Acta Stomatologica Naissi Decembar/December 2010, vol. 26, br./number 62 str./p 977 - 986

NAUČNI RAD
SCIENTIFIC ARTICLE

PRECIZNOST KERAMIČKIH KRUNA IZRAĐENIH PRIMENOM OPTIČKIH METODA SKENIRANJA CEREC 3D SISTEMA

ACCURACY OF CERAMIC CROWNS MADE BY OPTICAL SCANNING METHODS OF CEREC ®3D SYSTEM

Aleksandar B. Todorović*, Branka V. Trifković*, Dragoslav S. Stamenković*

*UNIVERZITET U BEOGRADU, STOMATOLOŠKI FAKULTET, KLINIKA ZA STOMATOLOŠKU PROTETIKU, BEOGRAD, SRBIJA

*UNIVERSITY OF BELGRADE, FACULTY OF DENTISTRY, CLINIC FOR PROSTHETIC DENTISTRY, BELGRADE, SERBIA

ABSTRAKT

Uvod: *Dugogodišnji razvoj Cerec®3D CAD/CAM sistema implementirao je u praktičnu upoterbu jednu intraoralnu i dve ekstraoralne metode optičkog skeniranja.*
Cilj: *Cilj rada je bio da se utvrdi stepen preciznosti keramičkih kruna izrađenih primenom različitih tehnika optičkog skeniranja Cerec®3D sistema.*
Materijal i metod: *Ispitivanje je sprovedeno u okviru tri eksperimentalne grupe kruna u čijoj izradi su primenjeni različiti postupci skeniranja Cerec®3D sistema. Metalokeramičke krune izrađene konvencionalnom metodologijom predstavljale su kontrolnu grupu. Preciznost kruna ispitivana je merenjem veličine marginalnog zjapa između ruba krune i demarkacije preparacije pomoću skenirajućeg elektronskog mikroskopa (SEM).*
Rezultati: *Rezultati istraživanja pokazuju da postoji razlika u preciznosti kruna izrađenih primenom različitih metoda skeniranja Cerec®3D sistema. Najviši stepen preciznosti (31,64±9,45μ) zabeležen je kod kruna u čijoj izradi je primenjena tehnika optičkog ekstraoralnog površinskog skeniranja, nešto niži stepen preciznosti (50,27±31,50μ) imale su krune izrađene tehnikom intraoralnog optičkog površinskog skeniranja. Krune izrađene primenom tehnike ekstraoralnog tačkastog skeniranja imale su stepen preciznosti od 102,58±31,23μ.*
Zaključak: *Krune izrađene primenom optičkih metoda skeniranja Cerec 3D sistema pokazuju visok i klinički prihvatljiv stepen preciznosti.*

Ključne reči: *Cerec, kompjuterom vođeno dizajniranje, keramika, krune, rubno zaptivanje.*

ABSTRACT

Introduction: *The results of many years technological development of Cerec® 3D CAD/CAM system, is implementation one intraoral and two extraoral optical scanning methods.*
Aim: *The aim of this study was to determine the precission of ceramic crowns made by optical scanning methods of Cerec®3D system .*
Methods: *The study was conducted in three experimental groups of ceramic crowns in whose manufacturing was applied three optical scanning methods of Cerec®3D system. Control group consisted of metal-ceramic crowns made by conventional metodology. The accuracy of ceramic crowns was examined by measuring of the marginal gap size between edge of crowns and demarcation by scanning electron microscope (SEM).*
Results: *The research found, that there is a difference in the accuracy of ceramic crowns made by Cerec®3D system. The highest level of accuracy was recorded in the group of crowns made by technique extraoral optical superficial scanning (31,64±9,45μ). Marginal gap size crowns made with technique intraoral optical superficial scanning showed a lower level of accuracy (50,27±31,50μ). Value of marginal gap size crowns made by technique extraoral laser point scanning was 102,58+31,23μ.*
Conclusion: *Ceramic crowns made by Cerec®3D optical scanners show a high and clinically acceptable precision level.*

Key words*: Cerec, Computer-Aided Design, ceramic, crowns, marginal adaptation.*

Uvod

Trodimenzionalno skeniranje, kompjutersko dizajniranje i numerički upravljana izrada predstavljaju značajna tehnološka dostignuća koja su doprinela povećanju preciznosti fiksnih zubnih nadoknada.[1] Kvalitet rubnog zaptivanja je jedan od najvažnijih kriterijuma u kliničkoj i

Introduction

Three-dimensional scanning, computer design and numerically controlled manufacturing are significant technological achievements which have contributed to increased precision of fixed dental restorations.[1] Accuracy of marginal adaptation is important criteria in the clin-

laboratorijskoj proceni vrednosti fiksnih zubnih nadoknada.[2]

Faze konvencionalnih i CAD/CAM postupaka izrade fiksnih zubnih nadoknada nisu apsolutno precizne. U „lancu" konvencionalne izrade fiksnih nadoknada tri najslabije karike koje utiču na njihovu preciznost su: postupak otiskivanja, manuelna izrada radnog modela i nadoknade. Analogno pomenutoj konstataciji u dentalnoj CAD/CAM tehnologiji na preciznost izrade utiču: prostorna digitalizacija, kompjutersko dizajniranje i mašinska izrada.

Kvalitet otisaka ima prvi i odlučujući uticaj na preciznost postupka izrade zubne nadoknade.[3] Trend u razvoju dentalne CAD/CAM tehnologije je da različite metode prostorne digitalizacije preparisanog zuba zamene njegovo konvencionalno otiskivanje.[4,5]

Optičko skeniranje, dugogodišnja primena i usavršavanje tehničkih karakteristika su neka od obeležja po kojima je prepoznatljiv Cerec®3D (Sirona Dental Systems, Bensheim Germany). Cerec®3D predstavlja sistem koji je u praktičnu upotrebu implementirao tri različita skenera: intraoralni optički površinski skener, Cerec Scan koji u postupku skeniranja koristi laserske zrake i InEos skener koji koristi svetlosne zrake.[6,7] Naučni principi na kojima su zasnovani postupci optičkog skeniranja u okviru Cerec®3D sitema su različiti.

Sistem pruža mogućnost da virtuelno dizajniranje i izrada fiksnih zubnih nadoknada budu isti za sve postojeće tehnike skeniranja. Obzirom na pomenutu konstataciju postavlja se pitanje:„ Da li postoji i kolika je razlika u preciznosti fiksnih zubnih nadoknada izrađenih primenom različitih postupaka skeniranja Cerec®3D sistema?".

Polazeći od pomenutih karakteristika definisana je radna hipoteza u kojoj se pretpostavlja da postoji razlika u preciznosti keramičkih kruna izrađenih primenom tri različita postupka skeniranja Cerec®3D sistema. Na osnovo radne hipoteze definisan je osnovni cilj istraživanja: utvrditi stepen preciznosti keramičkih kruna izrađenih primenom različitih postupaka skeniranja Cerec®3D sistema.

Materijal i metod

Istraživanje je sprovedeno u okviru tri eksperimentalne i jedne kontrolne grupe.

1. Grupa 1 - 15 keramičkih kruna izrađenih primenom tehnike intraoralnog optičkog površinskog skeniranja;

ical and laboratory evaluation of fixed partial denture.[2]

Accuracy of the conventional and CAD/CAM technology in manufacturing of fixed dental restoration are diferent. Precission of the conventional techniques depends on: impression procedure, both manual making of master die and restoration. Precision of manufacturing in the dental CAD/CAM technology affect: spatial digitalization, computer design and mechanical manufacturing.

The impression quality has the first impact on the precision of fixed dental restoration.[3] The trend in the development of the dental CAD/CAM technology is that various methods of spatial digitalization replace conventional impression.[4,5]

Optical scanning, long-term application and improvement of technical characteristics are some of the features by which Cerec®3D (Sirona Dental Systems, Bensheim Germany) is distinguished. Cerec®3D implemented three different scanners in practical use: intraoral optical surface scanner, Cerec Scan and InEos scanner.[6,7] The scientific principles of optical scanning within the Cerec®3D system, are different. The system offers the possibility for identical virtual design and manufacturing of all existing scanning techniques. Considering this statement, the following question arises: „Is there a difference in the precision of ceramic crowns made by different scanning methods of the Cerec®3D system?" Starting from the mentioned characteristics, an operating hypothesis was defined which surmises that there is a difference in precision of ceramic crowns made by Cerec®3D system. On the basis of the operating hypothesis, the research goal was defined: to establish the degree of acuraccy of ceramic crowns made by optical scanning methods of Cerec®3D system.

Materials and methods

The research was conducted within three experimental and one control group.

1. Group 1 – 15 crowns made by the intraoral optical surface scanning technique;

2. Grupa 2 - 15 keramičkih kruna izrađenih primenom tehnike ekstraoralnog optičkog površinskog skeniranja;

3. Grupa 3 - 15 keramičkih kruna izrađenih primenom tehnike ekstraoralnog optičkog laserskog tačkastog skeniranja;

Kontrolna grupa - 15 metalokeramičkih kruna izrađenih konvencionalnom metodologijom (IPS InLine,A3, Ivoclar Vivadent).

U okviru istraživanja upotrebljeni su akrilatni zubi (DSP-model teeth, Nr.11. KaVo,Germany), koji su za potrebe brušenja i otiskivanja postavljeni u radni model (KaVo, basic study model, Germany). Preparacija zuba izvedena je u skladu sa preporučenim dizajnom preparacije za Cerec®sistem, što je podrazumevalo demarkaciju oblika stepenika sa zaobljenim unutrašnjim zidom širine 1.00mm, nagib pojedinačne aksijalne površine 6° i okluzalno skraćenje 1,5mm. Sa aksijalnih površina uklonjeno je od 1 do 1,5mm zubne supstance.[8]

Primenom ove metodologije preparisano je 15 akrilatnih zuba koji su poslužili kao osnovni modeli.

Skeniranje radnih modela obavljeno je pomoću tri skenera Cerec®3D sistema:

1. Intraoralni skener (Cerec,Sirona)-tehnika intraoralnog optičkog površinskog skeniranja;

2. InEos skener (Cerec, Sirona)– tehnika ekstraoralnog optičkog površinskog skeniranja i

3. Cerec Scan laserski tačkasti skener integrisan u mašini za frezovanje (Cerec, Sirona) – tehnika ekstraoralnog optičkog tačkastog skeniranja.

Priprema modela zuba za intraoralno skeniranje obuhvatala je nanošenje tankog sloja praha na bazi titanijum dioksida (CEREC® – powder,VITA,Bad Sackingen,Germany) (Slika1).

Za potrebe tehnika ekstraoralnog skeniranja neophodno je izlivanje modela od gipsa. Kao osnova za otiskivanje upotrebljeni su modeli koji su skenirani intraoralnim skenerom. Otisak za izradu radnih modela uzet je adicionim silikonima (A silicone impression material-elite HD+, ZHERMACK), primenom jednofazne tehnike otiskivanja. Radni modeli izliveni su od gipsa (CAM STONE M, Siladent). Isti gipsani model skeniran je pomoću InEos i Cerec Scan skenera.

Tehničke karakteristike Cerec®3D sistema pružaju mogućnost da postupci kompjuterskog dizajniranja i mašinske izrade nadoknada budu

2. Group 2 – 15 crowns made by the extraoral optical surface scanning technique and

3. Group 3 – 15 crowns made by the extraoral optical point scanning technique.

The control groups consisted of 15 metal-ceramic crowns made by conventional methodology (IPS InLine, A3, Ivoclar Vivadent).

Within the research, acryl teeth were used (DSP-model teeth, No. 11 KaVo, Germany), which for the needs of grinding and impression were set in an operating model (KaVo, basic study model). The teeth where prepared for a crowns according to the following protocols of the Cerec® system: rounded shoulder (1.00 mm), inclination of the axial walls 6° and occlusal reduction of 1.5 mm. From the axial surfaces 1 – 1.5 mm of tooth substance was removed.[8]

By application of this methodology, 15 acrylc teeth were prepared to act as a master preparation.

Experimental samples were made, with the aid of selected scanning techniques.

The scanning of work models was performed by three scanners of the Cerec®3D system:

1. Intraoral scanner (Cerec, Sirona) – intraoral optical surface scanning technique;

2. InEos scanner (Cerec, Sirona) – extraoral optical surface scanning technique and

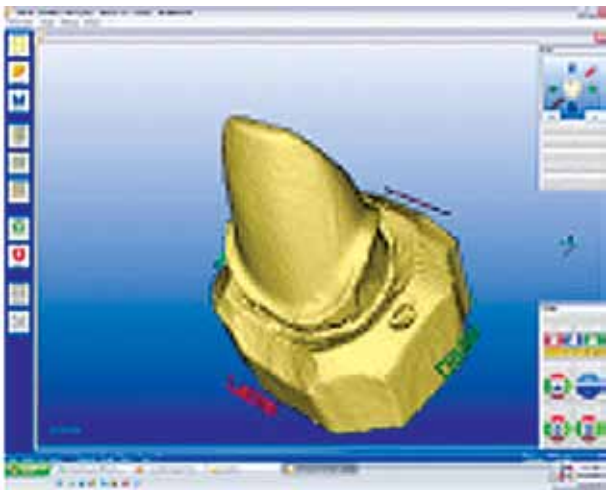
3. Cerec Scan laser point scanner integrated in the milling machine (Cerec, Sirona) – extraoral optical point scanning technique.

Intraoral scanning methods comprised application of titanium dioxide powder (CEREC® - powder, VITA, Bad Sackingen, Germany) on the tooth model (Figure 1).

Extraoral scanning methods needs the casting of a plaster model. Impressions were taken from the acrylc master die using a monophase technique (A-silicone impression material - elite HD+, ZHERMACK). The working models were cast from plaster (CAM STONE M, Siladent). The same plaster model was scanned by Cerec Scan and InEos scanner.

The technical characteristics of the Cerec®3D system offer the possibility to make the identical procedures of computer design and

Slika 1. Radni model sa aplikovanim prahom.
Figure 1. Powdered plaster model



Slika 2. Virtuelni radni model
Figure 2. Virtual plaster model

identični za sve načine 3D skeniranja. Kompjutersko dizajniranje vršeno je u Cerec®3D softveru, verzija 3,10, (Slika 2). Predviđena debljina prostora za cementni film determinisana je u sistemskom softveru i iznosila je 0µ.

Mašinska izrada kruna izvedena je u Cerec in Lab numerički upravljanoj glodalici. U postupku izrade nadoknada svake eksperimentalne grupe upotrebljeni su novi boreri. Za izradu kruna svih eksperimentalnih grupa upotrebljeni su blokovi od alumina keramike (Vita Mark II, A3, Vita).

Da bi mogli da se podvrgnu merenju svi uzorci morali su da zadovolje propisane kriterijume koji determinišu podobnost nadoknada za cementiranje (Ryge i Sayder). [9]

Priprema eksperimentalnih uzoraka za merenje podrazumevala je fiksiranje za osnovni model na osnovu koga su izrađeni eksperimentalni uzorci. Na pripremljenim uzorcima determinisano je 12 mernih tačaka.

Merenje rubnog zaptivanja vršeno je pomoću skenirajućeg elektronskog mikroskopa JOEL JSM-5800-SCANNING MICROSKOP, sa uveličanjem 100 x. Merenja su obuhvatala skeniranje uzoraka na determinisanim mernim tačkama i kvantifikaciju veličine diskrepance između krune i demarkacije preparacije. Za obradu skeniranih slika upotrebljen je program Image pro 40. Statistička analiza dobijenih rezultata obavljena ja pomoću statističkog programskog paketa SPSS (SPSS 17.0 za Windows , SPSS Inc., 2005).

Rezultati

U svih 12 tačaka najveće vrednosti rubnog zaptivanja izmerene su u kontrolnoj grupi kru-

mechanical manufacturing for all 3D scanning methods. The Cerec®3D software (v. 3.10.) was use for designing of the restoration (Figure 2). The luting space was set to 0µm.

The mechanical manufacturing of restorations was conducted on the *Cerec in Lab* unit. A new set of miling burs was used for each experimental group. In manufacturing of crowns all experimental groups blocks of alumina ceramics were used (Vita Mark II, A3, Vita).

Optimum fit was definided according to the criteria set by Ryge and Snyder.[9]

The preparation of experimental samples for measurement included the fixing on the acrylc master die of which the experimental samples were made. On the prepared samples, measuring 12 points were determined.

The measuring of the marginal adaptation was conducted by the scanning electron microscope JOEL JSM-5800-SCANNING MICROSCOPE, at 100 x magificatoin. The measurements comprised the scanning of samples on determined measuring points and the quantification of the discrepancy size between the restoration and the preparation demarcation. For the processing of the scanned images, the program Image pro 40 was used.

The statistical analysis of the obtained results were performed using in *SPSS* (SPSS 17.0 for Windows, SPSS Inc., 2005).

Results

In all 12 points, the lowest values of the marginal gap were measured in the group of

na, a najmanje u grupi kruna ekstraoralnog skeniranja (Tabela 1).

Analizom prosečnih vrednosti rubnog zaptivanja u 12 tačaka dobijeno je da:

- prosečne vrednosti rubnog zaptivanja kruna tačkastog skeniranja bile su statistički značajno veće od vrednosti izmerenih kod kruna intra- (p=0,001) i ekstraoralnog (p=0,000) skeniranja i nisu se statistički značajno razlikovale od vrednosti u kontrolnoj grupi (p=0,333);

- između kruna intra- i ekstraoralnog skeniranja (p=0,214) nije uočena statistički značajna razlika u prosečnim vrednostima rubnog zaptivanja, dok su u grupi kruna intraoralnog skeniranja vrednosti ovog parametra bile statistički značajno manje od vrednosti u kontrolnoj grupi (p=0,000);

- vrednosti rubnog zaptivanja u grupi kruna ekstraoralnog skeniranja bile su statistički značajno manje od vrednosti u kontrolnoj grupi (p=0,000), (Tabele 2 i 3).

Diskusija

Ova studija zasnovana je na hipotezi da postoji razlika u preciznosti keramičkih kruna izrađenih primenom tri različita metoda skeniranja Cerec®3D sistema. Definisanje ovakve radne hipoteze imalo je za cilj da utvrdi stepen preciznosti nadoknada koji će biti i jedan od indirektanih pokazatelja preciznosti primenjenog metoda skeniranja. Uticaj CAD i CAM segmenta na preciznost nadoknada nije zanemaren, ali su standardizacijom postupka greške ovih segmenata svedene na minimum.

U postupku izrade fiksnih zubnih nadoknada primenom Cerec®3D CAD/CAM sistema prisutno je mnoštvo faktora koji utiču na njihovu preciznost. Prvi segment u postupku izrade je prostorna digitalizacija modela, na čiju preciznost utiču neki od sledećih parametara: način prikupljanja skeniranih podataka, vrsta kamere za optičko skeniranje, klinički parametri (skoro 100% vlažnost vazduha u usnoj duplji, prisustvo pljuvačke, pokreti pacijenta i ruke terapeuta za vreme skeniranja), upotreba praha, udaljenost kamere od objekta koji se skenira, veličina triangulacionog ugla, preciznost i tačnost skenera isl. [10,11,12,13]

Neki autori u svojim istraživanjima ističu da determinisana debljina za cementni film od 10 do 50μ omogućava bolju marginalnu adaptaciju nadoknada izrađenih Cerec®3D sistemom.[14]

crowns obtained by extraoral surface scanning (Table 1).

The analysis of average values of the marginal adaptation on 12 points showed following:

- in the group of extraoral point scanning the values of marginal gap were statistically considerably higher than the values measured in the group of intra- (p=0,001) and extraoral scanning (p=0,000), between the crowns of extraoral point scanning and control group not observed statistically significant difference (p=0,333), (Table 2).

- between the crowns of intra- and extraoral scanning (p=0,214) not observed statistically significant difference in the average values of marginal gap, in the group of intraoral scanning values of marginal gap were statistically significantly lower in comparison with values in the control group (p=0,000).

- the values of marginal adaptation in the group of extraoral scanning were statistically significantly lower in comparison with the control group(p=0,000), (Table 2 i 3).

Discussion

The study was based on the hypothesis that there is a difference in precision of ceramic crowns made by three different optical scanning methods of the Cerec®3D system. The definition of such operating hypothesis had the goal to determine the degree of precision of restorations which would be an indirect indicator of precision of the applied scanning method. The impact of the CAD and CAM segment on the precision of restorations was not neglected, but was reduced to a minimum by the standardization of the error procedure of these segments.

In the procedure of making of fixed tooth restoration by application of the Cerec®3D CAD/CAM system, many factors are present which influence their precision. The first segment in the procedure of making is the spatial model digitalization, the precision of which is influenced by some of the following parameters: mode of collection of scanned data, type of camera for optical scanning, clinical parameters (almost 100% air humidity in the mouth cavity, presence of saliva, movements of the patient and therapist's hands during the scanning), use of powder, distance of the camera from the scanned object, size of the triangulation angle, precision of the scanner, and similar. [10,11,12,13]

Tabela 1. Izmerene vrednosti marginalnog zjapa (μm)
Table 1. Measured values of marginal gap (μm)

Marginalni zjap (X±SD) Marginal gap (X±SD)					
Posmatrana tačka Point of measurment	Posmatrane grupe Observed groups				Značajnost* Probability*
	Tačkasto skeniranje The point scanning	Intraoralno skeniranje The intraoral scanning	Ekstraoralno skeniranje The extraoral scanning	Kontrolna grupa The control group	
1. tačka 1. point	109,42±49,10	57,16±32,86	35,45±14,54	143,13±79,51	p=0,000¶
2. tačka 2. point	104,14±35,92	55,48±32,68	35,39±14,88	142,33±81,47	p=0,000¶
3. tačka 3. point	112,49±52,10	50,45±32,97	37,38±19,33	135,55±84,44	p=0,000¶
4. tačka 4. point	109,17±40,25	48,21±32,85	35,74±19,08	118,63±61,62	p=0,000¶
5. tačka 5. point	103,32±37,41	49,29±43,39	30,81±17,86	126,53±59,18	p=0,000¶
6. tačka 6. point	105,23±47,46	55,27±46,71	26,25±10,98	128,22±63,14	p=0,000¶
7. tačka 7. point	106,19±38,94	52,76±35,97	27,15±9,58	127,85±69,41	p=0,000¶
8. tačka 8. point	91,29±28,55	52,85±40,87	29,22±17,72	135,39±63,76	p=0,001¶
9. tačka 9. point	87,53±23,83	44,13±34,88	30,31±15,67	141,95±69,06	p=0,000¶
10. tačka 10. point	95,81±40,16	47,61±37,88	30,94±11,36	129,66±48,98	p=0,000¶
11. tačka 11. point	103,75±42,62	42,35±21,23	29,38±11,93	130,87±31,03	p=0,000¶
12. tačaka 12. point	102,63±47,20	47,69±21,82	31,67±12,91	134,87+37,75	p=0,000¶
Prosek Average value	102,58±31,23	50,27±31,50	31,64±9,45	132,92±53,21	p=0,000¶

*Jednofaktorska analiza varijanse; ¶Statistički značajna razlika
*Monofactorial analysis of variance; ¶Statistically significant difference

Rezultati našeg istraživanja pokazuju da su vrednosti rubnog zaptivanja kruna izrađenih primenom tehnike intraoralnog optičkog površinskog skeniranja u proseku 50,27±31,50μ. Ako uzmemo u obzir činjenicu da je determinisana dimenzija prostora za cementni film iznosila 0μ, i da su u postupku skeniranja eliminisani faktori koji su prisutni u usnoj duplji u toku skeniranja možemo da pretpostavimo da je jedan od mogućih razloga za ovo odstupanje aplikacija praha. Aplikacija praha ili adekvatnih zamena za prah dovodi do toga da se ne skenira direktno površina zuba. Prah i u najtanjem mogućem

Some authors stress in their research that the determined thickness for the cement film from 10 to 50 μ allows a better marginal adaptation of restorations made by the Cerec®3D system.[14] The results of our research show that the values of the marginal adaptation of crowns made by application of the intraoral optical surface scanning technique are on average 50,27±31,50μ. If we take into account the fact that the determined dimension of space for the cement film totalled 0 μ and that in the scanning procedure factors were eliminated that were present in the mouth cavity during the scanning, we can surmise that

Tabela 2. Prosečna vrednosti marginalnog zjapa u µm
Table 2. Average value of marginal gap in µm

Grup Groups	$\overline{X}$	Med	SD	min	max	95%CI
KT	102,58	96,40	31,23	68,50	132,67	85,29-119,88
KI	50,27	39,80	31,50	23,83	132,67	32,83-67,72
KE	31,64	33,54	9,45	17,10	55,32	26,41-36,87
KK	132,92	122,77	53,21	64,58	259,33	103,45-162,38

KT- tačkasto skeniranje; KI-intraoralno skeniranje; KE-ekstraoralno skeniranje; KK- kontrola grupa. $\overline{X}$ -aritmetička sredina; Med-medijana;SD-standardna devijacija; min-minimalna vrednost; max-maksimalna vrednost; 95%CI-95% interval poverenja.

KT- poin scanning; KI- intraoral scenning; KE-extraoral scanning; KK- control group; X- mean value; Med- mediana; SD- standard deviation; min- minimal value; max- maximal value; 95%CI-95% confidence interval.

Tabela 3. Rezultati međugrupnog poređenja
Table 3. Results of comparasion between groups

Tačka merenja Observed ponit	Posmatrane grupe kruna Observed group crowns	Test Test	Značajnost Probability
Prosečna vrednost rubnog zaptivanja Average value (marginal gap size)	KT-KI	Dunnett T3	p=0,001
	KT-KE	Dunnett T3	p=0,000
	KT-KK	Dunnett T3	p=0,333
	KI-KE	Dunnett T3	p=0,214
	KI-KK	Dunnett T3	p=0,000
	KE-KK	Dunnett T3	p=0,000

KT- krune tačkastog skeniranja, KI-krune intraoralnog skeniranja, KE- krune ekstraoralnog skeniranja, KK- kontrolna grupa.
KT- crowns (poin scanning); KI- crowns (intraoral scenning); KE- crowns (extraoral scanning); KK- control group;

sloju ima debljinu od 13-85µ.[15] Prevelika količina praha može da kompromituje preciznost skeniranja, jer se dimenzije i oblik izvorne površine menjaju. Stoga možemo konstatovati da veština terepeuta u nanošenju praha može značajno da utiče na preciznost skeniranih podataka, samim tim i na preciznost nadoknade.

Za razliku od ekstraoralnih metoda skeniranja Cerec®3D sistema, greške koje su posledica konvencionalnog otiskivanja i izrade radnog modela nisu prisutne u postupku primene intraoralnog optičkog površinskog skeniranja.

one of the possible reasons for such a deviation is the application of powder. The application of powder or of adequate powder restorations leads to the circumstance that the tooth surface is not scanned directly. The powder, even in the thinnest layer, leads to a precision error from 13 to 85 µ.[15] A too big quantity of powder compromises the scanning precision, as the dimensions and the form of the source surface are changed. Thus we can state that the therapist's skill of powder application significantly influences the precision of scanned data.

Ograničene mogućnosti intraoralnih metoda kompenzuje primena ekstraoralnih metoda skeniranja. Primena ekstraoralnih metoda zahteva konvencionalno otiskivanje i izradu radnih modela. Ove postupke prate problemi vezani za trodimenzionalne promene i dimenzionalnu stabilnost stomatoloških materijala.[16]

Rezultati nekih istraživanja pokazuju da odabrani postupci digitalizacije na različite načine utiču na preciznost i da je najvaća devijacija skeniranih podataka u zonama zuba koje naglo menjaju zakrivljenost, što se odnosi i na demarkaciju. U proseku, ukupna odstupanja u preciznosti između modela i gotove nadoknade izrađene CAD/CAM tehnologijama iznose od 50-75 μ, što potvrđuji i rezultati ovog istraživanja (Tabela 1).[17,18]

Izmerene vrednosti rubnog zaptivanja kruna izrađenih primenom tehnike ekstraoralnog površinskog skeniranja pokazuju najviši nivo preciznosti (31,64±9,45μ). Ovakav rezultat je mogući indirektni pokazatelj stepena preciznosti samog metoda skeniranja. Rezultati nekih *in vitro* istraživanja prikazuju veću preciznost fiksnih nadoknada izrađenih primenom ekstraoralnih metoda skeniranja u poređenju sa nadoknadama izrađenim primenom intraoralnih metoda skeniranja Cerec®3D sistema. Kao moguće razloge za ovakvu razliku autori navode različitu metodologiju postupaka digitalizacije modela kao i činjenicu da su dimenzionalne promene otisnih materijala u kliničkim uslovima znatno veće od dimenzionalnih promena u *in vitro* uslovima.[19] Između kruna koje su izrađene primenom intraoralnog i ekstraoralnog optičkog površinskog skeniranja nije postojala statistički značajna razlika u izmerenim vrednostima, što ukazuje na činjenicu da obe vrste kruna poseduju visok i klinički prihvatljiv stepen preciznosti.

Činjenica da ne postoji statistički značajna razlika u vrednostima rubnog zaptivanja između kruna tačkastog skeniranja i kontrolne grupe kruna ukazuje na to da se ukupna greška koje nastaje u postupku tačkastog skeniranja ne razlikuju bitno od ukupne greške konvencionalne tehnike izrade.

Praktična iskustva pokazuju da je poželjno da u toku postupka prostorne digitalizacije skener i model miruju, što je karakteristika većine ekstraoralnih optičkih skenera, međutim skeniranje pomoću Cerec Scan skenera zahteva da se model pomera, što može da utiče na preciznost

Errors which are the result of the conventional impression and making of the working model are not present in the procedure of application of the intraoral optical surface scanning.

The limited possibilities of intraoral methods are compensated by the application of extraoral scanning methods. The application of extraoral methods requires a conventional impression and making of working models. These procedures are accompanied by problems in connection with three-dimensional changes and dimensional stability of dental materials.[16]

The results of some research show that the selected digitalization procedures influence the precision in different ways and that the biggest deviation of scanned data is in tooth zones which suddenly change their curve, which also refers to demarcation. On average, total deviations in the precision between models and the ready restoration made by CAD/CAM technologies total 50-75 μ, which has been confirmed in this experiment (Tables 1). [17,18]

The measured values of marginal adaptation of crowns made by application of the extraoral surface scanning technique have the lowest value of marginal adaptation (31,64±9,45μ). Such a result is an indirect indicator of the precision degree of the scanning method itself. The results of some in vitro research show a higher precision of fixed restorations made by extraoral scanning methods in comparison with restorations made by intraoral scanning methods of the Cerec®3D system. As possible reasons for such a difference, the authors state a different methodology of model digitalization procedures, as well as the fact that dimensional changes of impression materials in clinical conditions are considerable bigger than dimensional changes *in vitro* conditions.[19] Between crowns made by application of intraoral and extraoral optical surface scanning, there was no statistically important difference in measured values of marginal adaptation. That show their high and clinically acceptable degree of precision.

The fact that there is no statistically important difference in values of marginal adaptation between crowns made by the point scanning technique and the control group shows that the total error which occurs in the point scanning procedure does not significantly differ from the total error of the conventional technique of making.

Practical experiences show that it is desirable that during the procedure of spatial digitalization the scanner and the model are at rest, which is a feature of most extraoral optical scanners; however, scanning with a Cerec Scan

skeniranih podataka.[20] Rezultati ovog eksperimenta pokazuju da tehnika ekstraoralnog tačkastog skenitanje pokazuje najniži nivo ptreciznosti u postupku izrade keramičkih kruna.

Prisusutvo statistički značajne razlike između izmerenih vrednosti rubnog zaptivanja u grupama kruna izrađenih primenom intraoralnog optičkog skeniranje i kruna izrađenih konvencionalnom medodologijom (p=0,000) pokazuje da tehnika intraoralnog optičkog skeniranja omogućava izradu nadoknada veće preciznosti u poređenju sa konvencionalnim načinom izrade. Razlog za ovakve rezultate treba tražiti u različitim tehnologijama izrade nadoknada.

Zaključak

Rezultati istraživanja objektivno potvrđuju radnu hipotezu da postoji razlika u preciznosti keramičkih kruna izrađenih primenom različitih metoda skeniranja Cerec®3D CAD/CAM sistema. Krune izrađene primenom intraoralnih i ekstraoralnih optičkih površinskih metoda skeniranja Cerec 3D sistema poseduju visok i klinički prihvatljiv stepena preciznosti.

Zahvalnost

Autori izražavaju zahvalnost Mili Simonović za pruženu pomoć u realizaciji ovog eksperimenta.

scanner requires that the model moves, which can influence the precision of scanned data.[20] The results of this experiment show that the technique of extraoral point scanning has the lowest level of precision in the procedure of making of cerramic crowns.

The presence of statistically significant difference between measured values of marginal adaptation of restorations made by application of intraoral optical scanning and restorations made by the conventional methodology (p=0.000) confirm the theses which stress that intraoral optical scanning techniques make possible the making of restorations with higher precision in comparison with the conventional way of making. The reason for such results should be searched in different technologies of making restorations.

Conclusion

the research results objectively confirm the operating hypothesis that there is a difference in precision of ceranic crowns made by Cerec®3D CAD/CAM system. The crowns made by intraoral and extraoral optical surface scanning methods of Cerec®3D system have high and clinically acceptable level of accuracy.

Acknowledgments

The authors would like to thank Mila Simonović for her help in realizing this study.

LITERATURA / REFERENCES

1. Lutard R, Weber A, Rudolph H, Schone C, Quaas S, Walter M. Design and production of dental prosthetic restorations: basic research on dental CAD/CAM technology. Int J Comput Dent 2002;5:165-176.

2. Tan P, Gratton D, Diaz-Arnold A, Holmes D. An in vitro comparsion of vertical marginal gaps of CAD/CAM titanium and conventional casr restorations. J Prosthodont 2008;17:378-383.

3. Luthardt RG, Bornemann G, Lemelson S, Walter MH, Hüls A. An innovative method for evaluation of the 3-D internal fit of CAD/CAM crowns fabricated after direct optical versus indirect laser scan digitizing. Int J Prosthodont 2004;17(6):680-685.

4. Rekow D. Computer aided design and manufacturing in dentistry: A revew of tere state of art. J Prostehet Dent 1987;58:512-516.

5. Becker J. CAD/CAM in Dentistry. Part I. ZWR 1996;105:119-125. (In Germany)

6. Schug J, Pfeiffer J, Sener B, Mörmann WH. Grinding precision and accuracy of the fit of Cerec-2 CAD/CIM–inlays. Schweiz Monatsschr Zahnmed 1995;105(7):913-919. (In Germany)

7. Arnetzl G, Pongratz D. Miling precision and fitting accuracy of Cerec Scan milled restorations. Int J Comput Dent 2005;8:273-281.

8. Wolfart S., Wegner S.M., Al-Halabu A., Kern M., Clinical evelauation of marginal fit of new experimental all-ceramic system before and cementaton, Int J Prosthodont 2003;16: 587-592.

9. Ryge G, Snyder M. Evaluating the clinical quality of restorations. J Am Dent Assoc 1973; 87:369-377.

10. Luthard RG, Koch R, Rudolph H, Walter MH. Qualitative computer aided evaluation of dental impressions in vivo. Dent Mater 2006;22:69-76.

11. Wang CJ, Millstein P, Nathannson D. Effects of cement, cement space, marginal design, setting aid materials, and setting force on crown cementation. Int J Prosthodont 2003; 16:587-592.

12. Wiedhahn K. The optical Cerec Impression-Electronic Model Produtcion. Int J Comput Dent 1998;1:41-54.

13. Todorović A., Primena CAD/CAM tehnologija u stomatološkoj protetici, 2005.

14. Nakamura T, Dei N, Kojima T,Wakabayashi K. Marginal and internal fit of Cerec 3CAD/CAM all-ceramic crowns. Int J Prosthodont 2003; 16:244-248.

15. Mörmann WH, Lutz F. Optimization of the powder application in the Cerec method with environment-friendly propellant systems. Schweizer Monatsschrift Zahnmedizin 1990; 100:1462-1468.

16. Price RB, Gerrow JD, Sutow EJ, MacSween R. The dimensional accuracy of 12 impression material and die stone combinations. Int J Prosthodont 1991;4:169-174.

17. Van der zel JM. Ceramic-fused-to-metal restorations whit a new CAD/CAM system. Quintessence 1993; 24(11):769-778.

18. Van der zel JM, Vlaar ST, De Ruiter WJ, Davidson C. The CICERO system for CAD/CAM fabrication of full-ceramic crowns. J Prosth Dent 2001;85:261-267.

19. Luthardt RG, Loos R, Quaas S. Accuracy of intraoral data acquisition in comparison to the conventional impression. Int J Comput Dent 2005; 8:283-294.

20. Persson A,Andersson M,Oden A,Sandborgh-Englund G. A three-dimensional evaluation of laser scaner and a touch-probe scanner. J Prosthet Dent 2006;95(3):194-200.

Adresa za korespondenciju:
Assis Mr sci stom Dr Branka Trifković,
specijalista stomatološke protetike
Stomatološki fakultet,
Klinika za stomatološku protetiku
Rankeova 4, 11000 Beograd
tel: 064 267 15 75
e-mail: brankatr@yahoo.com

Address of correspondence:
Branka Trifković, DDS, MSD, PhD student.
Faculty of dentistry,
Clinic for prosthetic dentistry
Rankeova 4, 11000 Beograd
tel: 064 267 15 75
e-mail: brankatr@yahoo.com