

Evaluation of bond strength of one step and two steps self-etch adhesive agents with two different pulp-capping materials

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SUMMARY

Primary purpose of restorative dentistry is to preserve pulp vitality. Besides calcium hydroxide, the application of calcium silicate cements as a material for direct pulp capping has become used recently.

The aim of our study was to investigate the influence of materials for direct and indirect pulp capping on the bond strength of composite restorations using two different self etch dentin adhesives.

The test was performed on 60 intact molars extracted for periodontal or orthodontic reasons. The prepared samples were divided into the two groups and three subgroups depending on the adhesive and pulp capping material. Two different calcium silicate based materials were used for pulp capping. One step and two steps self etch dentin adhesive was applied to prepared specimens depending on the group and with the help of a specially made metal mold set up a composite post. The share bond strength was assessed using a universal testing machine.

The results showed significant difference in the share bond strength between the samples treated with TheraCal LC and Biodentine with TheraCal LC being superior to Biodentine.

Keywords: TheraCal LC; Biodentine; share bond strength; dentin adhesives

INTRODUCTION

Calcium silicate based materials are bioactive materials capable of forming apatite using calcium silicate or calcium aluminates. These materials are also biointeractive and release ions needed to stimulate formation of a dentin bridge [1].

Biodentine is dentin substitute composed of powder of tricalcium silicate cement, zirconium oxide, calcium carbonate and liquid. Biodentine (BD) is a bioactive material, with mechanical properties similar to dentin and can be used as its replacement [2]. It has good mechanical properties, as well as excellent biocompatibility and bioactive behavior.

TheraCal LC is light-curing calcium silicate cement promoted by the manufacturer for direct pulp capping or as a liner under restorative materials. Studies show that TheraCal LC has calcium ions release properties in a concentration range that can stimulate activity of dental

pulp and odontoblasts [3–7]. Bioavailability of calcium ions plays a key role in the proliferation caused by the material, differentiation of human dental pulp cells and new formation of mineralized hard tissues. Compared to other materials for direct and indirect pulp capping it has been proven that TheraCal LC releases higher concentration of calcium ions compared to Dycal, but has lower level of released ions than Biodentine [1]. In clinical practice, self-etch adhesives are currently widely used. They are based on the use of acidic functional monomers that can simultaneously demineralize and prime dentin. Self-etch adhesives eliminate the rinsing phase, significantly reducing clinical application time, technique sensitivity, and risk errors during application [8]. Self-etch adhesives can be classified into two- step self-etch adhesives that include the application of an additional layer of solvent-free hydrophobic resin creating stronger adhesive layers, and one step self-etch adhesives which contain hydrophilic monomers, water, and volatile solvents [9, 10]. Bond strength

between dentin liners and composite depends on their physicochemical properties, nature of the bond between liner and RC, and the types of adhesive used.

The aim of our study was to investigate the influence of materials for direct and indirect pulp capping on the bond strength of composite restorations using two different self etch dentine adhesives.

MATERIAL AND METHOD

The study included 60 intact molars extracted for periodontal or orthodontic reasons. After removal of soft tissues, the teeth were stored in distilled water (ISO 3696 grade 3) at room temperature. The teeth were then molded in self-adhesive acrylate using 2.5 cm × 2.5 cm × 2.5 cm plastic molds and cut at the level of the occlusal surface with a high speed diamond disc with water cooling to obtain smooth dentinal surface. This way prepared samples were divided into the two groups (1 and 2), depending

on the adhesive used (One Coat 7 Universal-Coltene and Clearfil SE Bond Kuraray Noritake).

Each group was further subdivided into the three subgroups of 10 teeth each, with A, B and E subgroups from the first group where adhesive One Coat 7 Universal was used and C, D, F subgroups from the second group where Clearfil SE Bond was used. The specimens from subgroups A, B, C and D received cavity preparation on the occlusal surface using high speed handpiece and diamond bur with water cooling in 6 mm diameter and 2 mm depth to provide liner retention. Biodentine (Septodont, Saint- Maur-des-Fosses, France) was applied in cavities from subgroups A and C while Theracal LC (Bisco Inc., Schaumburg, IL, USA) was applied in the subgroups B and D. The teeth from subgroups E and F, where adhesive were applied directly to dentin served as control samples.

Dentin adhesive was applied to prepared specimens using a metal mold made specifically for this purpose; we set up the composite post (3 mm diameter and 3 mm height). The materials used in our research are shown in Table 1.

Table 1. Materials used in this study

Tabela 1. Materijali korišćeni u studiji

Material Materijal	Manufacturer Proizvođač	Composition Sastav
Resin modified Calcium silicate cement Smolom modifikovani silikatni cement	Theracal LC (Bisco Inc., Schaumburg, IL, USA)	Polymerizable methacrylate monomers, Portland cement type III, polyethylene glycol dimethacrylate, and barium zirconate. Polimerizujući metakrilatni monomeri, Portland cement tip 3, politilen glikol-dimetakrilat, barijum-cirkonat
Tricalcium silicate cement Trikalcijum silikatni cement	Biodentine (Septodont, Saint- Maur-des-Fosses, France)	Powder: tricalcium silicate, calcium carbonate, and zirconium oxide Liquid: water, calcium chloride (accelerator), and modified polycarboxylate Prah: trikalcijum-silikat, kalcijum-karbonat, cirkonijum-oksidi Tečnost: voda, kalcijum-hlorid (akcelerator) i modifikovani polikarboksilat
Resin Composite Kompozitna smola	Brilliant EverGlow (Coltene)	Universal Submicron Hybrid Composite Univerzalni submikrohibridni kompozit
Universal Dental adhesive Univerzalni dentalni lepak	One Coat 7 Universal (Coltene)	(HEMA), hydroxypropylmethacrylate, methacrylate modified polyacrylic acid, urethanedimethacrylate, glycerol dimethacrylate, amorph silicic acid, water (5%), initiators and stabilizers. (HEMA), hidroksipropilmetakrilat, metakrilatna modifikovana poliakrilna kiselina, uretanedimeta-krilat, glicerol-dimetakrilat, amorfn silicijumska kiselina, voda (5%), inicijatori i stabilizatori.
Universal Dental adhesive Univerzalni dentalni lepak	Clearfil SE Bond Kuraray Noritake	Primer: MDP, HEMA, dimethacrylate monomer, water, catalyst Bond: MDP, HEMA, dimethacrylate monomer, microfiller, catalyst Prajmer: MDP, HEMA, dimetakrilatni monomer, voda, katalizator Veza: MDP, HEMA, dimetakrilatni monomer, mikropunilo, katalizator

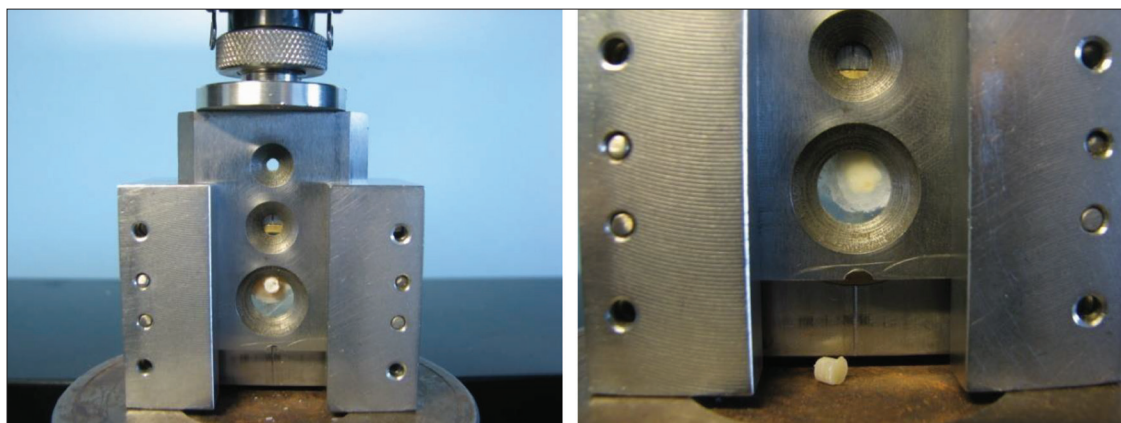


Figure 1. Instron 4301 Universal Testing machine

Slika 1. Univerzalna mašina za testiranje – Instron 43

Measurement of bond strength

The specimens were then mounted on a universal Instron 4301 bond strength-testing machine. A force of 1 mm/min was applied to each specimen by applying a notched edge blade with curved edge up to breaking of the bond between the composite and TLC/BD (Figure 1). Share bond strength values were measured in Newtons (N) and then converted to Mega pascals (MPa).

Fracture type analysis was performed using a stereomicroscope with magnification $\times 25$, and fracture was classified as cohesive (fracture in the material itself), adhesive (fracture of the interface between the composite and the liner) and mixed (when both types of fracture are present at the same time).

RESULTS

Descriptive analysis of the results obtained for the first and second groups is shown in Tables 2 and 3. Analysis between groups A and B indicated that, for $p < 0.05$, there was a significant difference between the two groups in relation to the average values of bond strength (Mann-Whitney U Test: $Z = -2.8111$; $p = 0.0049$) in favor of a significantly greater bond strength in group B. Further analysis between groups A/E and B/E indicated that, for $p < 0.05$, there was significant difference between the two groups in relation to the average values of bond strength (Mann-Whitney U Test: $Z = -2.8419$; $p = 0.0045$ / $Z = -2.1923$; $p = 0.0283$) in favor of significantly greater bond strength in Group E.

Analysis between groups C and D indicated that, for $p < 0.05$, there was a significant difference between the two groups in relation to the average values of the bond

strength (Mann-Whitney U Test: $Z = -2.3638$; $p = 0.0181$) in favor of a significantly greater bond strength in group D. Additional analysis between the C/F and D/S groups indicated that, for $p < 0.05$, there was a significant difference between the groups with respect to the average values of the bond strength (Mann-Whitney U Test: $Z = -2.6796$; $p = 0.0074$ / $Z = -1.7052$; $p = 0.0882$) in favor of a significantly greater bond strength in group F.

Analysis of the average bond strength between the A/C and B/D groups indicated that for $p > 0.05$, there was no significant difference between the two groups with respect to the average bond strength values (Mann-Whitney U Test: $Z = -0.8305$; $p = 0.4062$ and $Z = 0.0112$; $p = 1.0000$).

The observed modes of failure in the BD group were predominantly cohesive, whereas the TheraCal LC group had a mixed fracture besides the cohesive one.

DISCUSSION

Primary purpose of restorative dentistry is to preserve pulp vitality [11]. Calcium hydroxide has been the gold standard for a long time in direct pulp capping [12]. In addition to this material, the application of calcium silicate cements as a material for direct pulp capping has become more present recently. Calcium silicate based materials are bioactive materials capable of forming apatite using calcium silicate or calcium aluminates. These materials are also bio interactive and release ions needed to stimulate dentin bridge formation [13]. Biodentine is a bioactive material, with mechanical properties similar to dentin and can be used as its replacement to cause dentin bridge formation. It has good mechanical properties, as well as excellent biocompatibility and bioactive behavior. In ad-

Table 2. Descriptive analysis of the share bond strength in groups A, B, and E (One Coat 7 Universal-Coltene)

Tabela 2. Opisna analiza jačine adhezivne veze u grupama A, B i E (jednoslojni lepak 7 Universal Coltene)

Groups Grupe	Mean Srednja vrednost	N Broj	Std. Deviation St. devijacija	Min.	Max.	Percentiles Procenat		
						25 th 25.	50 th 50. Median Medijana	75 th 75.
A (Biodentine)	11.24	7	3.06	6.86	16.58	9.70	10.80	13.40
B TheraCal LC	19.28	7	3.97	13.40	23.90	15.12	19.27	23.20
E	25.29	5	4.26	19.00	31.00	25.00	25.53	25.90

Table 3. Descriptive analysis of the share bond strength in groups C, D, and F (Clearfil SE Bond)

Tabela 3. Opisna analiza jačine adhezivne veze u grupama C, D i F (Clearfil SE Bond)

Groups Grupe	Mean Srednja vrednost	N Broj	Std. Deviation St. devijacija	Min.	Max.	Percentiles Procenat		
						25 th 25.	50 th 50. Median Medijana	75 th 75.
C (Biodentine)	12.17	7	3.20	7.62	17.38	10.06	11.30	14.37
D TheraCal LC	19.24	7	4.46	13.40	25.26	13.53	19.70	22.70
F	23.88	5	5.15	15.70	28.28	22.00	26.40	27.02

dition, initial setting time of BD is about 12 minutes and it does not cause tooth changes [2, 14, 15].

A major drawback of Biodentine is its water-based chemistry that affects the bond with both dentin and composite, since the bond is mainly micromechanical. To overcome this limitation, tri calcium silicate (TheraCal LC), modified with resin, was introduced as a material for direct pulp capping. Light-curable resin-modified products have the advantages of precise placement, command set, superior physical strength, less solubility, and reduced heavy metal release. These products with hydrophilic polymer matrix allowed the high release of calcium and hydroxide ions. They are promising materials for dental treatment of direct pulp capping [16].

TheraCal LC is a light-cured polymerizing hydraulic silicate material that sets by hydration. Bonding begins with the contact of material and water. Unlike Biodentine, TheraCal LC does not include water to hydrate the material, and the bonding process depends on the water captured by the environment and its diffusion into the material [17].

Bond strength between restorative materials and materials for direct and indirect pulp capping is also important for the success of restorations. It depends on their physico-chemical characteristics, nature of the bond between the liner and the composite material and the type of adhesive system.

Presence of the resin component in TheraCal LC facilitates the placement of the final restoration in the same session. Various research have been done on the impact of these materials on bond strength. Deepa et al. compared and evaluated share bond strength of the composite with three different liners: TheraCal LC, Biodentine, and Fuji II LC after applying universal adhesive (Single Bond Universal). They found that bond strength of the composite with TheraCal LC and Fuji II LC was similar and significantly higher than that with Biodentine after application of universal adhesive [18]. Meraji and Camilleri's researches also show higher bond strengths of TheraCal LC than Biodentine, whether on composite material or Glass Ionomer Cements. The same authors concluded that bond strength between TheraCal LC and composite when applying total-etch adhesives was significantly better than bond strength when applying self-etch dentin adhesives [19].

The results of our study also showed that there was a significant difference in the share bond strength between the samples treated with TheraCal LC and Biodentine in the two tested dentin adhesives in favor of significantly greater bond strength in the TheraCal LC group. This may be due to the fact that the TheraCal LC exhibits early cohesive force upon photo-activation. In contrast, Biodentine shows low hardness of the material itself, at an early stage of application [20].

After initial setting, Biodentine is still a porous material that needs at least 2 weeks for complete polymerization of the hydrated calcium silicate gel and to form a solid mesh that will attain strength sufficient to withstand the stresses of polymerization [15, 18]. In our study, we applied the adhesive and composite material in the same session

shortly after the initial setting of BD. This may be the reason for the low bond strength, as well as the cohesive type of material fracture.

The effectiveness of bonding of current commercial dentin adhesives is variable. Karadas et al. investigated bond strength of different dentin adhesives with TheraCal LC. They reported that etch and rinse adhesives provided better bond strength restoration than self-etch adhesives [21]. The study also showed that two-step self-etch adhesives had higher bond strength values than one-step self-etch adhesives, with the exception of Clearfil S3, probably due to the fact that it contains 10-Methacryloyloxydecyl dihydrogen phosphate (MDP), which is known to bond chemically to the tooth calcium [21, 22]. In contrast, our study showed that there was no significant difference in the bond strength between one-step and two-step self-etch adhesives in the two examined liners. The application of one-step dentin adhesives provides optimal bonding efficiency with a simplified application protocol.

It has been proven that in order to resist the material's contraction forces and provide good enamel and dentin retention, bond strength of the composite material should be minimum 17-20 MPa [23]. This bond strength was achieved in both tested dentin adhesives only in the samples where we used TheraCal LC as the liner. Cantekin showed in his research that light-cured MTA showed clinically acceptable and higher shear bond scores compared to MTA when used with Methacrylate-based composite, as composite material used in our research. According to the same authors, Methacrylate-based composites achieved greater bond strength than silorane-based composites and GI Cement [24].

Despite the high bond strength values of the TheraCal LC samples, the results of our study showed that this bond strength was significantly lower than that of the control group in the two tested dentin adhesives, indicating that despite the presence of the resin component, TheraCal LC as well as Biodentine have an effect on the bond strength of the composite material with dentin.

CONCLUSION

TLC has achieved bond strength sufficient to resist material's contraction forces and provide good enamel and dentin retention at an early stage after application. However, the application of TheraCal LC has an impact on the bond strength of the composite material to the dentin.

BD showed significantly lower bond strength in the early stage after the initial bonding of the material, as well as cohesive fracture confirming the fact that, prior to placement of definitive restoration, this material should be allowed to mature long enough to achieve the required hardness to withstand the forces of the contraction of the restorative material and to provide good retention. The type of dentin adhesive (one-step and two-step self-etch adhesives) had no effect on the bond strength of the two examined liners.

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Procena čvrstoće veze jednokomponentnih i dvokomponentnih adhezivnih sredstava sa dva različita materijala za direktno prekrivanje pulpe

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KRATAK SADRŽAJ

Primarna svrha restorativne stomatologije je očuvanje vitalnosti pulpe. Pored kalcijumovog hidroksida, primena kalcijum-silikatnih cementa kao materijala za direktno zatvaranje pulpe u poslednje vreme je sve prisutnija.

Cilj naše studije bio je istražiti uticaj materijala za direktno i indirektno zatvaranje pulpe na čvrstoću vezivanja kompozitnih restauracija korišćenjem dva različita samonagrizajuća dentinska lepka.

Ispitivanje je izvršeno na 60 intaktnih kutnjaka izvađenih iz parodontskih ili ortodontskih razloga. Pripremljeni uzorci su podeljeni u dve grupe i tri podgrupe, u zavisnosti od lepka i materijala za prekrivanje pulpe.

Dva materijala na bazi kalcijumovog silikata korišćena su kao materijali za prekrivanje pulpe.

Jednokomponentni i dvokomponentni dentinski lepkovi nanoseni su na pripremljene uzorke u zavisnosti od grupe, a uz pomoć posebno izrađenog metalnog kalupa postavljen je kompozitni post. Jačina veze je procenjena korišćenjem univerzalne mašine za testiranje.

Rezultati su pokazali da postoji značajna razlika u jačini veze između uzoraka tretiranih sa TheraCal LC i biodentinom u dva testirana dentinska lepka u korist značajno veće čvrstoće vezivanja kod TheraCal LC grupe.

Ključne reči: TheraCal LC; biodentin; jačina veze; dentinski lepak

UVOD

Materijali na bazi kalcijum-silikata su bioaktivni materijali koji mogu formirati apatit koristeći kalcijum-silikat ili kalcijum-aluminat. Ovi materijali su takođe biointeraktivni i oslobađaju jone potrebne za podsticanje formiranja dentinskog mosta [1].

Biodentin (BD) jeste zamena za dentin koji se sastoji od praška trikalcijum-silikatnog cementa, cirkonijum-oksida i kalcijum-karbonata i tečnosti. BD je bioaktivni materijal, mehaničkih svojstava sličnih dentinu i može se koristiti kao njegova zamena [2]. Ima dobra mehanička svojstva, kao i odličnu biokompatibilnost i bioaktivno ponašanje.

TheraCal LC (TLC) svetlosno je vezujući kalcijum-silikatni cement koji promovise proizvođač za direktno zatvaranje pulpe ili kao oblogu ispod restorativnih materijala. Studije pokazuju da TheraCal LC ima svojstva oslobađanja jona kalcijuma u rasponu koncentracija koje mogu podstaći aktivnost zubne pulpe i odontoblasta [3–7]. Bioraspoloživost kalcijumovih jona igra ključnu ulogu u proliferaciji koju prouzrokuje materijal i diferencijaciji ćelija zubne pulpe kod ljudi i novom stvaranju mineralizovanog tvrdog tkiva. U poređenju sa drugim materijalima za direktno i indirektno zatvaranje pulpe, dokazano je da TheraCal LC oslobađa veću koncentraciju kalcijumovih jona u poređenju s Dicalom, ali ima niži nivo oslobođenih jona od BD [1]. U kliničkoj praksi trenutno se široko koriste samonagrizajući lepkovi. Zasnivaju se na upotrebi kiselih funkcionalnih monomera, koji mogu istovremeno demineralizovati i pripremiti dentin. Samonagrizajući dentinski lepkovi uklanjaju fazu ispiranja, značajno smanjujući vreme kliničke primene, osetljivost tehnike i greške rizika tokom nanošenja [8]. Lepkovi za samonagrizanje mogu se klasifikovati

u dvokomponentne samonagrizajuće lepkove, koji uključuju nanošenje dodatnog sloja hidrofobne smole bez rastvarača koji stvaraju jače lepljive slojeve, i jednokomponentne lepkove, koji sadrže hidrofilne monomere, vodu i isparljive rastvarače [9, 10].

Čvrstoća veze između dentinskih slojeva i kompozita zavisi od njihovih fizičko-hemijskih svojstava, prirode veze između lajnera i kompozita i vrste korišćenog lepka.

Cilj naše studije bio je istražiti uticaj materijala za direktno i indirektno prekrivanje pulpe na čvrstoću vezivanja kompozitnih restauracija korišćenjem dva različita samonagrizajuća dentinska lepka.

MATERIJAL I METODA

Ispitivanje smo obavili pomoću 60 netaknutih kutnjaka izvađenih iz parodontskih ili ortodontskih razloga. Posle uklanjanja mekih tkiva zubi su čuvani u destilovanoj vodi (ISO 3696, kvalitet 3) na sobnoj temperaturi. Zubi su ukalupljeni u samovezujući akrilat pomoću plastičnih kalupa veličine 2,5 cm × 2,5 cm × 2,5 cm i isečeni na nivou okluzalne površine dijamantskim diskom velike brzine vodenim hlađenjem da bi se dobila glatka dentinalna površina. Uzorci pripremljeni na ovaj način su podeljeni u dve grupe (1 i 2), zavisno od lepka koji smo koristili (One Coat 7 Universal-Coltene i Clearfil SE Bond Kuraray Noritake).

Svaka grupa je dalje podeljena u tri podgrupe od po 10 zuba, A, B i E podgrupe iz prve grupe, gde smo kao lepak koristili One Coat 7 Universal-Coltene, i C, D, F podgrupe iz druge grupe, gde smo koristili Clearfil SE Bond. Na uzorcima podgrupa A, B, C i D na okluzalnoj površini sa turbinom i dijamantnom opekinom

vodenim hlađenjem pripremljene su šupljine prečnika 6 mm i dubine 2 mm da bi se obezbedilo zadržavanje obloge. Za uzorke podgrupa A i C kao podlogu smo primenili BD (Septodont, Saint-Maur-des-Fosses, France), a za podgrupe B i D Theracal LC (Bisco Inc., Schaumburg, IL, USA). Zubi iz podgrupa E i F, gde smo lepak nanosili direktno na dentin, služili su kao kontrolni uzorci.

Dentinski lepak nanesen je na prethodno pripremljene uzorke i pomoću metalnog kalupa napravljenog posebno za ovu svrhu postavili smo kompozitni stub (promera 3 mm i visine 3 mm). Materijali korišćeni u našem istraživanju prikazani su u Tabeli 1.

Merenje čvrstoće veze

Uzorci su zatim montirani na univerzalnu mašinu za ispitivanje jačine veze Instron 4301. Snaga od 1 mm / min. primenjena je na svaki uzorak do prekida veze između kompozita i TLC / BD (Slika 1). Vrednosti čvrstoće veze su izmerene u njutnima (N) i zatim su pretvorene u megapaskale (MPa).

Analiza tipa preloma izvedena je stereomikroskopom sa uvećanjem H25, a fraktura je klasifikovana kao kohezivna (lom u samom materijalu), adhezivna (lom interfejsa između kompozita i košuljice) i mešana (kada postoje obe vrste preloma istovremeno).

REZULTATI

Analiza rezultata dobijenih za prvu i drugu grupu prikazana je u tabelama 2 i 3.

Analiza između grupa A i B pokazala je da postoji značajna razlika između dve grupe u odnosu na prosečne vrednosti čvrstoće veze, $p < 0,05$ (Man-Vitnijev U test: $Z = -2,8111$; $p = 0,0049$) u korist značajno veće čvrstoće veze u grupi B. Dalja analiza između grupa A / E i B / E pokazala je da postoji značajna razlika između dve grupe u odnosu na prosečne vrednosti čvrstoće veze, $p < 0,05$ (Man-Vitnijev U test: $Z = -2,8419$; $p = 0,0045$ / $Z = -2,1923$; $p = 0,0283$) u korist značajno veće čvrstoće veze u grupi E.

Analiza između grupa C i D pokazala je da je za $p < 0,05$ postojala značajna razlika između dve grupe u odnosu na prosečne vrednosti čvrstoće veze (Man-Vitnijev U test: $Z = -2,3638$; $p = 0,0181$) u korist značajno veće čvrstoće veze u grupi D. Dodatna analiza između grupa C / F i D / S je pokazala da je za $p < 0,05$ postojala značajna razlika između grupa u odnosu na prosečne vrednosti čvrstoće veze (Man-Vitnijev U test: $Z = -2,6796$; $p = 0,0074$ / $Z = -1,7052$; $p = 0,0882$) u korist značajno veće čvrstoće veze u grupi F.

Analiza prosečne vrednosti čvrstoće veze između grupa A / C i B / D pokazala je da nije bilo značajne razlike između dve grupe u odnosu na prosečne vrednosti čvrstoće veze, $p > 0,05$ (Man-Vitnijev U test: $Z = -0,8305$; $p = 0,4062$ i $Z = 0,0112$; $p = 1,0000$).

Kod grupe BD zapažen je pretežno kohezivni tip preloma, dok je kod Theracal LC grupe bio prisutan i kohezivni i mešoviti prelom.

DISKUSIJA

Primarna svrha restorativne stomatologije je očuvanje vitalnosti pulpe [11]. Kalcijum-hidroksid je već duže vreme zlatni standard kod direktnog pokrivanja pulpe [12]. Pored ovog materijala,

primena kalcijum-silikatnih cementa kod direktnog pokrivanja pulpe u poslednje vreme je sve prisutnija. Materijali na bazi kalcijum-silikata su bioaktivni materijali koji mogu formirati apatit koristeći kalcijum-silikate ili kalcijum-aluminate. Ovi materijali su takođe biointeraktivni i oslobađaju jone potrebne za podsticanje formiranja dentinskih mostova [13]. BD je bioaktivni materijal, mehaničkih svojstava sličnih dentinu i može se koristiti kao njegova zamena koja stimuliše stvaranje dentinskih mostova. Ima dobra mehanička svojstva, kao i odličnu biokompatibilnost i bioaktivno ponašanje. Pored toga, početno vreme vezivanja BD je oko 12 minuta i ne izaziva promene zuba [2, 14, 15].

Glavni nedostatak BD je njegova hemija na bazi vode, koja utiče na vezu i sa dentinom i sa kompozitom, pošto je veza uglavnom mikromehanička.

Da bi se prevazišlo ovo ograničenje, uveden je trikalcium-silikat (Theracal LC), modifikovan smolom, kao materijal za direktno zatvaranje kaše.

Proizvodi modifikovani smolom imaju prednosti preciznog postavljanja, brzog vezivanja, vrhunske fizičke snage, manje rastvorljivosti i smanjenog oslobađanja teških metala. Ovi proizvodi sa hidrofilnom polimernom matricom omogućavaju visoko oslobađanje kalcijuma i hidroksidnih jona. Oni su perspektivni materijali za direktno pokrivanje pulpe [16].

Theracal LC je svetlosno polimerizacioni hidraulični silikatni materijal koji se veže hidratacijom. Vezivanje započinje dodiranjem materijala i vode. Za razliku od BD, Theracal LC ne uključuje vodu za hidrataciju materijala, a proces vezivanja zavisi od vode koju zarobi iz okoline i njene difuzije u materijal [17].

Snaga veze između restorativnih materijala i materijala za direktno i indirektno zatvaranje pulpe takođe je važna za uspeh restauracija. To zavisi od njihovih fizičko-hemijskih karakteristika, prirode veze između lajnera i kompozitnog materijala i vrste adhezivnog sistema.

Prisutnost komponente smole u Theracal LC olakšava postavljanje konačne restauracije u istu sesiju. Učinjeno je mnogo istraživanja o uticaju ovih materijala na čvrstoću veze.

Deepa i saradnici uporedili su i procenili čvrstoću veze kompozita s tri različita lajnera: Theracal LC, BD i Fuji II LC pri nanošenju univerzalnog lepka (Single Bond Universal). Otkrili su da je čvrstoća vezivanja kompozita sa Theracal LC i Fuji II LC slična i značajno veća od one sa BD posle nanošenja univerzalnog lepka [18].

Meraji i Camilleri u svojim istraživanjima takođe pokazuju veću čvrstoću vezivanja Theracal LC u odnosu na BD, bilo da se radi o kompozitnom materijalu ili staklenom jonomernom cementu. Isti autori su zaključili da je čvrstoća veze između Theracal LC i kompozita pri nanošenju dentinskog lepka sa kiselinskim nagrizanjem značajno bolja od čvrstoće veze kod nanošenja samonagrizajućih dentinskih lepkova [19].

Rezultati naše studije takođe su pokazali da postoji značajna razlika u jačini veze između uzoraka tretiranih sa Theracal LC i BD kod dva ispitivana dentinska lepka u korist značajno veće čvrstoće vezivanja u Theracal LC grupi. To može biti posledica činjenice da Theracal LC pokazuje ranu kohezivnu silu tokom fotoaktivacije. Suprotno tome, BD pokazuje nisku tvrdoću samog materijala u ranim fazama posle nanošenja [20].

Posle početnog vezivanja, BD je i dalje porozan material, kome treba najmanje dve nedelje za potpunu polimerizaciju hidriranog kalcijum-silikatnog gela i za formiranje čvrste mreže koja će dobiti snagu dovoljnu da izdrži napore polimerizacije [15, 18].

U našoj studiji lepak i kompozitni materijal smo naneli u istoj sesiji nedugo posle početnog postavljanja BD. To može biti razlog slabe čvrstoće vezivanja, kao i kohezivni tip loma materijala.

Efikasnost adhezije trenutnih komercijalnih dentinskih lepkova je promenljiva. Karadas i saradnici ispitivali su čvrstoću adhezije različitih dentinskih lepkova sa Theracal LC. Izveštavali su da su lepkovi za nagrizanje i ispiranje omogućili bolje obnavljanje čvrstoće vezivanja od samolepljivih lepkova [21]. Studija je takođe pokazala da dvokomponentni samonagrizajući dentinski lepkovi imaju veće vrednosti čvrstoće vezivanja u odnosu na jednokomponentne samonagrizajuće lepkove, sa izuzetkom Clearfil S3, verovatno zbog činjenice da sadrže 10-metakriloloksidecil dihidrogen-fosfat, za koji se zna da se hemijski veže sa kalcijumom zuba [21, 22]. Suprotno tome, naša studija je pokazala da nije bilo značajne razlike u jačini veze između jednokomponentnih i dvokomponentnih samonagrizajućih dentinskih lepkova kod dva ispitivana lajnera. Primena jednokomponentnih samonagrizajućih dentinskih lepkova pruža optimalnu efikasnost adhezije uz pojednostavljeni protokol primene.

Da bi se suprotstavio silama kontrakcije materijala i obezbedio dobru retenciju za cakline i dentine, dokazano je da čvrstoća vezivanja kompozitnog materijala treba da bude najmanje 17–20 MPa [23]. Ova čvrstoća vezivanja postignuta je u oba testirana dentinska lepka samo u uzorcima gde smo koristili Theracal LC kao podlogu. Cantekin K. je u svom istraživanju pokazao da svetlosno polimerizaciona MTA pokazuje klinički prihvatljive i veće rezultate jačine veza u poređenju sa MTA kada se koristi u kombinaciji sa kompozitom na bazi metakrilata, kao što je

to kompozitni materijal korišćen u našem istraživanju. Prema istim autorima, kompoziti na bazi metakrilata postižu veću čvrstoću veze od kompozita na bazi silorana i glas-jonomernog cementa [24].

Uprkos visokim vrednostima čvrstoće vezivanja za Theracal LC uzorke, rezultati našeg istraživanja pokazali su da je ta čvrstoća veze bila značajno niža od snage kontrolne grupe kod dva testirana lepka za dentin, što ukazuje da uprkos prisustvu komponente smole, TheraCal LC kao i BD utiču na čvrstoću vezivanja kompozitnog materijala sa dentinom.

ZAKLJUČAK

Theracal LC je postigao čvrstoću vezivanja dovoljnu da se odupire silama kontrakcije materijala i obezbedi dobru retenciju u ranoj fazi posle nanošenja.

Međutim, primena Theracal LC ima uticaj na čvrstoću vezivanja kompozitnog materijala na dentin.

BD je pokazao značajno nižu čvrstoću vezivanja u ranoj fazi posle inicijalnog vezivanja materijala, kao i kohezivni, koji je potvrdio činjenicu da pre postavljanja konačne restauracije BD treba ostaviti dovoljno dugo da bi se postigla potrebna tvrdoća i otpornost silama kontrakcije kod postavljanja restaurativnog materijala i obezbedila dobra retencija restauracije.

Tip dentinskog lepka (jednokomponentni i dvokomponentni samonagrizajući dentinski lepak) nije imao uticaja na čvrstoću veze dvaju ispitivanih lajnera.