like" (although, solid ones were also found). They are probably a result of the continuation of the setting reaction in the air voids of the original polyalkenoate matrix, which appears because of water diffusion from the humid dentin. The EDAX analysis proved that these formations consist of high quantity of strontium, silica and aluminium. **Conclusions:** The described spherical formations may lead to improvement of the compressive strength, which is found in old restorations with conventional glass-ionomer cements.

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Key words
Glass Ionomer Cements; Dental Materials; Dentin

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