ACTA
STOMATOLOGICA
CROATICA
www.ascro.hr

Acta stomatol Croat. 2017;51(3):179-187.
DOI: 10.15644/asc51/3/1

IZVORNI ZNANSTVENI RAD
ORIGINAL SCIENTIFIC PAPER

Syed Rashid Habib[1], Mohammed Ginan Al Ajmi[1], Mohammed Al Dhafyan[1], Abdulrehman Jomah[1], Haytham Abualsaud[1], Mazen Almashali[2]

Utjecaj cervikalnog oblika preparacije na rubnu prilagodbu cirkonij-oksidnih kapica

Effect of Margin Designs on the Marginal Adaptation of Zirconia Copings

[1] Stomatološki fakultet, Sveučilište King Saud, Saudijska Arabija
College of Dentistry, King Saud University, Saudi Arabia
[2] Bolnica sigurnosnih snaga, Rijad, Saudijska Arabija
Security Forces Hospital, Riyadh, Saudi Arabia

Sažetak

Cilj: Cilj ovog in vitro istraživanja bio je usporediti utjecaj zaobljene i pravokutne stepenice na rubnu prilagodbu kapica od cirkonij-oksida (ZrO_2).**Materijali i metode:** 40 izvađenih kutnjaka uloženo je u smolu i preparirano za krunice od cirkonij-oksida s dva oblika cervikalnog završetka preparacije (20 = zaobljena stepenica i 20 = pravokutna stepenica). Kapice za svaki zub izrađene su s pomoću Cercon® (DeguDent GmbH, Njemačka) CAD/CAM sustava. Kapice su prilagođene svakom zubu, cementirane, termociklirane, uložene u smolu i nakon toga poprečno prerezane na dvije jednake polovice, mezijalnu i distalnu. Analiza je provedena pod elektronskim mikroskopom pri povećanju od 200 x s mjerenjima na 5 unaprijed određenih točaka u mikrometrima (**µm**). **Rezultati:** Ukupna prosječna dimenzija međuprostora za obje skupine iznosila je 206,98 ± 42,78 **µm**, pri čemu je kod preparacije s pravokutnom stepenicom rubna prilagodba bila bolja (međuprostor = 199,50 + 40,72 **µm**) u usporedbi sa zaobljenom stepenicom (međuprostor = 214,46 + 44,85µm). T-test za nezavisne uzorke nije pokazao statistički značajnu razliku (p = 0,113) između prosječnih dimenzija međuprostora kod pravokutne i zaobljene stepenice za mjerenja na 5 unaprijed određenih točaka u objema skupinama. **Zaključak:** Cervikalni završetak preparacije u obliku pravokutne stepenice rezultira jednakom rubnom prilagodbom kao i zaobljena stepenica.

Zaprimljen: 30. ožujka 2017.
Prihvaćen: 6. svibnja 2017.

Adresa za dopisivanje
Prod. dr. sc. Syed Rashid Habib B.D.S., F.C.P.S.
King Saud University
College of Dentistry
Department of Prosthetic Dental Sciences,
P. O. Box 60169, King Abdullah Road,
Riyadh, 11545, Saudi Arabia.
Phone: 966-1-467 7325
Fax: 966-1-467 8548
rashidhabib@hotmail.com

Ključne riječi
cirkonij-oksid; rub zubne krunice; rubna prilagodba; CAD/CAM

Uvod

Potpuno keramički sustavi postali su popularni kao rezultat povećanih estetskih zahtjeva pacijenata i potražnje za bezmetalnim nadomjescima. Postoje mnoge vrste dentalnih keramika s različitim tehnološkim postupcima obrade: keramike koje se strojno obrađuju u mekšem (nesinteriranom) obliku kao što su cirkonijev (Zr) (Y-TZP) i aluminijev oksid (Al_2O_3), i u tvrdom obliku poput litijeva disilikata ($Li_2Si_2O_5$) i leucitima ojačane staklokeramike ($KalSi_2O_6$). Dentalne keramike također se klasificiraju prema primjeni i kristalnoj fazi. Zbog loših fizičkih svojstava, indikacije za potpuno keramičke nadomjestke ograničene su na krunice prednjih zubi. Posljednjih godina, itrijem stabilizirani polikristalni tetragonalni cirkonijev oksid (Y-TZP) sve više se koristi za potpuno keramičke nadomjestke. Taj materijal, koji se nekad rabio samo u industriji, kombinira estetiku, izvrsnu biokompatibilnost, malu sklonost nakupljanju plaka i malu toplinsku vodljivost s velikom čvrstoćom, što ga čini poželjnim za primjenu

Introduction

All-ceramic reconstructions have become popular as a result of increased patient demands for dental materials without metallic shape, thus allowing excellent esthetics. There are many types of dental ceramics based on different fabrication techniques: the soft-machined techniques such as zirconia (Zr) (Y-TZP) and alumina (Al_2O_3), the hard-machined techniques such as lithium disilicate (($Li_2Si_2O_5$) and leucite ($KalSi_2O_6$). Dental ceramics types are also based on their application and crystalline phase. However, because of their poor physical properties, all-ceramic restorations are limited to crowns in anterior regions. In recent years, yttria-stabilized polycrystalline tetragonal zirconia (Y-TZP) has been increasingly applied to the manufacture of all-ceramic restorations. This Zr material, once only used in engineering, combines high esthetics, excellent biocompatibility, low plaque accumulation and low thermal conductivity with high strength gives high importance for dental application. The main ad-

u ustima. Glavna prednost Y-TZP-a je velika čvrstoća. Također, odupiranje širenju pukotina kroz materijal moglo bi biti izvrsno svojstvo (1 – 3).

Dugoročni uspjeh keramičkih nadomjestaka ovisi o mehaničkim svojstvima i mogućnosti adhezivnog vezanja materijala. Na njega također utječe rubna i unutarnja prilagodba. Loša rubna prilagodba odgovorna je za nakupljanje plaka, mikropropuštanje i popuštanje cementa. Tako se povećava rizik od karijesa, parodontne bolesti i endodontske upale, što može imati neželjene učinke na zdravlje nosača i njegov izgled (6). Loša rubna prilagodba kapice može povećati debljinu cementa i time utjecati na mehaničku stabilnost nadomjestaka s cirkonij-oksidnom osnovom. Nekoliko autora bavilo se vrijednostima najviše dopuštene dimenzije rubnog međuprostora. In vitro, dimenzije međuprostora između 100 i 150 µm smatraju se klinički prihvatljivima. Pogreška u dosjedu može se smatrati prihvatljivom kad je vizualno nezamjetljiva ili se ne može otkriti zubnom sondom. Rubni međuprostor manji od 80 µm dokazano se vrlo teško može klinički detektirati (4 – 9).

U literaturi su opisana dva glavna protokola procjene rubne prilagodbe. Jedan je destruktivni protokol kod kojeg se uzorak ili replika prerezuju nakon čega slijedi mikroskopska analiza. Drugi je nedestruktivni protokol u kojem se izvode samo mjerenja vanjskog razmaka. Konvencionalne metode, kojima se pokušava procijeniti rubna prilagodba nadomjestka, omogućuju procjenu samo u dvjema dimenzijama: u različitim presjecima međuprostor između nadomjestka i batrljka obično se mjeri s pomoću mikroskopa u 4 do 24 točke (10 – 14).

U literaturi postoje istraživanja o utjecaju kutova preparacije (15), proizvodnih procesa (16), cemenata (17), razlika u dubini preparacije (18), postojanja ili nepostojanja uobičajenih pogrešaka u preparaciji (19) i preparacije okluzalne površine na prilagodbu cirkonij-oksidnih (ZrO_2) kapica (20). Prema spoznajama autora, još nedostaju znanstveni podaci o utjecaju dvaju najčešćih oblika cervikalnog završetka preparacije (pravokutna i zaobljena stepenica) na rubnu prilagodbu cirkonij-oksidnih kapica. Svrha ovog istraživanja bila je usporediti utjecaj pravokutne i zaobljene stepenice na rubnu prilagodbu ZrO kapica. Nulta hipoteza bila je da različiti oblici cervikalnog završetka preparacije ne utječu na rubnu prilagodbu ZrO_2 kapica.

Materijali i metode

Ovo in vitro istraživanje provedeno je na Zavodu za protetiku, Stomatološki fakultet, Sveučilište King Saud u Rijadu od listopada 2014. do ožujka 2015. Istraživanje je planirao i odobrio Centar za stomatološka istraživanja (CDRC) na Sveučilištu King Saud (CDRC # IR0110).

Ukupno 40 zdravih ili minimalno restauriranih izvađenih kutnjaka (uglavnom umnjaka) odraslih pacijenata prikupljeno je i pohranjeno u razrijeđenoj vodenoj otopini hidroksida na Zavodu za maksilofacijalnu kirurgiju. Korijen svakog zuba uložen je u samovezujuću ortodontsku smolu (Ortho-Resin, DeguDent GmbH, Njemačka) (2 cm x 2 cm), pri čemu je anatomska kruna i početna 2 mm korijena ostalo izloženo. Uzorak je podijeljen u dvije skupine (A = cervikalna prepara-

vantage of (Y-TZP) is high strength. Also, crack deflection could be an excellent property of Y-TZP to resist crack propagation (1-3).

The long-term success of ceramic restorations depends on the mechanical and bonding properties of the materials. It is also influenced by the marginal and internal fit. An inaccurate marginal fit is responsible for plaque retention, micro leakage and cement breakdown. The risk of caries, periodontal disease and endodontic inflammation is thus increased, which can have adverse effects on the health of underlying abutments and optical properties (6). A poor marginal fit of a coping can increase the thickness of the cement and thus influence the mechanical stability of Zr-based restorations. Several authors have estimated maximal marginal gap (MG) values. *In vitro*, MG values between 100 and 150µm are considered clinically acceptable. A marginal misfit can be considered acceptable when it is visually imperceptible or cannot be detected using a dental probe. A MG of less than 80µm is proven to be very difficult to detect clinically (4-9).

Two main fit assessment protocols are described in the literature. One is a destructive protocol, where a specimen or replica is sectioned, followed by microscopic analysis; the second is a nondestructive protocol, where only external gap measurements are performed. The conventional methods aiming to evaluate the marginal fit of restorations can do it only in two dimensions: in different sections, the gaps between the restoration and the die are usually measured by a microscope at 4–24 points (10-14).

In the literature, there are studies that focused on the effects of preparation angles (15), manufacturing processes (16), cement used for cementation (17), preparation depth differences (18), presence or absence of common preparation errors (19) and effect of occlusal surface preparations for the adaptation of Zr copings (20). To the authors' knowledge, there is still a lack of scientific data on the effect of two most common margin designs (Shoulder and Chamfer) on the marginal fit of Zr copings. The purpose of this study was to investigate the effect of shoulder versus chamfer margin designs on the marginal adaptation of Zr copings. The null hypothesis was that different margin design of preparations does not affect the marginal adaptation of the Zr copings.

Materials and Methods

This *in-vitro* research study was conducted at the Department of Prosthodontics, College of Dentistry, King Saud University Riyadh from October 2014 to March 2015. The research study was planned and approved by the College of Dentistry Research Center (CDRC) at King Saud University (CDRC Reg. # IR0110).

A sample size of 40 sound or minimally restored extracted molar teeth (mostly third molars) from adult patients were collected and stored in hydroxide-diluted water at The Department of Maxillofacial Surgery. The root of each tooth was embedded in self-curing orthodontic resin (Ortho-Resin, DeguDent GmbH, GERMANY) base (2 cm x 2 cm), exposing the anatomic crown and 2 mm of the coronal root. The sam-

cija u obliku pravokutne stepenice i B = cervikalna preparacija u obliku zaobljene stepenice) slučajnim odabirom.

Prije brušenja zubi izrađen je silikonski indeks (Ivoclar Vivadent, SAD) koji je prerezan u meziodistalnom smjeru kako bi se mogli kontrolirati količina i oblik preparacije.

Svaki zub je za potpuno keramičku ZrO_2 krunicu izbrusio iskusan protetičar prema trenutačnim smjernicama/preporukama. Svi zubi preparirani su u skladu s istim smjernicama koje uključuju kut konvergencije od 5 do 10 stupnjeva, zakošavanje funkcijske kvržice, 2 mm okluzalne redukcije, 1 mm aksijalne redukcije te zaobljene i glatke prijelaze. Jedina je razlika napravljena u obliku cervikalnog završetka preparacije, koji je za skupinu A podrazumijevao pravokutnu stepenicu širine od 1 do 1,5 mm, a za skupinu B zaobljenu stepenicu širine od 1 do 1,5 mm s glatkom kontinuiranom završnom linijom (21, 22). U skupini A za preparaciju su korištena dugačka dijamantna svrdla ravnog završetka (# TF-14, ISO 172/023, Mani Inc., Japan), a u skupini B dugačka svrdla zaobljena vrha (# TR-14, ISO 198/022, Mani Inc., Japan).

Zubi su zatim digitalno skenirani s pomoću CERCON EYE® skenera (DeguDent GmbH, Njemačka). Kapice su dizajnirane u softveru CERCON®ART 3.2 (DeguDent GmbH, Njemačka). Sve kapice izrađene su s jednakom dimenzijom cementnog međuprostora od 30 µm. Izrađene su u glodalici CERCON®BRAIN (DeguDent GmbH, Njemačka) i sinterirane u peći CERCON®HEAT (DeguDent GmbH, Njemačka). Sve postupke proveo je isti dentalni tehničar.

Sve kapice najprije su vizualno pregledane kako bi se otkrili mogući nedostaci i zatim su očišćene parom. Nakon toga, postavljeni su na odgovarajuće preparirane zube. Rubna prilagodba provjerena je vizualno i taktilno s pomoću oštre sonde. Unutarnji dosjed provjeren je Fit-Checkerom (Occlude, Aerosol Indicator Spray, Pascal Company, Inc., Washington, SAD) i prilagodbe su provedene dijamantnim svrdlom (# BR31, Mani, Inc., Tochigi, Japan) uz obilno hlađenje vodom. Taj je postupak ponovljen tri puta. Nakon toga, unutarnje površine svih kapica pažljivo su očišćene pjeskarenjem BegoDousrarom (Korox 110 i 50 µm, posebni materijal za pjeskarenje s 99,6 % aluminijeva oksida). Kapice su zatim cementirane staklenoionomernim cementom modificiranim smolom (RelyX Luting 2, 3M ESPE, St. Paul, MN 5514-1000, SAD) uz standardiziranu aksijalnu silu od 30 N rabeći Drill Press (DREMEL-MOTOTOOL, Model 212, SAD) tijekom 10 minuta, a višak cementa uklonjen je četkicom za jednokratnu uporabu, slijedeći protokole koje su opisali autori nedavnih istraživanja u kojima se procjenjuje prilagodba ZrO_2 kapica (1, 7, 23). Nakon cementiranja kapica uzorci su termociklirani tijekom 24 sata u stroju za termocikliranje (Huber, SD Mechatronik Thermocycler, Njemačka) kako bi se simuliralo oralno okruženje. Kapice su uložene u ortodontsku smolu (Ortho-Resin, DeguDent GmbH, Njemačka) kako bi se spriječilo njihovo pomicanje na zubu tijekom rezanja uzoraka. Uzorci su potom uzdužno prerezani na jednake mezijalne i distalne polovice s pomoću precizne pile (Isomet 2000 Precision Saw, Buehler, SAD).

Svaki prerezani uzorak označen je slovima *a* i *b* za mezijalnu i distalnu polovicu. Postavljeni su na metalni cilin-

ple was divided into two groups (A=Shoulder Margin Design & B=Chamfer Margin Design) using a random draw method.

A silicone putty index (Ivoclar, Vivadent Inc., USA) of each tooth was recorded before the preparation of the teeth and was used to provide a mesiodistally sectioned index for verifying the amount and design of preparation reduction.

Each tooth was prepared for an all-ceramic Zr crown according to current guidelines/recommendations by an experienced prosthodontist. All of the teeth were prepared by following the same guidelines which included a 5 to 10 degrees combined convergence angle, a functional cusp bevel, 2 mm of occlusal reduction, 1 mm of axial reduction, an overall rounded and smooth line angles except for the margin design, which for Group A was a 1 to 1.5 mm deep shoulder and for Group B was 1 to 1.5 mm deep heavy chamfer with a smooth continuous gingival finishing line (21, 22). The preparations for the Group A were performed using long Flat-ended tapered diamond burs (Bur # TF-14, ISO 172/023, Mani Inc., Japan) and for the Group B preparations were performed using long round-ended tapered diamond burs (Bur # TR-14, ISO 198/022, Mani Inc., Japan).

The teeth were then scanned digitally with CERCON EYE®, Digital Scanner (DeguDent GmbH, Germany). Copings were designed using CERCON®ART 3.2 (DeguDent GmbH, Germany). All of the copings were prepared with the same cement gap of 30 µm. They were milled in CERCON®BRAIN (DeguDent GmbH, Germany) and sintered in a sintering device CERCON®HEAT (DeguDent GmbH, Germany) by one technician.

All of the copings were first examined visually for any defects or retained debris and steam cleaned. Subsequently, they were placed on their corresponding prepared teeth. The marginal fit of the copings was examined visually and tactically using a sharp explorer. The internal fit of the copings was verified further with a fit checker (Occlude, Aerosol Indicator Spray, Pascal Company, Inc., Washington USA) and adjustments were made using a high speed round diamond bur (#BR31, Mani, Inc., Tochigi, Japan) under copious water irrigation, if required. This procedure was repeated three times. Subsequently, the internal surfaces of all the copings were cleaned carefully with BegoDousrar using 60 psi sandblasting (Korox 110 & 50 µm, special corundum blasting material of 99.6% aluminum oxide). The copings were then cemented with a Resin Modified Glass Ionomer Cement (RelyX Luting 2; 3M ESPE, St. Paul, MN 5514-1000, USA) under standardized axial force of 30 Newton's using Drill Press (DREMEL-MOTOTOOL, Model 212, U.S.A) for 10 minutes and excess cement was removed by a small disposable brush, following protocols described by authors of recent studies, evaluating the fit of zirconia copings (1, 7, 23). After cementation of the copings, the samples were thermocycled for 24 hours in a thermocycling machine (Huber, SD Mechatronik Thermocycler, Germany) to simulate the oral environment. The copings were again re-embedded with orthodontic resin (Ortho-Resin, DeguDent GmbH, Germany) to avoid any dislodgement of the coping from the teeth during the sectioning of the samples. The samples were then cross sectioned centrally into two equal mesial and distal halves using

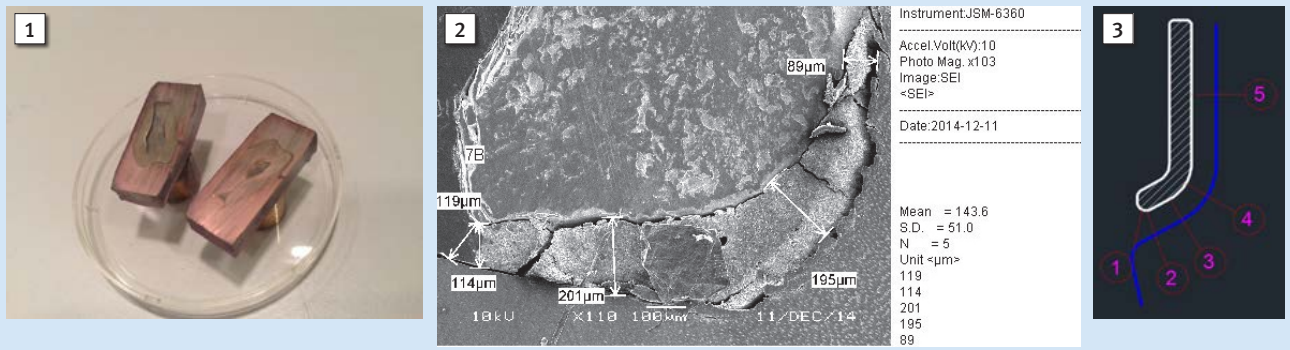
dar (Slika 1.) i obloženi zlatom (Fine Coat Ion Sputter JFC-1100, Tokio, Japan) prije analize elektronskim mikroskopom (JEOL, JSM-6360LV, Tokyo, Japan) pri čemu su rezane površine smještene paralelno s bazom mikroskopa. Uzorci su analizirani pod uvećanjem od 200 x stručnim tehničkim elektronskim mikroskopom na 5 unaprijed određenih točaka vestibularno i oralno za svaku polovicu (Slike 2., 3. i Tablica 1). Tehničar je u početku osposobljen za istraživanje proučavanjem 5 prerezanih oglednih uzoraka. Tehničar je mjerio debljinu cementa između površine kapica i zubi na rubovima u mikrometrima (μm).

Podaci su analizirani korištenjem softverskog paketa SPSS 22 (SPSS, Inc., Chicago, IL, USA). Za svaku polovicu bilježene su izmjerene vrijednosti na vestibularnim i oralnim točkama, a zatim je izračunata srednja vrijednost očitanja za dvije polovice, što se smatralo konačnom vrijednošću za svaki uzorak. Analize su obuhvatile srednje vrijednosti i standardne devijacije za svako od pet mjesta mjerenja i za svaku skupinu (A i B) od 20 zubi s pomoću statističkih stupaca te njihovu usporedbu s pomoću T-testa (interval pouzdanosti 95 %). Vjerojatnost za statistički značajnu razliku postavljena je na a = 0,05.

precision saw (Isomet 2000 Precision Saw, Buehler, USA).

Each of the sectioned specimen was designated *a* and *b* for mesial and distal half, respectively. They were placed over a metallic cylinder (Figure 1) and gold coated (using Fine Coat Ion Sputter JFC-1100, Tokyo, Japan) for placement in a Scanning Electron Microscope (JEOL, JSM-6360LV, Tokyo, Japan), keeping the exposed sectioned surfaces parallel to the base of the microscope. The copings were examined at 200X magnification by an expert electron microscope technician at 5 predetermined points for the buccal and lingual margins for each of the sectioned half (Figure 2, 3 and Table 1). The technician was initially trained for the study by studying a pilot sample of 5 sectioned copings. The cement thickness between the fitting surfaces of the copings and the teeth at the margins were measured in micrometers (μm) by the technician.

The data were analyzed using SPSS Version 22 software package (SPSS, Inc., Chicago, IL, USA). The buccal and lingual marginal readings for each half were recorded and then the mean of the readings for the two halves was calculated and considered as the final reading for each sample. Analyses included the mean values and standard deviations for each of the 5 gap sites and for each group (A and B) of 20 teeth using column statistics; and comparison of these latter means (95% CIs) using T-test. The probability for statistical significance was set at α = 0.05.



Slika 1. Prerezane kapice
Figure 1 Mounted Sectioned Copings.
Slika 2. Pregled elektronskim mikroskopom u 5 mjernih točaka
Figure 2 Scanning electron microscope examinations at 5 measurement areas.
Slika 3. Shematski prikaz presjeka 5 mjernih točaka
Figure 3 Cross sectional diagrammatic representation of the 5 measuring areas.

Tablica 1. Pojedinosti mjerenja u 5 točaka za svaku ZrO_2 kapicu
Table 1 Details of the 5 points of measurements for each coping

Točka • Point	Skraćenica • Abbreviation	Opis • Description
1.	AMP	**Apsolutni rubni međuprostor.** Udaljenost između ruba kapice i ruba preparacije. • **Absolute Marginal Gap.** The distance from the edge of the coping to the edge of the finish line.
2.	MG	**Rubni međuprostor.** Okomita udaljenost od površine ruba preparacije do ruba kapice. • **Marginal Gap.** The perpendicular distance from the surface of the finish line to the coping's margin.
3.	MMG	**Središnji rubni međuprostor.** Okomita udaljenost od unutarnje površine kapice do središnje točke dna preparacije. • **Mid Marginal Gap.** The perpendicular distance from the internal surface of the coping to the mid-point of the floor of the margin.
4.	AG	**Kutni međuprostor.** Okomita udaljenost od unutarnje površine kapice do kuta između dna i aksijalne stijenke preparacije. • **Angle Gap.** The perpendicular distance from the internal surface of the coping to angle between floor and axial wall of the finish line.
5.	AWG	**Aksijalni međuprostor.** Okomita udaljenost od unutarnje površine kapice do aksijalne stijenke. • **Axial wall Gap.** The perpendicular distance from the internal surface of the coping to the axial wall.

Rezultati

Srednje vrijednosti izmjerenih dimenzija međuprostora za dvije skupine prikazane su u Tablici 2. Prosječna dimenzija međuprostora za skupinu A (pravokutna stepenica) bila je manja u usporedbi sa skupinom B (zaobljena stepenica). Analiza T-testom pokazala je razliku koja nije bila statistički značajna (p = 0,113) između pravokutne i zaobljene stepenice (Tablica 2.).

Tablica 3. prikazuje srednje vrijednosti za skupine A i B u 5 točaka mjerenja. Za područje broj 2 (rubni međuprostor) izmjerena je najmanja srednja vrijednost, a za područje 4 (kutni međuprostor) najveća srednja vrijednost (Tablica 3.). Rezultati T-testa za nezavisne uzorke pokazali su razliku između dviju skupina za svih 5 točaka mjerenja koja nije bila statistički značajna (Tablica 3.).

Slika 4. prikazuje razlike u srednjim vrijednostima za obje skupine u 5 točaka mjerenja dobivenih elektronskim mikroskopom. Najveća razlika između skupina pronađena je u točki 1 (apsolutni rubni međuprostor), a najmanja razlika pronađena je u području 4 (kutni međuprostor).

Results

The overall mean gap values for the two groups are presented in Table 2. The mean marginal gap for Group A (Shoulder Margin Design) was lower compared to Group B (Chamfer Margin Design). Assessment by T-test showed a statistically non-significant difference (p = .113) between the Shoulder and Chamfer margin designs (Table 2).

Table 3 shows the mean values for the Group A and B at 5 areas of measurements. The area number 2 (Marginal Gap) showed the lowest mean gap values and area number 4 (Angle Gap) showed the highest mean gap values measured (Table 3). The results with Independent Sample T-test showed a statistically non-significant difference between the two groups for all the 5 areas of measurements (Table 3).

Figure 4 shows the differences in the mean values for the two groups at 5 evaluated regions obtained with electron microscope. The highest difference among the groups was found in the Area 1 (Absolute Marginal Gap) and the least difference was found in the Area 4 (Angle Gap).

Tablica 2. Srednje vrijednosti (standardna devijacija) rubnog međuprostora za eksperimentalne skupine mjereno elektronskim mikroskopom (n = 40)
Table 2 Mean values (standard deviation) of the marginal gap for the experimental groups measured by the electron microscope (n=40)

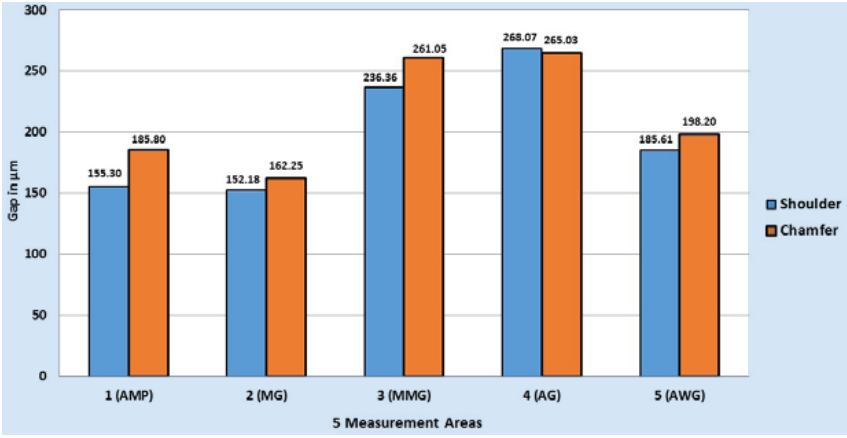
Skupina • Group	Oblik preparacije • Margin Design	*Prosječna dimenzija međuprostora na objema polovicama • *Mean gap of two halves	Ukupna srednja vrijednost • Overall mean	Standardna devijcija • Standard Deviation	T Test p value
A (n=20)	Pravokutna stepenica • Shoulder	**a = 201.74	199.50	40.72	.113
		***b = 197.26			
B (n=20)	Zaobljena stepenica • Chamfer	a = 212.90	214.46	44.85	
		b = 216.02			
Ukupno • Total			206.98	42.78	

* Dimenzija međuprostora mjerena u mikrometrima (μm) • Mean gap was measured in micrometers (μm)
** Prerezane mezijalne polovice uzoraka • Sectioned mesial half of the specimens.
*** Prerezane distalne polovice uzoraka • Sectioned distal half of the specimens.

Tablica 3. Deskriptivna statistika i rezultati T-testa za 5 mjernih točaka
Table 3 Descriptive statistics plus T test results for 5 points of measurements

Točka • Points	Skupnina • Groups	Srednja vrijednost (SD) • Mean (Std. D.) (n=20)	***Srednja vrijednost (SD) • ***Mean (Std. D) (n=40)	T-test • Independent Samples test
1.	*A	155.30 (88.25)	170.55 (100.08)	.167
2.	**B	185.80 (111.92)		
3.	A	152.18 (66.85)	157.21 (66.67)	.491
4.	B	162.25 (66.50)		
5.	A	236.36 (55.72)	248.70 (59.89)	.063
6.	B	261.05 (64.07)		
7.	A	268.06 (73.42)	266.54 (62.67)	.829
8.	B	265.02 (51.92)		
9.	A	185.61 (78.93)	191.9 (68.18)	.410
	B	198.19 (57.44)		

* Pravokutna stepenica • Shoulder Margin, **Zaobljena stepenica • Chamfer, ***Prosječna dimenzija međuprostora mjereno u mikrometrima (μm) • Mean gap was measured in micrometers (μm)



Slika 4. Usporedba srednjih vrijednosti dimenzija međuprostora u 5 mjernih točaka
Figure 4 Comparison of the mean values of gaps for the two groups at 5 measured areas.

Rasprava

U ovom in vitro istraživanju analizirana je rubna prilagodba pojedinačnih cirkonij-oksidnih kapica proizvedenih iz polusinteriranih blokova cirkonijeva oksida s pomoću sustava Cercon® (DeguDent GmbH, Njemačka) koje su cementirane na prepariranim izvađenim zubima s dvama različitim oblicima preparacije cervikalnog završetka. Prema spoznajama autora, u literaturi nema istraživanja u kojima se uspoređuje rubna prilagodba cirkonij-oksidnih kapica na preparaciji s pravokutnom i zaobljenom stepenicom kao najčešćim oblicima preparacije za potpuno keramičke cirkonij-oksidne krunice (24). Istraživanje je zamišljeno kao pokušaj otkrivanja oblika ruba preparacije koji će rezultirati boljom rubnom prilagodbom između zuba i ruba kapice, pri čemu su korišteni prirodni zubi umjesto umjetnih. Određena ograničenja istraživanja mogla su utjecati na rezultate, kao što je standardizacija preparacije zubi, individualno dizajniranje svake kapice, prilagodba kapice na zubu, postupak cementiranja, rezanje uzoraka, previše ljudi uključenih u cjelokupan proces i konačno mjerenje elektronskim mikroskopom. Međutim, pokušali smo riješiti svaki od navedenih problema.

Prema rezultatima dobivenim u ovom istraživanju, mogla bi se prihvatiti nulta hipoteza prema kojoj oblik ruba preparacije ne utječe na rubnu prilagodbu cirkonij-oksidne kapice. Rezultati nisu pokazali statistički značajnu razliku ($p > 0{,}113$) u prosječnim vrijednostima za ukupnu dimenziju međuprostora između dviju skupina na pet mjerenih točaka. Srednja vrijednost širine međuprostora za preparaciju sa zaobljenom stepenicom od 214,46 ± 44,85 µm bila je veća nego za preparaciju s pravokutnom stepenicom koja je iznosila 199,50 ± 40,72 µm. No, ta je razlika zanemariva što se tiče kliničkog značenja. Rezultati istraživanja pokazali su da je u 4 od 5 mjerenih točaka rubna prilagodba za preparaciju s pravokutnom stepenicom bila bolja nego u slučaju zaobljene stepenice.

U literaturi su mnoga istraživanja proučavala rubnu prilagodbu cirkonij-oksidnih kapica analizirajući različite sustave i materijale, a samo jedno istraživanje koje su proveli Habib i sur. (20) imalo je rezultate slične ovom istraživanju s pojedinačnim krunicama izrađenim na izvađenim prirodnim zubima. Rezultate svih tih istraživanja teško je interpretirati zbog varijacija veličine uzoraka, mjerenja uzoraka i različitih meto-

Discussion

In the present *in vitro* study, the marginal adaptation of the single unit of zirconia copings, manufactured from semi sintered zirconia blocks using Cercon® (DeguDent GmbH, Germany) system and cemented on prepared extracted teeth with two different types of margin designs, was investigated. To the best of the authors' knowledge, there are no such studies in the literature comparing the marginal adaptation of zirconia copings in Shoulder and Chamfer margin designs which are the most commonly used margin designs when preparing the teeth for all ceramic zirconia crowns (24). This study was an attempt to find the margin design that will result in least marginal gap between the finishing lines and the coping margin using natural teeth instead of using artificial dies. There were some limitations of the study which may have affected the results such as standardization of the preparation of teeth, individual designing of the coping for each tooth, trial fitting of the coping on the teeth, effect of cementation procedure, sectioning of the coping with the saw, too many persons involved in the complete process and finally the measurements recorded with the electron microscope. However, an attempt was made to address each of the abovementioned issues.

According to the data obtained in this study, the null hypothesis stating that the margin design does not affect the marginal adaptation of the zirconia copings could be accepted. The results showed a difference that is not statistically significant ($p>.113$) between the means of the overall gap between the two groups and at 5 points measured for the Shoulder and Chamfer margin design preparations. The mean gap measurement for the Chamfer margin preparation of 214.46±44.85µm was found to be higher than for the Shoulder margin preparation of 199.50±40.72µm. However, this difference is negligible in terms of clinical significance. The results of the study revealed that 4 out of the 5 measured gap points showed Shoulder margin design to have better marginal adaptation compared to the Chamfer margin design.

In the literature, many studies have evaluated the fit of zirconia copings using various systems and materials and only one study carried out by Habib SR et al (20) has reported the results similar to this study with respect to sin-

da mjerenja. Nekoliko je autora nepodudarnost između 100 i 150 µm smatralo klinički prihvatljivom (4 – 9). U ovom je istraživanju utvrđeno da je srednja vrijednost dimenzije međuprostora ili rubne pukotine iznosila 206,98 ± 42,78 µm, što je više od rezultata drugih istraživanja. Takva varijacija rezultata može se objasniti razlikom u korištenom CAD/CAM sustavu i uporabi različitih zubi za izradu pojedinačne kapice. Drugi razlog za veće vrijednosti rubnog međuprostora može se objasniti činjenicom da je srednja vrijednost zabilježena u 5 različitih točaka korištena kao konačna vrijednost, a u drugim je istraživanjima dimenzija međuprostora mjerena samo vestibularno ili oralno. S obzirom na takvu varijaciju možemo predvidjeti da u kliničkim slučajevima također postoji određena varijacija u prilagodbi ZrO_2 kapica, što je teško procijeniti samo vizualnim pregledom.

U ovom istraživanju zabilježena su mjerenja za vestibularne i oralne dimenzije rubnog međuprostora za svaku polovicu, a zatim je izračunata srednja vrijednost očitanja za dvije polovice, što se smatralo konačnom dimenzijom za svaki uzorak. Ograničenje te tehnike jest u tome što daje dvodimenzionalni uvid u postojeći međuprostor i ne analizira 3D (trodimenzionalnu) prilagodbu (13). U istraživanju Wakabayashija i sur. (13) prilagodba potpuno keramičkih krunica analizirana je nedestruktivnom tehnikom primjenom mikrofokalnoga rendgenskog CT sustava. Iako su naveli nekoliko prednosti tehnike, utvrđeno je da ukupna dimenzija međuprostora (119 + 7 µm) primjenom te tehnike nije značajnije različita od onih koje su zabilježene u drugim istraživanjima (1, 4, 5, 14).

U ovom istraživanju slijedile su se smjernice preparacije koje preporučuju proizvođači cirkonij-oksidne keramike tako da je korištena pravokutna i zaobljena stepenica koje su ujedno najčešće upotrebljavani oblici preparacije (24). Istraživači su izvijestili o razinama naprezanja, čvrstoći, primjerenosti i biomehaničkim svojstvima pravokutne i zaobljene stepenice (24 – 27). Međutim, u literaturi još nedostaje znanstvenih podataka o obliku cervikalnog završetka preparacije koji će rezultirati najmanjim rubnim odstupanjima. Rezultati istraživanja pokazali su da nema statistički značajne razlike između pravokutne i zaobljene stepenice, što upućuje na to da ni jedan od tih dvaju oblika preparacije nije bolji od drugog u smislu rubne prilagodbe. Na temelju tih nalaza pretpostavljamo da, ovisno o kliničkom zahtjevu, kliničar ima slobodu odabrati oblik cervikalnog završetka preparacije. Iako na kliničku odluku o izboru oblika preparacije i konačni ishod utječu mnogobrojni čimbenici, iskustvo kliničara i sklonost određenoj tehnici imaju važnu ulogu tijekom preparacije zuba za cirkonij-oksidnu krunicu.

gle tooth zirconia copings, fabricated on prepared extracted natural teeth. The results of all these studies are difficult to interpret because of the variations in the sample size, measurements of the specimens and different methods used for the measurements. Several authors have considered marginal discrepancies between 100 and 150 µm to be in a range of clinical acceptance (4-9). In the present study, the mean of the buccal marginal gap and lingual marginal gap was found to be 206.98±42.78µm which is higher compared to the results of other studies. This variation in the results obtained in the present study could be explained by the difference in the CAD/CAM system and use of individual teeth for the fabrication of each coping. Another reason for higher marginal gap values may be explained by the fact that the mean value recorded at 5 different points were considered and used as the final value, while calculating the marginal gap values in the study samples compared to the vertical marginal gaps were measured only buccally or lingually in other studies. With this variation we can also predict that a certain percentage of variation in the fit of Zr copings exists in clinical cases and is difficult to predict with the visual examination alone.

In the current study, the buccal and lingual marginal readings for each half were recorded and then the mean of the readings for the two halves was calculated and considered as the final reading for each sample. The limitation of using this technique is that it gives a two dimensional view for measuring the thickness of gap in a single section and does not examine the 3D (three dimensional) adaptation (13). In a study by Wakabayashi et al (13) the adaptation of the all ceramic crowns was analyzed in a non-destructive technique using microfocus X-ray CT system. Although they reported several advantages of using the technique, the overall mean gap thickness measured (119±7µm) by this technique was found to be not more significantly different than that reported by other studies (1, 4, 5, 14).

The current study followed the guidelines recommended by the manufacturers of Shoulder and Chamfer types of margin designs for the zirconia crowns which in fact are the most commonly used types of margin designs prepared by the dentists (24). Researchers have reported the stress levels, fracture resistance, adequacy and biomechanical performance between the Shoulder and Chamfer types of margin designs (24-27). However, there is still lack of scientific data in the literature about the type of the margin design that will result in least marginal discrepancy. The results of the current study showed that there is not a statistically significant difference between the Shoulder and Chamfer margin designs which indicates that none of the two margin designs is superior to the other in terms of marginal fit. On the basis of these findings we hypothesize that, depending on the clinical requirement, the clinician has freedom to choose the proper type of margin design. Although, clinical decisions regarding the choice of margin design and the ultimate outcome are dictated by many factors, the clinician's experience and preferences play an important role during the preparation of teeth for zirconia crowns.

Zaključak

Uzimajući u obzir ograničenja ovog istraživanja može se zaključiti da je rubna prilagodba cirkonij-oksidnih kapica jednaka i kod pravokutne i kod zaobljene stepenice. Nisu pronađene statistički značajne razlike između tih dvaju oblika preparacije.

Zahvala

Autori su zahvalni Haythamu Abualsaudu (tehničar za CAD/CAM), Ali Asiriju (tehničar za SEM) za pružene usluge i Nassru Maflehiju za pomoć u statističkoj analizi. Istraživački projekt odobrio je i podupro Centar za stomatološka istraživanja (Registracijski broj IR0110)/Znanstveno istraživanje na Sveučilištu King Saud.

Sukob interesa

Nema sukoba interesa.

Conclusions

Within the limitations of this study, it was concluded that marginal adaptation of zirconia copings with either Shoulder or Chamfer margin design is the same. No statistically significant differences were found between the Shoulder and Chamfer types of margin design.

Acknowledgements

The authors are grateful to Mr. Haytham (Technician CAD/CAM), Mr. Ali Asiri (Technician Scanning Electron Microscope) for their valuable services and to Mr. Nassr Maflehi for his help in the statistical analysis. The research project was approved and supported by the College of Dentistry Research Center (Registration number IR0110) / Deanship of Scientific Research at King Saud University.

Conflict of Interest

None declared

Abstract

Objective: The aim of this *in vitro* study was to investigate the effect of Shoulder versus Chamfer margin design on the marginal adaptation of zirconia (Zr) copings. **Materials and Methods:** 40 extracted molar teeth were mounted in resin and prepared for zirconia crowns with two margin preparation designs (20=Shoulder and 20=Chamfer). The copings were manufactured by Cercon® (DeguDent GmbH, Germany) using the CAD/CAM system for each tooth. They were tried on each tooth, cemented, thermocycled, re-embedded in resin and were subsequently cross sectioned centrally into two equal mesial and distal halves. They were examined under electron microscope at 200 X magnification and the measurements were recorded at 5 predetermined points in micrometers (µm). **Results:** The **o**verall mean marginal gap for the two groups was found to be 206.98±42.78µm with Shoulder margin design (Marginal Gap=199.50±40.72µm) having better adaptation compared to Chamfer (Marginal Gap=214.46±44.85µm). The independent-samples t-test showed a statistically non-significant difference (p=.113) between the means of marginal gap for Shoulder and Chamfer margin designs and the measurements were recorded at 5 predetermined points for the two groups. **Conclusions: T**he Chamfer margin design appeared to offer the same adaptation results as the Shoulder margin design.

Received: March 30, 2017
Accepted: June 6, 2017

Address for correspondence
Dr. Syed Rashid Habib B.D.S., F.C.P.S.
Associate Professor
King Saud University
College of Dentistry
Department of Prosthetic Dental Sciences,
P. O. Box 60169, King Abdullah Road,
Riyadh, 11545, Saudi Arabia.
Phone: 966-1-467 7325
Fax: 966-1-467 8548
rashidhabib@hotmail.com

Key words
Dental Crown Margin; Dental Marginal Adaptation; CAD/CAM

References

1. Grenade C, Mainjot A, Vanheusden A. Fit of single tooth zirconia copings: comparison between various manufacturing processes. J Prosthet Dent. 2011 Apr;105(4):249-55.
2. Kohorst P, Junghanns J, Dittmer MP, Borchers L, Stiesch M. Different CAD/CAM-processing routes for zirconia restorations: influence on fitting accuracy. Clin Oral Investig. 2011 Aug;15(4):527-36.
3. Inokoshi M, Vanmeensel K, Zhang F, De Munck J, Eliades G, Minakuchi S, et al. Aging resistance of surface-treated dental zirconia. Dent Mater. 2015 Feb;31(2):182-94.
4. Abduo J, Lyons K, Swain M. Fit of zirconia fixed partial denture: a systematic review. J Oral Rehabil. 2010 Nov;37(11):866-76.
5. Beuer F, Aggstaller H, Edelhoff D, Gernet W, Sorensen J. Marginal and internal fits of fixed dental prostheses zirconia retainers. Dent Mater. 2009 Jan;25(1):94-102.
6. Colpani JT, Borba M, Della Bona A. Evaluation of marginal and internal fit of ceramic crown copings. Dent Mater. 2013 Feb;29(2):174-80.
7. Beuer F, Naumann M, Gernet W, Sorensen JA. Precision of fit: zirconia three-unit fixed dental prostheses. Clin Oral Investig. 2009 Sep;13(3):343-9.
8. Wettstein F, Sailer I, Roos M, Hämmerle CH. Clinical study of the internal gaps of zirconia and metal frameworks for fixed partial dentures. Eur J Oral Sci. 2008 Jun;116(3):272-9.
9. Fransson B, Oilo G, Gjeitanger R. The fit of metal-ceramic crowns, a clinical study. Dent Mater. 1985 Oct;1(5):197-9.
10. Matta RE, Schmitt J, Wichmann M, Holst S. Circumferential fit assessment of CAD/CAM single crowns--a pilot investigation on a new virtual analytical protocol. Quintessence Int. 2012 Oct;43(9):801-9.
11. Moldovan O, Luthardt RG, Corcodel N, Rudolph H. Three-dimensional fit of CAD/CAM-made zirconia copings. Dent Mater. 2011 Dec;27(12):1273-8.
12. Kohorst P, Junghanns J, Dittmer MP, Borchers L, Stiesch M. Different CAD/CAM-processing routes for zirconia restorations: influence on fitting accuracy. Clin Oral Investig. 2011 Aug;15(4):527-36.
13. Wakabayashi K, Sohmura T, Nakamura T, Kojima T, Kinuta S, Takahashi J, et al. New evaluation method by microfocus radiograph CT for 3D assessment of internal adaptation of all ceramic crowns. Dent Mater J. 2005 Sep;24(3):362-7.
14. Gonzalo E, Suarez MJ, Serrano B, Lozano JF. A comparison of the marginal vertical discrepancies of zirconium and metal ceramic posterior fixed dental prostheses before and after cementation. J Prosthet Dent. 2009 Dec;102(6):378-84.
15. Beuer F, Aggstaller H, Richter J, Edelhoff D, Gernet W. Influence of preparation angle on marginal and internal fit of CAD/CAM-fabricated zirconia crown copings. Quintessence Int. 2009 Mar;40(3):243-50.

16. Grenade C, Mainjot A, Vanheusden A. Fit of single tooth zirconia copings: comparison between various manufacturing processes. J Prosthet Dent. 2011 Apr;105(4):249-55.
17. Quintas AF, Oliveira F, Bottino MA. Vertical marginal discrepancy of ceramic copings with different ceramic materials, finish lines, and luting agents: an in vitro evaluation. J Prosthet Dent. 2004 Sep;92(3):250-7.
18. Azar MS, Lehmann KM, Dietrich H, Weibrich G, Schmidtmann I, Scheller H. Effect of Preparation Depth Differences on the Marginal Fit of Zirconia Crown Copings: An In Vitro Study. Int J Prosthodont. 2011 May-Jun;24(3):264-6.
19. Renne W, McGill ST, Forshee KV, DeFee MR, Mennito AS. Predicting marginal fit of CAD/CAM crowns based on the presence or absence of common preparation errors. J Prosthet Dent. 2012 Nov;108(5):310-5.
20. Habib SR, Asiri W, Hefne MJ. Effect of anatomic, semi-anatomic and non-anatomic occlusal surface tooth preparations on the adaptation of zirconia copings. J Adv Prosthodont. 2014 Dec;6(6):444-50.
21. Shillingburg, HT Jr; Hobo, S; Whitsett, LD. Principles of tooth preparations. In: Shillingbur, HT; Hobo, S; Whitsett, LD – editors. Fundamentals of Fixed Prosthodontics. 3rd ed. Chicago: Quintessence; 1997. pp. 119-154.
22. Rosenstiel, S; Land, M; Fujimoto , J – editors. Contemporary Fixed Prosthodontics. St Louis: Mosby Elsevier; 2006.
23. Black S, Amoore JN. Measurement of forces applied during the clinical cementation of dental crowns. Physiol Meas. 1993 Aug;14(3):387-92.
24. Jalalian E, Atashkar B, Rostami R. The effect of preparation design on the fracture resistance of zirconia crown copings (computer associated design/computer associated machine, CAD/CAM system). J Dent (Tehran). 2011 Summer;8(3):123-9.
25. Jalalian E, Aletaha NS. The effect of two marginal designs (chamfer and shoulder) on the fracture resistance of all ceramic restorations, Inceram: an in vitro study. J Prosthodont Res. 2011 Apr;55(2):121-5.
26. Di Iorio D, Murmura G, Orsini G, Scarano A, Caputi S. Effect of margin design on the fracture resistance of Procera all ceram cores: an in vitro study. J Contemp Dent Pract. 2008 Feb 1;9(2):1-8.
27. Aykul H, Toparli M, Dalkiz M. A calculation of stress distribution in metal-porcelain crowns by using three-dimensional finite element method. J Contemp Dent Pract. 2008 Feb 1;9(2):1-8.