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Clinical Survival of Reduced-Thickness Monolithic Lithium-Disilicate Crowns: A 3-Year Randomized Controlled Trial

Klinička trajnost monolitnih litijevih disilikatnih krunica smanjene debljine: trogodišnje randomizirano kontrolirano ispitivanje

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Abstract

Objectives: The aim of this randomized controlled trial was to see if the minimally invasive approach (reduced restoration thickness) would result in good clinical success of monolithic ceramic crowns compared to conventional layered all-ceramic crowns, and thus be an alternative to conventional tooth preparation. **Materials and methods:** The ceramic that was investigated was IPS e.max lithium-disilicate ceramic produced using two different processing methods. A comparison was made between monolithic crowns with reduced thickness and standard layered crowns. Fifty-two patients, who had undergone endodontic treatment on either a premolar or molar, were randomly assigned into two groups. The teeth intended for layered crowns underwent to a 2 mm occlusal reduction with a 1 mm rounded shoulder, whereas the teeth intended for monolithic crowns underwent to a 1 mm reduction in the occlusal area with a 0.6 mm rounded shoulder. The clinical success was evaluated in eight categories using modified United States Public Health Service (USPHS) criteria. The observation period was 36 months, with control appointments every 6 months. **Results:** There was no significant difference in clinical success between monolithic and conventional layered crowns after 3 years. One monolithic crown fractured while all other crowns were intact and the survival rate was 96%. All layered crowns were intact and the survival rate was 100%. **Conclusion:** The results of this study indicate that the minimally invasive approach can be a good alternative to conventional tooth preparation. IPS e.max lithium-disilicate ceramic demonstrated an exceptional three-year survival rate independently of the thickness of the material.

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Introduction

In order to prepare teeth for an indirect aesthetic restoration, a significant amount of tooth tissue must be removed, often more than 60% (1). Things get considerably worse when it comes to teeth that underwent root canal treatment because they are already structurally weakened (2). Given that many endodontically treated teeth have already experienced dental structure loss it is crucial to restore them in order to provide functional stability and ensure their long clinical survival. This is especially true for molars which need to withstand high occlusal stresses during mastication (3).

The amount of tooth structure that remains after endodontic treatment is an essential factor in determining the strength and lifetime of the endodontically treated teeth (2,4–8). The loss of dental structure increases the cuspal deflection, particularly in the posterior teeth which are more

Uvod

Priprema zuba za indirektnu estetsku restauraciju zahtijeva uklanjanje velike količine tvrdoga zubnog tkiva, često i više od 60 % (1). Taj je postotak još veći kada je riječ o endodontski liječenim zubima koji su već strukturno oslabljeni (2). Kako većina endodontski liječenih zuba već ima gubitak određene količine tvrdoga zubnog tkiva, iznimno je bitno restaurirati ih da bismo osigurali funkcionalnu stabilnost i dugotrajno kliničko preživljavanje. To je osobito slučaj sa stražnjim zubima koji moraju izdržati velike okluzalne sile tijekom žvakanja (3).

Preostali dio tvrdoga zubnog tkiva koji ostaje nakon endodontske terapije ključan je čimbenik koji određuje snagu i dugovječnost endodontski liječenih zuba (2, 4 – 8). Gubitak zubne strukture povećava otklon kvržica osobito na stražnjim zubima zato što su podložniji okomitom opterećenju

susceptible to vertical stresses (6). Occlusal preparation results in a 20% reduction in stiffness, whereas MOD preparation leads to a stiffness loss of about 60% (6,9,10). In addition, the removal of the pulp leads to a decrease in the sensory feedback mechanism (3). The force required for the proprioceptor response in endodontically treated teeth is 2.5 times higher than in vital ones (3). This can lead to greater forces during mastication on already structurally weakened teeth, and as a result bigger probability of fracture or other complications (11). Considering all the above, as the endodontically treated teeth are already structurally weakened due to the previous loss of tooth tissue, ensuring long-term function was the main reason why they were included in the study.

Crown coverage increases the clinical survival of endodontically treated teeth (12,13). Furthermore, studies have shown that root canal treated teeth fitted with a crown have a comparable chance of experiencing clinical failure as teeth that are vital (3,12,14,15). In addition to providing cuspal coverage, it is crucial to have a well-designed occlusal surface of the restoration in order to provide even distribution of axial stresses and reduce the impact of non-axial forces (16).

Given that endodontically treated teeth already have compromised structural integrity resulting from factors such as access preparations, caries, fractures, or previous restorations, it is preferable to minimize any additional tooth preparation in order to retain as much of the remaining tooth structure as possible. Preparing a tooth for layered all-ceramic crown involves the removal of a significant quantity of hard tooth tissue. Due to this, excellent aesthetics can be achieved, but often more than 70% of hard dental tissue is removed (1). This results in a structurally compromised tooth, and often less than 1.5 mm of dentine thickness remains (17). Even with such a substantial reduction, it frequently happens that teeth are overprepared, thus worsening the structural integrity (18). When it comes to endodontically treated teeth, where part of the hard dental tissue has already been removed, this percentage is even higher.

Lithium-disilicate ceramics were introduced in 1998 by Ivoclar, and were named IPS Empress 2 (19). The composition comprised of a glass matrix containing lithium-disilicate crystals of micron size, with sub-micron-sized lithium-orthophosphate crystals scattered within it (20). Approximately 70% of the volume consisted of crystals of lithium disilicate (21,22). Further development led to introduction of IPS e.max, which had better translucency and mechanical properties (23, 24). Thanks to better optical properties, IPS e.max allows production of fully contoured, monolithic restorations (25–27).

IPS e.max is available as CAD blocks or Press ingots, both industrially produced, resulting in a solid, high-quality material free of pores (28–30). The fully crystallized ceramic is composed of 70% rod-like crystals of lithium-disilicate evenly distributed and cross-linked in a glass matrix, with a flexural strength of 360 MPa for CAD blocks and 400 MPa for Press ingots (25,26). Apart from good mechanical and optical characteristics, lithium-disilicate ceramics also have good biological characteristics that are manifested in contact

(6). Okluzalna preparacija uzrokuje gubitak krutosti od 20 %, a MOD gubitak krutosti od oko 60 % (6, 9, 10). Uz to, uklanjanje pulpe rezultira gubitkom mehanizma povratne sprege (3). Sila koja je potrebna za proprioceptorni odgovor kod liječenih zuba 2,5 puta je veća nego kod vitalnih (3). To može rezultirati većim silama tijekom žvakanja na već strukturno oslabljene zube i posljedično veću vjerojatnost frakture ili pojavu neke druge komplikacije (11).

S obzirom na sve navedeno, kako su endodontski liječeni zubi već strukturno oslabljeni zbog prethodnog gubitka zubnoga tkiva, osiguranje dugotrajne funkcije bio je glavni razlog za uključivanje u istraživanje.

Opskrba zuba krunicom povećava kliničko preživljavanje endodontski liječenih zuba (12, 13). U studijama je istaknuto da liječeni zubi opskrbljeni krunicom mogu doživjeti jednaku funkcijsku trajnost kao i vitalni zubi (3, 12, 14, 15). Uz samo pokrivanje kvržica, ključno je imati i dobro dizajniranu okluzalnu površinu restauracije kako bi se osiguralo ravnomjerno aksijalno opterećenje i smanjio utjecaj neaksijalnih sila (16).

S obzirom na to da je endodontski liječenim zubima već kompromitiran strukturni integritet što je rezultat čimbenika kao što su preparacija kaviteta, karijes, prijelomi ili prethodne restauracije, poželjno je minimizirati svaku dodatnu preparaciju zuba da bi se zadržala što je moguće veća količina preostale strukture zuba. Priprema zuba za slojevanu potpuno keramičku krunicu uključuje uklanjanje znatne količine tvrdoga zubnog tkiva. Tako se može postići izvrsna estetika, no često se ukloni više od 70 % tvrdoga zubnog tkiva (1). To rezultira strukturno kompromitiranim zubom jer često ostaje manje od 1,5 mm debljine dentina (17). Čak i uz tako veliku redukciju, često se događa da zubi budu i više preparirani, čime se dodatno pogoršava strukturni integritet (18). Kod endodontski liječenih zuba, kojima je dio tvrdoga zubnog tkiva već uklonjen, taj je postotak još veći.

Litijevu disilikatnu keramiku proizveo je 1998. godine Ivoclar pod nazivom IPS Empress 2 (19). Sastojala se od staklene matrice koja sadržava kristale litijeva disilikata mikronske veličine s kristalima litijeva ortofosfata submikronske veličine raspršenima unutar nje (20). Otprilike 70 % volumena činili su kristali litijeva disilikata (21, 22). Daljnji razvoj rezultirao je IPS e.max litijevom disilikatnom keramikom koja je imala bolju translucenciju i mehanička svojstva (23, 24). Zahvaljujući boljim optičkim svojstvima, IPS e.max omogućuje izradu potpuno anatomskih, monolitnih nadomjestaka (25 – 27).

IPS e.max dostupan je u obliku CAD blokova ili Press ingota koji se industrijski proizvode, što rezultira čvrstim, visokokvalitetnim materijalom bez pora (28 – 30). Potpuno kristalizirana keramika sastoji se od 70 % štapićastih kristala litijeva disilikata ravnomjerno raspoređenih i umreženih u staklenoj matrici, sa savojnom čvrstoćom od 360 MPa za CAD blokove i 400 MPa za Press ingote (25, 26). Osim dobrih mehaničkih i optičkih svojstava, litijeva disilikatna keramika ima i dobra biološka svojstva koja se očituju u kontaktu s mekim tkivima i u njihovoj reakciji (31 – 33). Analizirajući koncentraciju indikatora upale u sulkusnoj te-

with soft tissues and their reaction (31–33). Analyzing the concentration of inflammation indicators in the gingival sulcus fluid in contact with lithium disilicate ceramics, no significant difference was found between a healthy tooth and the aforementioned ceramic (33).

Layered crowns are made from the lithium-disilicate base (core) on which the aesthetic, but weaker, veneering ceramic is applied. The technique is called the layering technique. Due to the similar coefficient of thermal expansion (CTE), fluorapatite aesthetic ceramics are used for layering lithium-disilicate base constructions. Thanks to the multi-layering technique, the unique combination of opalescence, brightness and translucency ensures the superb aesthetic, and a natural-looking appearance can be achieved. On the other hand, a monolithic crown is fully anatomic and is fully made from the same material. As the whole crown is made from lithium-disilicate ceramic, the use of weaker veneer ceramic is excluded, thus minimizing the possibility of chipping or delamination.

This randomized controlled trial aimed to investigate if a thinner all-ceramic crown, monolithic IPS e.max CAD (Ivoclar Vivadent, Schaan, Lichtenstein) lithium-disilicate crown with a wall thickness less than the manufacturer's recommendation can offer a comparable survival rate to a traditional layered all-ceramic crown composed of a lithium-disilicate core (IPS e.max CAD, Ivoclar Vivadent, Schaan, Lichtenstein) and layered with aesthetic ceramic (IPS e.max Ceram, Ivoclar Vivadent, Schaan, Lichtenstein).

The null hypothesis stated for this study was that there exists no statistically significant difference in the clinical survival rate between thinner monolithic IPS e.max CAD and layered IPS e.max CAD single posterior crowns.

Materials and Methods

The Ethical Committee of the School of Dentistry, University of Zagreb, Croatia, approved the study. This research was double-blind with participants being divided into two parallel groups. An equal number of male and female participants were assigned to the control group and intervention groups. The age of the patients was between 18 and 65 years. Patients with signs of parafunctions were not included in the research; hence the presence of parafunctions did not affect the research results.

Patients who visited general dentistry practices (GDPs) in Bjelovar and Zagreb, Croatia, were chosen as study participants. The number of patients that took part in the study was 52, 26 in each group, which was by 20% more than usual, to ensure that the results are unaffected by potential withdrawals. The number of patients was calculated using computer software.

All patients attending the specified GDP underwent a screening process based on specific inclusion and exclusion criteria (Table 1 and 2). The study ran for a total of 45 months, during which the evaluation of the crowns lasted 36 months, with scheduled follow-up appointments every six months. Patients were enrolled in the trial upon meeting the inclusion criteria, rather than upon completion of recruit-

kućini u kontaktu s litijevom disilikatnom keramikom, nije utvrđena značajna razlika između zdravoga zuba i spomenute keramike (33).

Slojevane krunice izrađuju se od litijeve disilikatne baze (jezgre) na koju se nanosi estetska, ali slabija keramika za slojevanje. Takva se tehnika naziva tehnikom slojevanja. Zbog sličnoga koeficijenta toplinskog širenja (CTE), fluorapatitna estetska keramika koristi se za slojevanje litijevih disilikatnih baznih konstrukcija. Zahvaljujući višeslojnoj tehnici, jedinstvena kombinacija opalescencije, svjetline i translucencije osigurava vrhunsku estetiku i omogućuje postizanje prirodnog izgleda. S druge strane, monolitna krunica u cijelosti je anatomski oblikovana i cijela je izrađena od istog materijala. Budući da je cijela krunica izrađena od litijeve disilikatne keramike, isključena je upotreba slabije keramike za slojevanje, čime se minimizira mogućnost otkrhnuća ili raslojavanja.

Ovo randomizirano kontrolirano ispitivanje ima za cilj istražiti može li tanja potpuno keramička krunica, monolitna IPS e.max CAD (Ivoclar Vivadent, Schaan, Lihtenštajn) litijeva disilikatna krunica s debljinom stijenke manjom od preporuke proizvođača, ponuditi usporedivu stopu preživljavanja kao tradicionalna slojevana potpuno keramička krunica izrađena od litijeve disilikatne jezgre (IPS e.max CAD, Ivoclar Vivadent, Schaan, Lihtenštajn) i slojevana estetskom keramikom (IPS e.max Ceram, Ivoclar Vivadent, Schaan, Lihtenštajn).

Nulta hipoteza postavljena za ovu studiju bila je da ne postoji statistički značajna razlika u stopi kliničkoga preživljavanja između tanjih monolitnih IPS e.max CAD i slojevanih IPS e.max CAD pojedinačnih stražnjih krunica.

Materijali i metode

Istraživanje je odobrilo Etičko povjerenstvo Stomatološkog fakulteta Sveučilišta u Zagrebu. Bilo je dvostruko slijepo, sa sudionicima podijeljenima u dvije paralelne skupine. Podjednak broj muških i ženskih ispitanika raspoređen je u kontrolnu i interventnu skupinu. Dob pacijenata određena je između 18 i 65 godina. Pacijenti sa znakovima parafunkcija nisu bili uključeni u istraživanje, tako da prisutnost parafunkcija nije utjecala na rezultate istraživanja.

Ispitanici za studiju izabrani su između pacijenata privatne ordinacije dentalne medicine (GDP) u Bjelovaru i Zagrebu, Hrvatska. Broj onih koji su sudjelovali u istraživanju bio je 52, 26 u svakoj skupini, što je 20 % više kako bi se osiguralo da eventualno odlasci iz studije ne utječu na rezultate. Broj pacijenata izračunat je u računalnom programu.

Pacijenti koji su dolazili u navedene ordinacije pregledani su prema specifičnim kriterijima za uključivanje i isključivanje kako bi se ustanovilo mogu li sudjelovati u istraživanju (tablice 1. i 2.). Studija je trajala ukupno 45 mjeseci tijekom kojih je procjena krunica trajala 36 mjeseci, s dogovorenim kontrolnim pregledima svakih šest mjeseci. Pacijenti su bili uključeni u ispitivanje nakon što su ispunili kriterije za uključivanje, a ne nakon završetka izbora svih sudionika u

Table 1 Inclusion criteria
Tablica 1. Kriteriji za uključivanje

Inclusion Criteria • Kriteriji za uključivanje
Men and women with endodontically treated premolar or molar teeth • Muškarci i žene s endodontski liječenim premolarom i molarom
Aged between 18 and 65 • Dob između 18 i 65 godina
Successful endodontic treatment assessed by the post-endodontic radiograph • Uspješan endodontski tretman procijenjen RTG snimkom poslije tretmana
Presence of opposite tooth (to have occlusal contact after placement of the crown) • Prisutnost zuba antagonista (postojanost okluzalnog kontakta poslije postavljanja krunice)
Good oral hygiene and no active caries lesions on selected tooth • Dobra oralna higijena i odsutnost karijesa na izabranom zubu
Patient's ability to attend regular follow-up appointments according to agreed schedule • Pacijentova mogućnost dolaska na kontrole prema unaprijed dogovorenom rasporedu

Table 2 Exclusion criteria
Tablica 2. Kriteriji za isključenje

Exclusion Criteria • Kriteriji za isključivanje
The tooth is restored with amalgam restoration, in this case, the restoration will be replaced with a composite one • Zub je restauriran amalgamskim ispunom; u tom slučaju ispun je zamijenjen kompozitnim
Previous indirect restoration on selected teeth • Prethodna indirektna restauracija na izabranome zubu
Pain or any other discomfort from selected tooth • Bol ili bilo koja druga nelagoda na izabranome zubu
General uncontrolled periodontal disease • Generalizirani nekontrolirani parodontitis
Acute gingivitis on selected tooth • Akutni gingivitis oko izabranog zuba
Sulcus depth more than 3.5 mm • Dubina sulkusa veća od 3,5 mm
Grade 2 or more mobility of selected tooth • Stupanj 2 pomičnosti zuba ili više
Furcation involvement on selected tooth • Izložena furkacija na izabranome zubu
Signs of parafunctions (cheek ridging, tongue scalloping, history of tooth/restoration fracture) • Znakovi parafunkcija

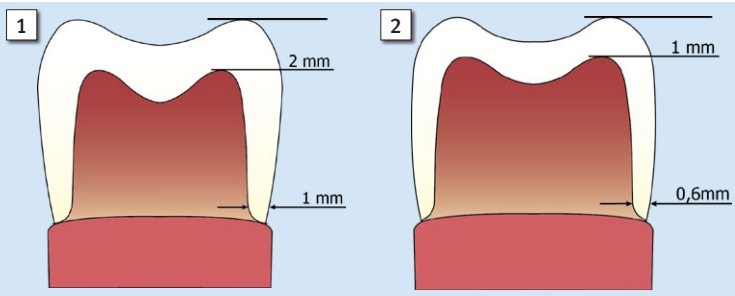

Figure 1 Tooth preparation for layered crown
Slika 1. Preparacija zuba za slojevanu krunicu
Figure 2 Tooth preparation for monolithic crown
Slika 2. Preparacija zuba za monolitnu krunicu

ment of all study participants. The participants were randomly allocated into two groups using computer software, and each participant got a unique identity number. Each patient received only one crown.

Prior to preparation, two silicon impressions were obtained using putty material (EXA'lence; GC, Tokyo, Japan). The first one was divided into vertical sections and employed as a silicon guide to facilitate precise axial and occlusal tooth preparation. The other impression was used for making immediate provisional crowns. Teeth used for layered crowns were prepared with either an equigingival or supragingival gingival finish line. The preparation included a 1 mm wide rounded shoulder, 2 mm occlusal reduction, and an axial inclination of about 10° (Figure 1) (34). All angles were rounded. The preparation of teeth for monolithic crowns followed the same procedure as for layered crowns, with the exception that for monolithic crowns, a 0.6 mm wide rounded shoulder and 1 mm occlusal reduction were performed (Figure 2) (34). The impression was taken using vinyl polyether silicone mate-

ispitivanju. Sudionici su nasumično raspoređeni u dvije grupe s pomoću računalnog softvera, a svaki je sudionik dobio jedinstveni identifikacijski broj. Svaki pacijent bio je opskrbljen samo jednom krunicom.

Prije preparacije uzeta su dva silikonska otiska sa silikonom kitaste konzistencije (EXA'lence; GC, Tokio, Japan). Prvi otisak podijeljen je na okomite dijelove i korišten je kao silikonski ključ za kontrolu aksijalne i okluzalne preparacije zuba. Drugi je korišten je za izradu privremenih krunica. Zubi koji su bili opskrbljeni slojevanim krunicama bili su preparirani s ekvigingivnom ili supragingivnom stepenicom. Preparacija je uključivala zaobljenu stepenicu širine 1 mm, okluzalnu redukciju od 2 mm i aksijalni nagib od oko 10° (slika 1.) (34). Svi su kutovi bili zaobljeni. Preparacija zuba za monolitne krunice bila je jednaka kao i za slojevane, s time da je za monolitne krunice preparacija uključivala zaobljenu stepenicu širine 0,6 mm i okluzalnu redukciju od 1 mm (slika 2.) (34). Otisak je uzet korištenjem vinil-polieterskoga silikonskog materijala (EXA'lence; GC, Tokio, Japan), a rad-

rial (EXA'lence; GC, Tokyo, Japan) and the working models made using type 4 dental stone (Fujirock EP; GC, Tokyo, Japan). The tooth shade was assessed with the VITA Easyshade V (Vita Zahnfabrik, Bad Säckingen, Germany).

All crowns were manufactured in the same laboratory by the same technician. The restorations were fabricated with the CAD/CAM system (Dentsply Sirona, Charlotte, USA). The prepared teeth were scanned with an Omnicam scanner (Dentsply Sirona, Charlotte, USA). The cores for the layered crowns were designed using computer software (in-Lab SW 4.4; Dentsply Sirona, Charlotte, USA) with a consistent thickness of 0.6 mm (34). The entire monolithic crowns were designed using the same program, with a marginal thickness of 0.6 mm and an occlusal thickness of 1 mm. Partially crystallized blue blocks were milled using a CAD/CAM milling unit (inLab MC XL; Dentsply Sirona, Charlotte, USA).

Partially crystallized ceramic cores and monolithic crowns were examined in the mouth. Following the try-in procedure, the monolithic crowns were returned to the laboratory and finalized. The ceramic cores were layered with fluorapatite glass-ceramic (IPS e.max Ceram, Ivoclar Vivadent, Schaan, Lichtenstein) and finalized.

The finished crowns were tried in the mouth. The occlusal contacts were assessed with 8µm articulation foil (Interdent, Celje, Slovenia). Final refinements were made concerning occlusion or proximal contacts. The crowns that underwent adjustments were returned to the laboratory and finished. The crowns were cemented using a clear dual-cure adhesive resin cement (Variolink Esthetic DC, Ivoclar Vivadent, Schaan, Lichtenstein), following manufacturer's recommendations.

The initial evaluation was conducted one week after the cementation. Following the initial baseline assessment, subsequent follow-up appointments were scheduled every six months. During each appointment, the identical assessment protocol was utilized to evaluate the clinical survival of the crowns.

Clinical survival of tested crowns was evaluated in eight categories using modified United States Public Health Service (USPHS) criteria (35). Tested categories were ceramic fracture, marginal adaptation, color, caries, marginal discoloration, occlusal contact, proximal contact and retention. The assessment was double blind as both the participants and the examiner did not know which type of crown was provided. Since the intervention was equal for all participants (tooth preparation), they could not observe any differences among them. The crowns were clinically examined using standardized diagnostic dental instruments under 2.5 × magnifications. According to these criteria, restorations that had an Alfa or Beta rating were considered successful, while those rated Charlie or Delta were considered failures.

Differences between the initial and the final values within each group were assessed by the Mc Nemar test (for categorical characteristics of crowns). Differences between categorical variables between the studied groups were analyzed using the Fisher-Freeman-Halton test. All P values less than 0.05 were considered significant. The analysis used licensed program support IBM SPSS for Windows, version 25.0.

ni modeli izrađeni su u dentalnoj sadri tipa 4 (Fujirock EP; GC, Tokio, Japan). Boja zuba određena je s pomoću VITA Easyshade V (Vita Zahnfabrik, Bad Säckingen, Njemačka).

Sve krunice izradio je u istom laboratoriju uvijek isti tehničar. Krunice su izrađene CAD/CAM sustavom (Dentsply Sirona, Charlotte, SAD). Preparirani zubi skenirani su Omnicam skenerom (Dentsply Sirona, Charlotte, SAD). Jezgre za slojevane krunice oblikovane su u računalnom programu (in-Lab SW 4.4; Dentsply Sirona, Charlotte, SAD) s jedinstvenom debljinom od 0,6 mm (34). Isti program korišten je i za dizajniranje monolitnih krunica s rubnom debljinom od 0,6 mm i okluzalnom debljinom od 1 mm. Djelomično kristalizirani plavi blokovi glodani su pomoću CAD/CAM jedinice (inLab MC XL; Dentsply Sirona, Charlotte, SAD).

Djelomično kristalizirane keramičke jezgre i monolitne krunice isprobane su u ustima. Poslije toga su monolitne krunice vraćene u laboratorij i završene. Keramičke jezgre slojevane su fluorapatitnom keramikom (IPS e.max Ceram, Ivoclar Vivadent, Schaan, Lihtenštajn) i završene.

Gotove krunice isprobane su u ustima. Okluzalni kontakti procijenjeni su artikulacijskom folijom od 8 µm (Interdent, Celje, Slovenija). Prema potrebi završno su korigirani okluzalni i aproksimalni kontakti. Krunice koje su korigirane vraćene su u laboratorij i dorađene. Cementirane su prozirnim dvostruko stvrdnjavajućim adhezivnim cementom (Variolink Esthetic DC, Ivoclar Vivadent, Schaan, Lihtenštajn) prema preporukama proizvođača.

Prva procjena krunica obavljena je tjedan dana poslije cementiranja. Nakon početne procjene naknadni pregledi bili su svakih šest mjeseci. Tijekom svakog pregleda korišten je identični protokol za procjenu kliničkoga preživljavanja krunica.

Klinički uspjeh testiranih krunica procjenjivan je u osam kategorija korištenjem modificiranih kriterija Službe za javno zdravstvo Sjedinjenih Američkih Država (USPHS) (35). Ispitivane kategorije bile su puknuće keramike, rubni dosjed, boja, karijes, rubna diskoloracija, okluzalni kontakt, aproksimalni kontakt i retencija. Procjena je bila dvostruko slijepa jer ni sudionici, ni ispitivač nisu znali koja je vrsta krunice napravljena. Kako je intervencija bila jednaka za sve sudionike (preparacija zuba), sudionici nisu mogli uočiti nikakve razlike među njima. Krunice su klinički pregledane standardnim dijagnostičkim instrumentima pod povećanjem od 2,5 puta. Na temelju kriterija krunice koje su dobile ocjenu Alfa ili Beta smatrane su uspješnima, a one s ocjenom Charlie ili Delta smatrane su neuspješnima.

Razlike između početnih i konačnih vrijednosti unutar svake skupine procijenjene su Mc Nemarovim testom (za kategorička svojstva krunica). Fisher-Freeman-Haltonovim testom analizirane su razlike između kategoričkih varijabli između ispitivanih skupina. Sve P vrijednosti manje od 0,05 smatrane su značajnima. Za analizu je korištena licencirana programska podrška IBM SPSS za Windowse, verzija 25.0.

Results

Differences between study groups in clinical characteristics of crowns immediately after the cementation are shown in Table 3. The only significant difference was observed in color, with monolithic crowns exhibiting greater gradation B compared to veneered crowns: 9 (34.6%) versus 0 (0.0%); P=0.002.

Differences between study groups in clinical characteristics of crowns 36 months after the cementation are shown in Table 4. After 36 months, a significant difference in color remained (P<0.001) - differences were related to the group of monolithic crowns and to the more frequent classification B, while in the case of layered crowns, in 100% of cases with the above characteristics, classification A was noted.

The differences between the final values and the initial ones within the group of monolithic crowns are shown in Table 5. Significant difference in marginal discoloration was

Rezultati

Razlike u kliničkim karakteristikama između ispitivanih skupina neposredno poslije cementiranja prikazane su u tablici 3. Jedina značajna razlika uočena je u boji, pri čemu monolitne krunice pokazuju veću gradaciju B u usporedbi sa slojevanim krunicama: 9 (34,6 %) prema 0 (0,0 %); P = 0,002.

Razlike u kliničkim karakteristikama krunica između ispitivanih skupina 36 mjeseci poslije cementiranja prikazane su u tablici 4. Poslije 36 mjeseci ostala je značajna razlika u boji (P < 0,001) – razlike su se odnosile na skupinu monolitnih krunica i na češću ocjenu B, a kod slojevanih krunica u 100 % slučajeva u kategoriji boje zabilježena je ocjena A.

Razlike između konačnih i početnih vrijednosti unutar skupine monolitnih krunica prikazane su u tablici 5. Uočena je značajna razlika u rubnoj diskoloraciji, gdje je udio lošije ocijenjenih krunica (od ocjene A do ocjene B) porastao tijekom 36 mjeseci na 20,0 % (P = 0,023).

Table 3 Differences in the clinical characteristics of the crowns between the examined groups at the beginning of the study (immediately after cementation)
Tablica 3. Razlike u kliničkim karakteristikama krunica između ispitivanih skupina na početku istraživanja (neposredno poslije cementiranja)

		Group • Grupa				P
		Monolithic • Monolitne N=26		Layered • Slojevane N=26		
		N	%	N	%	
Ceramic fracture after cementation • Puknuće keramike poslije cementiranja	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Marginal adaptation after cementation • Rubni dosjed poslije cementiranja	A	25	96,2 %	26	100,0 %	1,000
	B	1	3,8 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Color after cementation • Boja poslije cementiranja	A	17	65,4 %	26	100,0 %	0,002
	B	9	34,6 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Caries after cementation • Karijes poslije cementiranja	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Marginal discoloration after cementation • Rubna diskoloracija poslije cementiranja	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Occlusal contact after cementation • Okluzalni kontakt poslije cementiranja	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Approximal contact after cementation • Aproksimalni kontakt poslije cementiranja	A	26	100,0 %	26	100,0 %	
	B	0	0,0 %	0	0,0 %	na
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Retention after cementation • Retencija poslije cementiranja	A	26	100,0 %	26	100,0 %	
	B	0	0,0 %	0	0,0 %	na
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	

Table 4 Differences in the clinical characteristics of the crowns between the studied groups 36 months after cementation
Tablica 4. Razlike u kliničkim karakteristikama krunica između ispitivanih skupina 36 mjeseci poslije cementiranja

		Group • Grupa				P
		Monolithic • Monolitne N=25		Layered • Slojevane N=26		
		N	%	N	%	
Ceramic fracture after 36 months • Puknuće keramike poslije 36 mjeseci	A	25	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Marginal adaptation after 36 months • Rubni dosjed poslije 36 mjeseci	A	22	88,0 %	26	100,0 %	0,110
	B	3	12,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Color after 36 months • Boja poslije 36 mjeseci	A	15	60,0 %	26	100,0 %	**<0,001**
	B	10	40,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Caries after 36 months • Karijes poslije 36 mjeseci	A	25	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Marginal discoloration after 36 months • Rubna diskoloracija poslije 36 mjeseci	A	20	80,0 %	25	96,2 %	0,099
	B	5	20,0 %	1	3,8 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Occlusal contact after 36 months • Okluzalni kontakt polsije 36 mjeseci	A	25	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Approximal contact after 36 months • Aproksimalni kontakt poslije 36 mjeseci	A	25	100,0 %	24	92,3 %	0,490
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	2	7,7 %	
	D	0	0,0 %	0	0,0 %	
Retention after 36 months • Retencija poslije 36 mjeseci	A	25	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	

noted, where the proportion of poorly rated crowns (from grade A to grade B) increased over 36 months to 20.0% (P= 0.023).

The differences between the final values and the initial values within the group of layered crowns did not show significant differences (Table 6).

Discussion

After the clinical survival of crowns had been considered, the null hypothesis was accepted. Regarding the ceramic fracture, there was no statistically significant difference in the clinical survival between monolithic IPS e.max lithium-disilicate crowns with reduced wall thickness and classic layered IPS e.max lithium-disilicate crowns. One

Razlike između konačnih i početnih vrijednosti unutar skupine slojevanih krunica nisu pokazale značajne razlike (tablica 6.).

Rasprava

S obzirom na kliničko preživljavanje krunica prihvaćena je nulta hipoteza. Kad je riječ o puknuću keramike, nije bilo statistički značajne razlike u kliničkom preživljavanju između monolitnih IPS e.max litijevih disilikatnih krunica sa smanjenom debljinom stijenke i klasičnih slojevanih IPS e.max litijevih disilikatnih krunica. Jedna je monolitna kru-

Table 5 Differences in final values (after 36 months) compared to initial values within the group of monolithic crowns
Tablica 5. Razlike u konačnim vrijednostima (poslije 36 mjeseci) u odnosu prema početnim vrijednostima unutar skupine monolitnih krunica

		Monolithic group • Monolitna grupa				P
		After cementation • Nakon cementiranja		Final assessment • Završno mjerenje		
		N	%	N	%	
Ceramic fracture • Puknuće keramike	A	26	100,0 %	25	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Marginal adaptation • Rubni dosjed	A	25	96,2 %	22	88,0 %	0,350
	B	1	3,8 %	3	12,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Color • Boja	A	17	65,4 %	15	60,0 %	0,776
	B	9	34,6 %	10	40,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Caries • Karijes	A	26	100,0 %	25	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Marginal discoloration • Rubna diskoloracija	A	26	100,0 %	20	80,0 %	0,023
	B	0	0,0 %	5	20,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Occlusal contact • Okluzalni kontakt	A	26	100,0 %	25	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Approximal contact • Aproksimalni kontakt	A	26	100,0 %	25	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Retention • Retencija	A	26	100,0 %	25	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	

monolithic crown fractured and was characterized as a clinical failure. On all other crowns, there was no damage on the ceramic, and the clinical survival of the monolithic crowns after 36 months was 96%. In the group of layered crowns, there was no damage on any of the crowns, and after 36 months the clinical survival rate was 100%. In all other categories regarding clinical performance of the crowns (marginal adaptation, caries, marginal discoloration, occlusal contact, proximal contact, retention) there was also no statistical difference between monolithic and layered crowns. The only category in which the statistical significant difference was noticed was color, but it is not related to clinical survival.

Modern dental medicine is no longer based only on the replacement of lost dental tissue. Biological factors are be-

nica puknula i okarakterizirana je kao klinički neuspjeh. Na svima ostalima nije bilo oštećenja na keramici, a kliničko preživljavanje monolitnih krunica poslije 36 mjeseci iznosilo je 96 %. U skupini slojevanih krunica nije bilo oštećenja ni na jednoj od njih i poslije 36 mjeseci stopa preživljavanja iznosila je 100 %. U svim ostalim kategorijama, kad je riječ o kliničkoj izvedbi krunica (rubni dosjed, karijes, rubna diskoloracija, okluzalni kontakt, aproksimalni kontakt, retencija), također nije bilo statističke razlike između monolitnih i slojevanih krunica. Jedina kategorija u kojoj je uočena statistički značajna razlika bila je boja, ali ona nije izravno povezana s kliničkim uspjehom.

Moderna dentalna medicina više se ne temelji samo na nadoknadi izgubljenoga zubnog tkiva. Biološki čimbenici

Table 6 Differences in final values (after 36 months) compared to initial ones within the group of layered crowns
Tablica 6. Razlike u konačnim vrijednostima (poslije 36 mjeseci) u odnosu prema početnima unutar skupine slojevitih krunica

		Layered group • Slojevana grupa				P
		After cementation • Nakon cementiranja		Final assessment • Završno mjerenje		
		N	%	N	%	
Ceramic fracture • Puknuće keramike	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Marginal adaptation • Rubni dosjed	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Color • Boja	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Caries • Karijes	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Marginal discoloration • Rubna diskoloracija	A	26	100,0 %	25	96,2 %	1,000
	B	0	0,0 %	1	3,8 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Occlusal contact • Okluzalni kontakt	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	
Approximal contact • Aproksimalni kontakt	A	26	100,0 %	24	92,3 %	0,490
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	2	7,7 %	
	D	0	0,0 %	0	0,0 %	
Retention • Retencija	A	26	100,0 %	26	100,0 %	na
	B	0	0,0 %	0	0,0 %	
	C	0	0,0 %	0	0,0 %	
	D	0	0,0 %	0	0,0 %	

coming more and more important and the preservation of hard dental tissue is becoming the main focus of modern dental therapy. At the same time, new techniques and new materials are being developed that enable modifications of standard procedures in order to preserve as many healthy tooth as possible. Taking all this into consideration, the main focus of this clinical research was to preserve as much hard dental tissue as possible while ensuring good clinical survival.

Lithium-disilicate ceramic was introduced in 1998 and since then it has been one of the most commonly used material in fixed prosthodontics (20,21). Many years of clinical application, as well as numerous clinical studies, have proven high reliability and long-term clinical success of monolithic, and layered crowns, with success rate of more than 96% after two and four years, and more than 80% after 15 years for monolithic crowns and between 94.8% and 100% over periods of 4 to 11 years for layered crowns (34,36–48). As the reported success rate of monolithic crowns in one study af-

postaju sve važniji, a očuvanje tvrdoga zubnog tkiva postaje glavni fokus moderne dentalne terapije. Istodobno se pojavljuju nove tehnike i novi materijali koji omogućuju modifikaciju standardnih postupaka kako bi se sačuvalo što više zdravoga zuba. Uzimajući sve to u obzir, glavni fokus ovoga kliničkog istraživanja bio je očuvati što više tvrdoga zubnog tkiva uz osiguranje dobroga kliničkog preživljavanja.

Litijeva disilikatna keramika predstavljena je 1998. godine i od tada je jedan od najčešće upotrebljavanih materijala u fiksnoj protetici (20, 21). Dugogodišnja klinička primjena, kao i mnoge kliničke studije, dokazale su visoku pouzdanost i dugoročnu kliničku uspješnost monolitnih i slojevanih krunica, sa stopom uspješnosti većom od 96 % poslije dvije i četiri godine, te više od 80 % poslije 15 godina za monolitne krunice i između 94,8 % i 100 % tijekom razdoblja od 4 do 11 godina za slojevane krunice (34, 36 – 48). Kako je navedena stopa uspješnosti monolitnih krunica u jednoj studiji poslije 15 godina bila mnogo niža nego kod slojevanih, mo-

ter 15 years is much lower than for layered crowns, it must be mentioned that both the technical and biological failures were included, that affect the outcome. In most other studies the success rate of monolithic crowns was similar to those of layered crowns.

Currently, there are no documented clinical studies regarding the clinical longevity of monolithic lithium-disilicate crowns with thickness reduced below the guidelines of the manufacturers, whether used on teeth that have undergone root canal treatment or on healthy teeth. Furthermore, no clinical trials have been conducted to directly evaluate the reliability of reduced-thickness monolithic lithium-disilicate crowns with layered lithium-disilicate crowns or other types of all-ceramic or metal-ceramic crowns.

Apart from adequate cleaning and filling of the root canals, to ensure good endodontic treatment, restoration of hard tooth tissue is also necessary (2,3,5). Although these two therapies are separate, they are a whole that makes up the entire endodontic therapy. Adequate postendodonthic therapy ensures the structural integrity of treated tooth and good clinical survival. The amount of remaining hard tooth structure represents the most important factor in the structural integrity and longevity of endodontically treated teeth (2,5,6). Since the structural integrity of teeth treated by root canal therapy had already been compromised due to caries, access preparation, fracture or previous restorations, this becomes even more pronounced. Since the amount of remaining hard dental tissue directly affects the clinical survival of pulpless teeth, and the provision of a crown represents the best therapy, any preservation of dental tissue during tooth preparation can significantly affect its clinical success.

Modern ceramic systems enable the elimination of metal and the use of only ceramic for almost all indications. In addition, the increasing demands for restorations without metal and with exceptional aesthetics led to the development of many new all-ceramic systems (49). These systems allow the production of all-ceramic restorations made entirely from solid materials, while maintaining high aesthetics.

In parallel with the development of ceramic materials, adhesive techniques are also improving, thus leading to modifications of the classic principles of preparations in fixed prosthodontics(50). Modern dental medicine is increasingly turning to minimally invasive procedures and preservation of as many tooth as possible, leading to rejection of conventional retention preparations (4,49,51,52).

Despite the lack of clinical studies, several authors have performed laboratory studies to evaluate the fracture resistance of monolithic lithium-disilicate crowns with various wall thicknesses (53–56). The results of this study align with the results of the aforementioned laboratory studies, which demonstrated that monolithic crowns with a wall thickness of 1 mm exhibited great resistance to fractures.

Regarding the clinical survival of tested crowns, there were no statistically significant differences in most categories after 36 months. Ceramic fracture occurred on one monolithic crown, whereas on all other crowns whether they were monolithic or layered no fractures, delamination or surface chipping of ceramic occurred. In the group of monolithic

ra se spomenuti da su u navedenoj studiji, osim komplikacija vezanih za same krunice, bile uključene i biološke komplikacije što je utjecalo na ishod. U većini drugih studija stopa uspješnosti monolitnih krunica bila je slična onoj slojevanih.

Do danas nema ni jedne kliničke studije u kojoj je ispitivana klinička trajnost monolitnih litijevih disilikatnih krunica s debljinom stijenke manjom od preporuke proizvođača, ni na endodontski liječenim zubima, ni na vitalnima. Nema ni kliničkih ispitivanja u kojima je uspoređena pouzdanost monolitnih litijevih disilikatnih krunica smanjene debljine sa slojevanim litijevim disilikatnim krunicama ili drugim vrstama potpuno keramičkih ili metal-keramičkih krunica.

Osim adekvatnog čišćenja i punjenja korijenskih kanala, za dobro endodontsko liječenje nužna je i restauracija tvrdoga zubnog tkiva (2, 3, 5). Iako su te dvije terapije odvojene, one su cjelina koja čini cjelokupnu endodontsku terapiju. Odgovarajuća postendodontska terapija osigurava strukturni integritet liječenoga zuba i dugoročno kliničko preživljavanje. Količina preostale tvrde zubne strukture najvažniji je čimbenik u strukturnom integritetu i dugovječnosti endodontski liječenih zuba (2, 5, 6). Budući da endodontski liječeni zubi već imaju narušen strukturni integritet zbog karijesa, pripreme kaviteta, prijeloma ili prijašnjih restauracija, to je još izraženije. Kako količina preostaloga tvrdog zubnog tkiva izravno utječe na kliničko preživljavanje zuba bez pulpe, a postavljanje krunice najbolja je terapija, svako očuvanje zubnoga tkiva tijekom preparacije zuba može znatno utjecati na kliničku uspješnost rada.

Moderni keramički sustavi omogućuju eliminaciju metala i korištenje samo keramike za gotovo sve indikacije. Uz to, sve češći zahtjevi za restauracijama bez metala i s iznimnom estetikom rezultirali su razvojem mnogih novih potpuno keramičkih sustava (49). Ti sustavi omogućuju izradu potpuno keramičkih nadomjestaka izrađenih u cijelosti od čvrstoga materijala, uz zadržavanje visoke estetike.

Paralelno s razvojem keramičkih materijala usavršavaju se i adhezijske tehnike, što je rezultiralo modifikacijom klasičnih načela preparacije u fiksnoj protetici (50). Suvremena dentalna medicina sve se više okreće minimalno invazivnim zahvatima i očuvanju što više tvrdog zubnog tkiva, što dovodi do odbacivanja klasičnih retencijskih preparacija (4, 49, 51, 52).

Unatoč nedostatku kliničkih studija, nekoliko je autora provelo laboratorijska istraživanja procjene otpornosti na lom monolitnih litijevih disilikatnih krunica s različitim debljinama stijenke (53 – 56). Rezultati ovog istraživanja poklapaju se s rezultatima spomenutih laboratorijskih istraživanja koja su pokazala da monolitne krunice s debljinom stijenke od 1 mm pokazuju veliku otpornost na lomove.

Kad je riječ o kliničkom uspjehu testiranih krunica, poslije 36 mjeseci nije bilo statistički značajnih razlika u većini kategorija. Puknuće keramike dogodilo se na jednoj monolitnoj krunici, a na svima ostalima, monolitnima i slojevanima, nije bilo loma, raslojavanja ili površinskog otkrhnuća keramike. U skupini monolitnih krunica na rubu triju krunica uočeno je blago zapinjanje sonde bez ulaska njezina vrha u pukotinu i eksponiranog dentina, a krunice su ocijenjene ocjenom B. U skupini slojevanih krunica nije bilo rubne

crowns slight probe catch without gap and visible dentine was noticed on the margin of three crowns, and the crowns were graded B. In the group of layered crowns, there was no marginal gap, and all the crowns were graded with A. With regard to the marginal adaptation, there was also no significant difference between both groups. None of the crowns in both groups had caries at the margin of the crown and the tooth, and all crowns were graded A. Also, there was no loss of occlusal contact on any crown in both groups, and all crowns were graded A. Considering these two categories, there was no significant difference between the groups. Proximal contact loss was observed on two layered crowns, which is not necessarily related to the observed tooth and is not the result of a complication of the ceramic itself, and the crowns were graded C. In the group of monolithic crowns, no proximal contact loss was observed in any of the crowns. There was no significant difference in this category. Not a single crown in both groups lost retention; hence there were no significant differences between monolithic and layered crowns in this category either.

The only significant difference between the examined groups was in the color of the crowns. In the group of monolithic crowns, 15 crowns were graded A, and on 10 crowns a slight discrepancy in color was observed and they were graded B. All layered crowns were graded A. The slight mismatch in color noted in monolithic crowns is probably the result of thinner ceramics and differences in translucency, which was noticed by clinicians, but in most cases not by patients.

Marginal discoloration was noted in five monolithic and one layered crowns, but only as a slight discoloration at the restoration-tooth margin without spreading under the restoration, and these crowns were graded B. Although there were no significant differences in marginal discoloration between groups, a significant difference was noted within the monolithic group after 36 months. A higher incidence of marginal discoloration may be due to slight color change of composite cement. Several laboratory studies have proven that composite cements change color at the edge of the restoration yet after a year, and that this color change can affect the aesthetic appearance of the restoration (57–61). The ceramic thickness at the margin of the restorations also affects the visibility of marginal discoloration. As a greater number of marginal discolorations were observed on monolithic crowns, the thickness of the ceramics at the margin of the crown (0.6 mm) was probably the reason for such an occurrence. In addition, dual-curing composite cement was used for crown cementation, which is an additional possible reason for the increased number of marginal discolorations on monolithic crowns.

This clinical study showed excellent clinical survival of IPS e.max lithium-disilicate monolithic crowns with reduced wall thickness, comparable to conventional layered IPS e.max lithium-disilicate crowns. As this is the only clinical study that examined the durability of a lithium disilicate crown with reduced wall thickness, further research is required to make this clinical approach standard. Besides, the duration of the study is partially a limiting factor, and further assessment is needed to determine long-term clinical survival.

pukotine na dosjedu krunica i sve su krunice ocijenjene s A. Kad je riječ o rubnom dosjedu, također nije bilo značajne razlike između obiju skupina. Nijedna od krunica u objema skupinama nije imala karijes na rubu krunice i zuba te sve su ocijenjene s A. Također nije bilo gubitka okluzalnog kontakta ni na jednoj krunici u objema skupinama, i sve su dobile ocjenu A. Uzimajući u obzir te dvije kategorije, nije bilo značajne razlike između skupina. Na dvjema slojevanim krunicama uočen je gubitak aproksimalnog kontakta koji nije nužno povezan s promatranim zubom i nije posljedica komplikacije same keramike, a krunice su ocijenjene s C. U skupini monolitnih krunica ni na jednoj nije zabilježen gubitak aproksimalnog kontakta. U ovoj kategoriji nije bilo značajne razlike. Ni jedna krunica u objema skupinama nije izgubila retenciju, pa ni u toj kategoriji nije bilo značajne razlike između monolitnih i slojevitih krunica.

Jedina značajna razlika između ispitivanih skupina bila je u boji krunica. U skupini monolitnih krunica njih 15 ocijenjeno je s A, a kod 10 krunica uočeno je malo odstupanje u boji te su ocijenjene s B. Sve slojevane krunice dobile su ocjenu A. Mala nepodudarnost u boji uočena kod monolitnih krunica vjerojatno je rezultat tanje keramike i razlike u translucenciji, što je primijetio kliničar, ali u većini slučajeva ne i pacijenti.

Rubna diskoloracija zabilježena je u pet monolitnih krunica i u jednoj slojevanoj, ali samo kao blaga diskoloracija na rubu restauracije i zuba bez širenja ispod restauracije, i te su krunice ocijenjene s B. Iako nije bilo značajne razlike u rubnoj diskoloraciji između skupina, značajna razlika uočena je unutar monolitne skupine poslije 36 mjeseci. Veća učestalost rubne diskoloracije može biti posljedica lagane promjene boje kompozitnog cementa. U nekoliko laboratorijskih studija dokazano je da kompozitni cementi mijenjaju boju na rubu nadomjestka već poslije godinu dana te da ta promjena može utjecati na estetski izgled nadomjestka (57 – 61). Debljina keramike na rubu ispuna također utječe na vidljivost rubne diskoloracije. Kako je na monolitnim krunicama uočen veći broj rubnih diskoloracija, vjerojatno je uzrok takvoj pojavi debljina keramike na rubu krunice (0,6 mm). Uz to, za cementiranje krunica korišten je dvostruko stvrdnjavajući kompozitni cement, što je dodatni mogući razlog za povećani broj rubnih diskoloracija na monolitnim krunicama.

Ova klinička studija pokazala je izvrsno kliničko preživljavanje IPS e.max litijevih disilikatnih monolitnih krunica sa smanjenom debljinom stijenke, u usporedbi s klasičnim slojevanim IPS e.max litijevim disilikatnim krunicama. Budući da je ovo jedina klinička studija u kojoj se ispitivala trajnost litijeve disilikatne krunice sa smanjenom debljinom stijenke, potrebna su daljnja istraživanja kako bi ovaj klinički pristup postao standard. Osim toga, trajanje studije djelomično je ograničavajući čimbenik te je potrebno daljnje praćenje kako bi se utvrdio dugoročni klinički uspjeh.

Conclusions

Considering the limitations of this investigation, it can be concluded that the three-year survival rate of reduced-thickness IPS e.max lithium-disilicate posterior crowns is comparable to that of layered IPS e.max lithium-disilicate crowns.

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Zaključak

Uzimajući u obzir ograničenja ovog istraživanja, može se zaključiti da se trogodišnja stopa preživljavanja IPS e.max litijevih disilikatnih stražnjih krunica smanjene debljine može usporediti s onom slojevanih IPS e.max litijevih disilikatnih krunica.

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Doprinos autora: **D. Š. i M. J.** – konceptualizacija; **D. Š** – metodologija, istraživanje, priprema i pisanje izvornog nacrta; **M. J.** – pisanje, recenzija, uređivanje, nadzor.

Sažetak

Cilj: Svrha ovoga randomiziranoga kontroliranoga ispitivanja bila je ustanoviti hoće li minimalno invazivni pristup (smanjena debljina nadomjestaka) rezultirati dobrim kliničkim uspjehom monolitnih keramičkih krunica u usporedbi s klasičnim slojevanim potpuno keramičkim krunicama te tako biti alternativa klasičnoj preparaciji zuba. **Materijali i metode:** Testirana keramika bila je IPS e.max litijeva disilikatna keramika izrađena dvjema različitim tehnikama. Monolitne krunice smanjene debljine uspoređene su sa standardnim slojevanim krunicama. Pedeset i dva pacijenta s endodontski liječenim pretkutnjakom ili kutnjakom bila su nasumično raspoređena u dvije skupine. Zubi za koje su bile namijenjene slojevane krunice podvrgnuti su okluzalnoj redukciji od 2 mm sa zaobljenom stepenicom od 1 mm, a zubi odabrani za monolitne krunice podvrgnuti su okluzalnoj redukciji od 1 mm uz zaobljenu stepenicu od 0,6 mm. Klinički uspjeh procijenjen je u osam kategorija korištenjem modificiranih kriterija Službe za javno zdravstvo Sjedinjenih Američkih Država (USPHS). Razdoblje praćenja krunica bilo je 36 mjeseci, s kontrolnim pregledima svakih 6 mjeseci. **Rezultati:** Nije bilo značajne razlike u kliničkom uspjehu između monolitnih i konvencionalnih slojevanih krunica poslije tri godine. Jedna je monolitna krunica puknula, a sve ostale bile su netaknute. Stopa preživljavanja iznosila je 96 %. Sve slojevane krunice bile su intaktne i stopa preživljavanja bila je 100 %. **Zaključak:** Rezultati ovog istraživanja pokazuju da minimalno invazivni pristup može biti dobra alternativa klasičnoj preparaciji zuba. IPS e.max litijeva disilikatna keramika pokazala je iznimnu trogodišnju stopu preživljavanja, neovisno o debljini materijala.

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