Procjena mikropropusnosti Zirconomer®: staklenoionomernog cementa ojačanog cirkonijevim oksidom

Evaluation of Microleakage in Zirconomer®: A Zirconia Reinforced Glass Ionomer Cement

Introduction

Microleakage is a phenomenon in operative dentistry resulting from diffusion of bacteria, fluids, food debris, other ions and molecules along the tooth-restoration interfaces (1). It causes recurrent caries, discoloration, restorative failure and/or pulpal pathology (1, 2). Therefore, controlling and eliminating the marginal leakage is an important goal of modern restorative dentistry.

Studies have reported various methods for in vitro investigation of microleakage. These include dye penetration, fluid filtration (3, 4), electrical conductivity (5), neutron activation method (6), radioisotope method (7) and so on. The most commonly used method however, is by using coloured dye agents or chemical traces which are able to penetrate easily into the micro gaps between the tooth-restoration interfaces (8, 9). It is well documented that the most common factors affecting the integrity of the tooth-restoration interface are polymerisation shrinkage, thermal expansion, properties of bonding agent, hydrophilic nature of the monomer, manipulations and handling of investigated materials (10, 11). For-
Materijali i metode

Specimen Preparation

Sixteen non-carious bovine incisors were selected, cleaned and stored at 4°C in 0.2% thymol solution for a maximum of two weeks. The teeth were randomly divided into four groups (n = 4). One operator prepared standardized cavities on the mesial and distal surfaces with dimension of 3.0 mm length x 2.0 mm width x 2.0 mm depth using ISO #014 Straight Fissure diamond bur (for preparation) and ISO #012 Inverted Cone diamond bur (for finishing) with a high-speed handpiece under water spray. No bevels were added at the preparation margins. The required time for each cavity was about 10 min and burs were replaced after the seventh preparation. Every seven prepared cavities were restored with one material; as following:
skupina I: Zirconomer (konvencionalni SIC, SHOFU, Japan), ručno miješan na staklenoj ploči plastičnom lopaticom u specifičnom omjeru praha i tekućine od 2:1; skupina II: Ketac™ Silver (konvencionalni SIC, 3M ESPE, Njemačka), ručno miješan na staklenoj ploči plastičnom lopaticom u specifičnom omjeru praha i tekućine od 1:1; skupina III: FiltekTM Z500 (Composite, 3M ESPE, Njemačka); skupina IV: Dispersalloy® (Amalgam, DENTSPLY, UK) u kapsulama. Svi restaurativni materijali korišteni su prema preporukama proizvođača. Uzorci SIC-a restaurirani su debelo slojnjenjem tehnikom te je uklonjen višak cementa. Površina ispuna odmah je premazana vazelinom kako bi se izbjegla apsorpcija vode i dehidracija. Za kompozitne ispune sve stijenke kavite-ta jetkane su 37-postotnim gelom ortofosforne kiseline koji je nanesen malom četkicom i ostavljen da djeluje 15 sekunda, nakon čega je odmah slijel didiranje i usušenje kavite-ta. Adheziv (OptiBond Solo Plus, Kerr, serijska br. 3536355) nanesen je i osvjetljen na svim rubovima 20 sekunda LED lampom (3M ESPE Elipar™). Kompozitni materijal postavljen je u slojevima sve dok kavitet nije ispunjen. Svaki sloj po-limitiziran je 20 sekunda. Amalgamski ispuni ručno su kon-denzirani. Oštar ručni rezač upotrijebljen je za reprodukciju pravilne anatomije zuba.

Provjera i vizualizacija mikropropuštanja

Vrhovi korijena zapečaćeni su ljepljivom voskom nakon čega su površine zuba dvostruko premazane lakom za nokte s razmakom od 1 mm od rubova restauracije. Zubi su uronjeni u rastaljenu smjesu za otiskivanje kako bi se oponašao oralni milje. Provjera i vizualizacija mikropropuštanja

Tablica 1. Kriterij procjene stupnja penetracije boje duž spoja ispuna i zuba

| Stupanj | Score | Spoj ispuna i zuba | Tooth-restoration interface |
|---------|-------|-------------------|-----------------------------|
| 0       | Nema prodiranja boje | No dye penetration |
| 1       | Prodiranje boje do 1/3 preparirane stijenke kaviteta | Dye penetration up to 1/3 of the prepared cavity wall |
| 2       | Prodiranje boje do 2/3 preparirane stijenke kaviteta | Dye penetration up to 2/3 of the prepared cavity wall |
| 3       | Prodiranje boje preko cijele preparirane stijenke kaviteta | Dye penetration onto the entire prepared cavity wall |
| 4       | Prodiranje boje na svim stijenkama kaviteta | Dye penetration onto the whole prepared cavity walls |
Statistička analiza

Rezultati procjene stupnja penetracije boje statistički su analizirani neparametrijskim testom (Kruskal-Wallis) softverom IBM SPSS (verzija 24, SPSS Inc., Chicago, SAD). Parametrijska usporedba (Mann-Whitney U-test) provedena je na razini značajnosti p < 0,05.

Rezultati

U ovom istraživanju pri uporabi svih ispitanih materijal- la dogodilo se znatno prodiranje boje; slika 1. (a – d). Kruskal-Wallisov test pokazao je značajne razlike u srednjim vrijednostima mikropropusnosti između četiri skupina (p = 0,000). Najveća srednja vrijednost mikropropuštanja utvrđena je za KetacTM Silver (3,71 ± 0,48). Srednja vrijednost penetracije boje za Zirconomer (2,86 ± 0,69) bila je slična kao srednja vrijednost za kompozitne restauracije (2,86 ± 1,06). Uzorci ispunjeni amalgamom imali su niže srednje vrijednost (0,57 ± 0,53) u usporedbi s drugim testiranim materijalima. Paralelna usporedba pokazala je statistički značajne varijacije između Zirconomer i drugih ispitivanih skupina, KetacTM Silvera i amalgama (P < 0,05), a nije bilo značajne razlike između Zirconomer i kompozitnih restauracija (P > 0,05). Razlike između svih ispitanih skupina i amalgamske skupine bile su statistički značajne (P < 0,05); tablice 2. i 3.

Rasprava

Testiranje mikropropusnosti naširoko se koristi kao glavni pokazatelj kojim kliničari i istraživači mogu predvidjeti kvalitetu vezivanja restaurativnih materijala. Klinički uspjeh uglavnom ovisi o svojstvu materijala da se čvrsto veže za površinu zuba i da se ta površina izolira od okoline te se tako spriječi pojava sekundarnog karijesa (25).
A Zirconia Reinforced Glass Ionomer Cement

Velik stupanj propuštanja utvrđen je na restauracijama u skupini I – Zirconomer nakon 24 sata uranjanja u boju: kao što se vidi na slici 1. (a). Takav nalaz u skladu je s istraživačkom skupinom I – Zirconomer nakon 24 sata uranjanja u boju; kao propuštanja statistički su analizirane između kompozitnih iscrtanja prikazano na slici 1. (c). Varijance u srednjim vrijednostima poliakrilne matrice u cementu i nakon dodavanja cirkonijevog oksida. Moguće je da će to punilo uzrokovati smetnje u kemijskom strukturnom Zirconomeru koji kao punilo sadržava keramičke čestice (cirkonijske čestice). Ovo se može objasniti kemijskom strukturom Zirconomer koji je u skladu sa istraživanjem Asafarlala (26) koji su dobili slične rezultate kada su testirali penetraciju boje kroz Zirconomer na ljudskim zubima. U nedavno provedenom istraživanju Asafarlal (26) je dogodio se ioksid). Moguće je da će to punilo uzrokovati smetnje u kemijskom strukturnom Zirconomeri koji kao punilo sadržava keramičke čestice (cirkonijsku česticu). U skupini II – Ketac™ Silver; kao što je prikazano na slici 1. (b). To se također može pripisati prekidu poliakrilne matrice u cementu i nakon dodavanja cirkonijevih oksidnih punila u Zirconomeru.

U nedavno provedenom istraživanju Asafarlal (26) je dogodio se ioksid). Moguće je da će to punilo uzrokovati smetnje u kemijskom strukturnom Zirconomeri koji kao punilo sadržava keramičke čestice (cirkonijsku česticu). U skupini II – Ketac™ Silver; kao što je prikazano na slici 1. (b). To se također može pripisati prekidu poliakrilne matrice u cementu i nakon dodavanja cirkonijevih oksidnih punila u Zirconomeru.

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Tablica 2. Srednje vrijednosti, standardne devijacije (SD), minimalne i maksimalne vrijednosti mikropropuštanja u različitim eksperimentalnim skupinama

| Skupina • Groups | Srednja vrijednost ± SD • Mean ± SD | min.-maks. • Min-Max |
|------------------|----------------------------------|---------------------|
| ZIRCONOMER      | 2.86 ± 0.69*                     | 2.00-4.00           |
| KETAC™ SILVER   | 3.71 ± 0.48b                     | 3.00-4.00           |
| FILTEK™ Z500    | 2.86 ± 1.06**                    | 1.00-4.00           |
| DISPERSALLOY®   | 0.57 ± 0.53*                     | 0.00-1.00           |

Različita slova u superskriptu predstavljaju statistički značajne razlike između ispitanih skupina (p < 0.05) • Different superscript letters represent the significant differences between the tested groups (p < 0.05)

A significant degree of leakage was exhibited in Group I-Zirconomer restorations after 24 hr of dye immersion; as seen in Figure 1 (a). This finding goes in a good agreement with the previous work by Patel et al., (22) who found almost similar outcomes when they tested the dye penetration of Zirconomer in human molar teeth. This could be explained due to the fact that the chemical structure of Zirconomer which comprises ceramic particles (zirconia) as fillers. It is possible that the zirconia fillers would cause interference in the chelating reaction between the carboxylic group (-COOH) of polyacrylic acid and the calcium ions (Ca ²⁺) of tooth apatite. The marginal leakage was also observed with silver reinforced glass ionomer filling material (Group II-Ketac™ Silver); as displayed in Figure 1 (b). This can also be attributed to the disruption of polyacrylate matrix in the cement as noted with the addition of zirconia fillers in Zirconomer.

A recent study by Asafarlal (26) investigated the microleakage of three different GICs-Zirconomer, Fuji IX Extra and Ketac Molar quantitatively. After immersion the teeth individually in 0.5% methylene blue dye for 24 hr, the samples were dissolved in 2ml of 65% nitric acid, the solutions were centrifuged and then spectrophotometer was used to assess the dye penetration. The results of the dye concentration in the experimental solutions showed that the microleakage value of Zirconomer was higher compared to the other GICs. This was believed to be owing to large size of the filler particles of zirconia which leading to poor adaptation at the tooth-restoration interface (26).

In addition, the examined composite (Group III-Filtek™ Z500) restorations in this study showed a substantial degree rounding environment and hence to prevent the secondary caries occurrence (25).
Staklenoionomerni cement ojačan cirkonijevim oksidom

Albeshti i sur.

punu i drugih skupina s konvencionalnim staklenoionomernim cementima (skupina I – Zirconomer i skupina II - KetacTM Silver), ali nisu utvrđene nikakve razlike (p > 0,05) – kao što je navedeno u tablicama 2. i 3. Mikropropusnost kompozitnih ispuna može se objasniti polimerizacijskim skupljanjem, što rezultira lošijim prianjanjem na površini zuba. Zbog toga korištenje adhezivnih sustava ovdje nije moglo smanjiti pojavu mikropukotina na sučelju.

Dobiveni rezultati također su pokazali da je na amalgamskim ispunama (skupina IV – Dispersalloy*) zabilježeno minimalno propuštanje u usporedbi s drugim testiranim materijalima – kao što je prikazano na slici 1. (d). Statistički je postojala razlika između amalgamskih ispuna i ostalih trija testiranih materijala (p < 0,05) – kao što je navedeno u tablicama 2. i 3. To je zbog činjenice da amalgam ima svojstvo brtvljenja mikropukotina tijekom procesa kondenzacije i modelacije. Osim toga, ti pokusi izvedeni su u idealnom okružju bez izlaganja bilo kakvim onečišćenjima. Bez obzira na loša estetska svojstva, toksični učinak žive, postupak pripreme i ekspanziju što rezultira stvaranjem pukotina na površini zuba (27), amalgam je i dalje jedna od alternativa u stomatologiji zbog razmjerno niske cijene.

U prethodnom istraživanju u kojemu su se uspoređivala svojstva brtvljenja amalgama i kompozitnih materijala zaključeno je da je amalgamski ispun I. razreda imao najmanju mikropropusnost od kompozitnoga (28). U drugom istraživanju dokumentirano je da oblaganje stijenki lakom nije spriječilo rubno propuštanje na amalgamskim ispunama (29). Uz smajnjenje popularnosti amalgama u posljednjih nekoliko godina i nedostatke materijala na bazi smola, postoji potreba za restaurativnim materijalom koji stvara jaku vezu i jednostavan je za primjenu. Zbog toga je Zirconomer (bijeli amalgam) novi razred staklenoionomernih cemenata i savršen izbor u restaurativnoj stomatologiji zbog svojstava razmjerno niske cijene.

Važno je istaknuti da konvencionalni SIC-ovi imaju jedinstveno svojstvo formiranja jake kemijske veze s prirodnim zubnim tkivom (30), pa nije potrebno korištenje vezivnih sredstava ili kiselina za jetkanje jer poliakrilna kiselina (tekuća komponenta SIC-a) može najutjecati površinu zuba i tako pomoći u izradci visok okvira. Uvjeranje se da se SIC veže kemijski stvaranjem ionske veze između karboksilnih skupina (COO-) cemenata i kalcija (Ca2+) iz zuba (32, 33).

SIC ima svojstvo remineralizacije i zaštite zuba jer otpušta ioni kao što su fluor, kalcij i fosfat. Otpuštanje iona iz ispuna također se može promotivati u mediju koji sadržava fluor (34). SIC tako djeluje kao spremnik fluora kako bi se postigao dugoročni protukarijensi učinak u usporedbi s kompozitnim materijalima. Van Duinen i suradnici (35) i Van Duinen (36) utvrdili su da se spojevi slični apatitu stvaraju na površini materijala temeljenih na SIC-u. Zbog toga je SIC može smatrati savršen izborom u restaurativnoj stomatologiji - osobito za ART tehniku (Atraumatic Restorative Treatment) zbog sposobnosti remineralizacije. To svojstvo (remineralizacije) razlikuje ove pametne materijale (SIC-ove) od drugih materijala za ispune kao što su kompoziti i amalgami zbog njihova jedinstvenog sastava. To bi moglo biti koristićno za minimum propuštanja u usporedbi s drugim materijalima u stomatologiji za restaurativnu kliniku.

Zbog toga korištenje adhezivnih sustava u usporedbi s amalgama i kompozitima za ispune živi u dolini tokom godinama (36) utvrdili su da se spojevi slični apatitu stvaraju na površini materijala. Van Duinen i suradnici (35) i Van Duinen (36) utvrdili su da se spojevi slični apatitu stvaraju na površini materijala temeljenih na SIC-u. Zbog toga je SIC može smatrati savršen izborom u restaurativnoj stomatologiji - osobito za ART tehniku (Atraumatic Restorative Treatment) zbog sposobnosti remineralizacije. To svojstvo (remineralizacije) razlikuje ove pametne materijale (SIC-ove) od drugih materijala za ispune kao što su kompoziti i amalgami zbog njihova jedinstvenog sastava. To bi moglo biti koristićno za minimum propuštanja u usporedbi s drugim materijalima u stomatologiji za restaurativnu kliniku.

GICs have the ability to remineralise and protect the tooth through therapeutic ion release such as fluoride, calcium and phosphate. Ions release from the restoration that also could be promoted in fluoride-containing media (34). The GICs therefore act as reservoir of fluoride to obtain a long-term anti-cariogenic action compared to the composite restorations. Therefore, Zirconomer (white amalgam) is a new class of glass ionomer restorative material and the perfect choice due to its advantages and capacity to be used for permanent posterior restorations in patients with high caries incidence (30). It is important to highlight that the conventional GICs have unique ability to form a strong chemical bond naturally to the tooth surfaces (31) without the need of bonding agents or etching solutions as the poly-acrylic acid (liquid component of GIC) can etch the tooth surfaces and make the restoration more chemical bonds would be improved. It is believed that GICs bond chemically via formation of an ionic bond between carboxyl groups (COO-) of the cements and calcium ions (Ca2+) of the tooth surfaces (32, 33).

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Abstract

Objective: To evaluate the microleakage of four direct restorative materials. Materials and Methods: Sixteen sound bovine incisors were chosen and randomly divided into four groups; Group I-Zirconomer, Group II-Ketac™ Silver, Group III-Filtek TM Z500 (composite) and Group IV-Dispersalloy® (amalgam). Seven proximal (mesial & distal) cavities, for each material were prepared and restored. All restored samples were stored in 37°C distilled water for 24 hr and then subjected to thermo-cycling process at temperatures between 5-55°C. The samples were immersed in dye solution of 0.5% methylene blue for 24 hr. Each filled cavity was sectioned through the centre of restoration and then studied under a stereomicroscope to assess the marginal leakage. The obtained microleakage scores were statistically analysed. Results: The highest mean score of leakage was recorded in Group II-Ketac™ Silver followed by Group I-Zirconomer and Group III-Filtek TM Z500 (composite). The lowest mean score of dye penetration was verified in Group IV-Dispersalloy® (amalgam). Statistically, there were significant differences between Ketac™ Silver and amalgam, but not with composite; IV. Amalgam showed the least microleakage scores and also there were highly significant variations between amalgam and other tested restorative materials.

Conclusions

Within the limitation of this study, it can be concluded that: I. None of the tested restorative materials was free from the microleakage; II. Cavities filled with Ketac™ Silver exhibited the highest microleakage scores followed by Zirconomer and composite; III. It found that the newer material (Zirconomer) had significant differences verses Ketac™ Silver and amalgam, but not with composite; IV. Amalgam showed the least microleakage scores and also there were highly significant variations between amalgam and other tested restorative materials.

Further experiments are required to be done in order to achieve the maximum enhancement of bonding characteristics in newly available GICs in the long-term.

Conflict of interest

None declared
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