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Učinak optičkog kondicioniranja preparacije sprejem za skeniranje na oblik preparacije

The Effect of Optical Conditioning of Preparations with Scan Spray on Preparation Form

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Sažetak

Svrha rada: Za primjenu sustava CAD/CAM u ordinacijama dentalne medicine potrebno je odabrati sprej za skeniranje. Njegovom primjenom mijenja se prekrivena preparacija, što može nepovoljno utjecati na rubno zatvaranje i interno prianjanje restauracije. Zadaća ovog istraživanja bila je odrediti utjecaj spreja na preparacijsku formu procjenom morfologije i debljine triju različitih sprejeva za skeniranje. **Materijali i metode:** Određivala se površinska morfologija prekrivanja triju (A, B, C) različitih sprejeva za skeniranje uz pomoć konfokalnoga laserskog mikroskopa. Debljina sprejem nanesenog premaza mjerila se na staklenoj pločici i u simuliranim kliničkim uvjetima profilometrom i uređajem za digitalizaciju površine. Podaci su analizirani jednosmjernim testom ANOVA ($\alpha = .05$). **Rezultati:** Konfokalni laserski mikroskop prikazao je grubu i nepravilnu sprejem pokrivenu površinu nakon uporabe svih sprejeva, te se od spreja A preko spreja B do spreja C broj malih zrnaca povećavao. Srednja debljina prekrivanja na staklenoj pločici iznosila je za sprej A 25,3 Mm, za B 18,9 Mm i za C 19,2 Mm. Statistički značajne razlike bile su između sprejeva A i B (p=0,017). U simuliranim kliničkim uvjetima srednja debljina prekrivanja iznosila je za sprej A 15,5 Mm, za B 15,0 Mm i za C 13,3 Mm. Razlika je bila statistički značajna samo između sprejeva A i C (p=0,033). **Zaključak:** Premazi nakon korištenja različitih sprejeva imali su drugačije površinske morfologije i različite debljine. Posljedično tome primjena spreja za skeniranje utječe i na konačnu CAD/CAM restauraciju, premda se kliničkim korištenjem postigla prihvatljiva debljina prekrivanja.

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Ključne riječi
računalom vođeno oblikovanje; računalna simulacija; mikroskopija, konfokalna; tehnike odlijevanja, stomatološke; tehnike uzimanja otiska, stomatološke

Uvod

Bezmetalne keramičke restauracije sve su zanimljivije i traženije na tržištu (1). U mnogobrojnim ispitivanjima *in vitro*, ali i u kliničkim testiranjima (2–17) pokazale su veliku izdržljivost i izvrsnu estetiku. Tehnologijom CAD/CAM liječnici se sve češće koriste za postavljanje restauracija uz pomoć optičkoga i mehaničkog skeniranja zubnih površina, a skeniranje u stomatološkom stolcu može dati bolje rezultate u rubnom i unutarnjem prianjanju (9). Sustavi CAD/CAM za korištenje na stomatološkom stolcu pogodni su samo za opakne površine (18–22). Kod njih je prijeko potrebno prekrivanje zuba titanijevim dioksidom. Kod standardnih sustava sprejem se na zub nanosi tanji sloj titanijeva dioksida, negoli u slučaju sustava s prahom (19). Sustavi sa sprejem mogu djelovati na morfologiju površine zuba. Nekoliko čimbenika može utjecati na ravnomjerno raspoređivanje premaza – način korištenja spreja, dinamika nanošenja i različita morfološka svojstva površine (23). Nakupljanje titanijeva dioksida u kutovima i zaobljavanje preparacije su očiti. Te ne-

Introduction

All ceramic dental restorations are a rapidly increasing market (1). In numerous *in vitro* studies and clinical trials (2-17), they proved durability combined with excellent aesthetics. The CAD/CAM technology is increasingly used for setting up restorations together with optical or mechanical scanning of tooth surfaces, whereas chairside tooth scanning by optical techniques may achieve better internal and marginal accuracy (9). However, CAD/CAM systems which are used chairside, are suited only for opaque surfaces (18-22). Therefore, coating of teeth with titanium dioxide is necessary. For this reason, spray systems are the standard and deposit thinner layers of titanium dioxide on tooth surfaces than powder systems (19). Scan spray, however, may affect tooth surface morphology. Several factors affect uniform distribution of the coatings, such as the user´s handling, the spray dynamic of the spray system and the different morphological surface properties (23). Accumulation of titanium dioxide in corners and a rounding of preparations are evident.

točne površinske koordinate podaci su koji se unose u optički skener te utječu na unutarnju točnost i unutarnje prianjanje restauracije, ali i na klinički rezultat (7, 23, 24, 25). To je važan čimbenik jer je rubna točnost nužna za prevenciju rekurentnog karijesa i parodontnih bolesti (26, 27), a precizno unutarnje prianjanje i homogeni sloj cementa sprječavaju slabljenje keramike (28, 29). Ustanovljeno je da su rubna i unutarnja točnost važni za rekonstrukciju i dugotrajnost restauracije izrađene sustavom CAD/CAM. Nažalost, literatura je zasad oskudna – objavljeno je samo nekoliko istraživanja o debljini premaza sprejem za skeniranje (19, 22). Svrha ovog istraživanja bila je analizirati površinsku morfologiju i debljinu premaza dobivenog korištenjem bijelog spreja s konvencionalnim i nedavno razvijenim pumpnim injektorom, te plavog spreja također s pumpnim injektorom, no u različitim uvjetima (staklena ploča i simulirani klinički uvjeti). Nulta hipoteza bila je da ne postoje razlike između površinske morfologije i debljine prekrivanja ispitivanih sprejeva za skeniranje.

Materijali i metode

Bijeli sprej (Scanspray plus, Dentaco, Bad Homburg, Njemačka) ispitivan je s konvencionalnim pumpnim injektorom (sprej A) i nedavno razvijenom injektorskom pumpom (sprej B). Plavi sprej (Bluespray, Dentaco, Bad Homburg, Njemačka) analiziran je samo s tek razvijenom injektorskom pumpom (sprej C). Sprejevima za skeniranje koristilo se u skladu s uputama proizvođača.

Površinska morfologija

Ispitivale su se morfologije površina svih sprejeva za skeniranje. To je učinjeno CLSM (*Confocal laser scanning microscopy)* mikroskopom (Leica TCS SP2, 50x/0,8 NA, Mannheim, Njemačka) opremljenim laserom (valne duljine 633 nm). Rezultati konfokalnih optičkih rezova prikupljeni su programskim paketom *LSM image browser* kao nizovi slika te su složene 3D topografske vizualizacije (Slike 3.–5a.) te 2D maksimalne projekcije (Slike 3. –5b.). Skenovi su u 8-bitnom obliku i rezoluciji 512 s 512 piksela. Za sve su se slike rabile standardne postavke za kontrast, svjetlost i snagu lasera (30).

Debljina prekrivanja na ravnoj površini

Najprije se procjenjivala debljina prekrivanja na staklenoj pločici. Zbog toga je bila prekrivena plastičnom folijom, ali s neprekrivenim područjem u sredini od jednog četvornog centimetra, a zatim je cijela poprskana sprejem za skeniranje. Kad je skinuta plastična folija, *profilometrom* (Perthometer, Perthen GmbH, Göttingen, Njemačka) je ocijenjena hrapavost površine po središnjoj crti (31). Za određivanje debljine prekrivanja izračunate su najbliže crte prekrivenog područja i površinski profil te lijevo i desno prilegnute površine stakla (Slika 1). Nakon mjerenja staklena pločica je temeljito očišćena te se postupak ponavljao šest puta za svaki sprej.

Since the inaccurate surface coordinates become input data for the optical scans, they affect the internal and marginal fit of restorations, and accordingly, the clinical outcome (7, 23, 24, 25). This is an important factor because the marginal accuracy is important for avoiding recurrent caries and periodontal disease (26, 27), while a precise internal fit and a homogeneous cement layer prevent weakening of the ceramic (28, 29). Hence, the marginal and internal accuracy are important for reconstructions with an adequate lifetime for CAD/CAM manufactured restorations. However, there are only a few published studies which evaluate the thicknesses of scan spray coatings (19, 22). The aim of this study was to analyze the surface morphologies and the coating thicknesses induced by a white scan spray with a conventional and a recently developed pump injector, and a blue scan spray with the recently developed pump injector under different conditions (glass plate and simulated clinical conditions). The null hypotheses were that there are differences between surface morphologies and coating thicknesses of the investigated scan sprays.

Materials and Methods

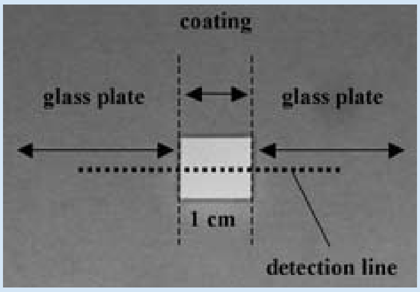
A white scan spray (Scanspray plus, Dentaco, Bad Homburg, Germany) was tested by a conventional pump injector (spray A) and a recently developed pump injector (spray B). A blue scan spray (Bluespray, Dentaco, Bad Homburg, Germany) was only tested by the recently developed pump injector (spray C). The scan sprays were used according to the manufacturers` instructions.

Surface morphology

The surface morphologies of the scan sprays of all sprays were evaluated. For this purpose, a CLSM (*Confocal laser scanning microscopy)* microscope (Leica TCS SP2, 50x/0,8 NA, Mannheim, Germany) equipped with a laser (wavelength 633 nm) was used. The resulting sets of confocal optical sections were collected by LSM image browser software as stacks of images and 3D topological visualization (Fig. 3 - 5 a) and 2 D maximum projection (Fig. 3 - 5 b) were obtained. Scans were taken in 8 bits at a resolution of 512 by 512 pixels. Standard settings for contrast, brightness and laser power were used for all images (30).

Coating thicknesses on planar surface

First, coating thicknesses were evaluated on a glass plate. For this purpose, a glass plate was laminated with a plastic foil keeping open a central square area of 1 cm^2, and sprayed with scan spray. After removing the plastic foil, the surface roughness along the midline was evaluated by a profilometer (Perthometer, Perthen GmbH, Göttingen, Germany) (31). To detect the coating thickness, best fit lines of the coated region`s surface profiles and the proximate left and right glass plate regions were calculated (Fig. 1). Following this, the glass plate was cleaned; this procedure was repeated sixteen times for all sprays.



Slika 1. Staklena pločica s kvadratnim područjem prekrivenim bijelim sprejem nanesenim s tek razvijenim pumpnim injektorom (sprej B).
Figure 1 Glass plate with a square region coated by white scan spray applied with the recently developed pump injector (spray B).

Debljine prekrivanja u simuliranim kliničkim uvjetima

Kako bi se procijenila debljina prekrivanja u simuliranim kliničkim uvjetima, uporabljena je bila glava lutke i model maksile. Na modelu maksile preparirana je zaobljena stepenica na zubu 25, umjetni zubi postavljeni su od zuba 17 do 24 te od LEGO-gipsa zub 26. On je služio za optimizaciju procesa prianjanja (32). Prvo je digitalizirana nepokrivena preparacija u maksilarnoj regiji drugoga lijevog pretkutnjaka i zub od LEGO-gipsa u regiji maksilarnoga prvog lijevog kutnjaka. Nakon toga je model površine izračunat metodom triangulacije, kombinirajući točke točkastih oblaka koji su predstavljali referentni model CAD (CRM) (Slika 2.). Za taj postupak bio je odabran uređaj za digitalizaciju površine (Dentascope, 3D Alliance, Bischoffen, Njemačka). Prije prekrivanja sprejem "champfer" preparacije drugoga lijevog maksilarnog pretkutnjaka, na ostatke gipsanog modela postavljena je folija za crtanje, tako da se sprejem za skeniranje prekrila samo preparacija. Nakon što je model maksile uklopljen u lutku, preparacija u maksili poprskana je sprejem, a folija za crtanje maknuta te su digitalizirani prvi lijevi maksilarni pretkutnjak, s preparacijom zaobljene stepenice i LEGO-gipsani zub. Točkasti klasteri i triangulirani model površine ponovno su izračunati, a za svaki sprej postupak se ponavljao sedam puta. Triangulirani modeli površine za svaku sprejem prekrivenu preparaciju upareni su i uspoređeni s modelom CRM uz pomoć programskih algoritama (XOV, INUS Technology, Seul, Južna Koreja) korištenjem funkcije "best–fit alignment". Maksimalni otklon bio je postavljen na 0,2 milimetra, iteracija je bila namještena tako da se zaustavi kada srednja vrijednost pogreške dosegne 0,001 milimetar. Računala se najkraća udaljenost od svake točke triangulirane površine za svaki sprejem prekriveni model u odnosu prema trianguliranoj površini modela CRM. Za tu funkciju koristili smo se postavkom „all deviation" programskog paketa XOV. Uparene površine preparacija podijeljene su u cervikalni, središnji i površinski dio u odnosu prema vertikalnoj dimenziji, zatim na bukalnu, distalnu, palatinalnu i mezijalnu stranu te okluzalnu površinu u odnosu prema horizontalnoj dimenziji. Kako bi se dobila kvantitativna analiza, izabrano je pet mjernih točaka u svakom odabranom području.

Statistička analiza

Podaci su uneseni u statistički program (SPSS 17,0, Muenchen, Njemačka). Za testiranje statistički značajne razlike među ispitanim sprejevima odabrana je jednosmjerna analiza varijance (ANOVA). Alfa-razina postavljena je na 0,05 posto te je primijenjena Bonferronijeva prilagodba.

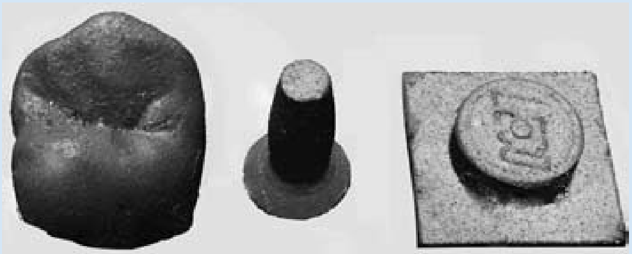
Coating thicknesses under simulated clinical conditions

A dummy head and a dental maxilla cast were used to evaluate the coating thicknesses under simulated clinical conditions. The maxilla cast exhibited a chamfer preparation in region of tooth 25, artificial teeth from tooth 17 to tooth 24 and a LEGO stone in region of tooth 26, which was used to optimize the fitting process (32). First, the unsprayed preparation in region of the maxillary left second premolar and the fixed LEGO stone in region of the maxillary left first molar, were digitized. Afterwards, a surface model was calculated by triangulation method combining the points of the point cloud, which represented the CAD reference model (CRM) (Fig. 2). For this purpose, a surface digitalization device (Dentascope, 3D Alliance, Bischoffen, Germany) was used.

Before the chamfer preparation in region of the maxillary left second premolar was sprayed, the remaining parts of the cast were covered by a deep drawing foil so that the preparation only could be covered with scan spray. Afterwards, the maxilla cast was incorporated into the dummy head. Having sprayed the preparation, the maxilla cast and the deep drawing foil were removed and the tooth in the region of the maxillary left first premolar, the chamfer preparation and the LEGO stone were digitized. The point cloud and triangulated surface model were subsequently calculated again. The procedure was performed sevenfold for each spray. Afterwards, the triangulated surface model of each sprayed preparation was matched with the CRM by software algorithms (XOV, INUS Technology, Seoul, Korea), using the feature "best-fit alignment". The maximum deviation was set to 0.2 mm and the iteration was set to stop when the mean error value reached 0.001 mm. The shortest distances from each point of the triangulated surface of each sprayed model to the points of the triangulated surface of the CRM were calculated. For this purpose, the feature "all deviation" of XOV software was used. Then, the matched surfaces of the preparations were separated into a cervical, median and topmost region with regard to the vertical dimension, and a buccal, distal, palatinal, mesial and occlusal region with regard to the horizontal dimension. In order to make a quantitative analysis, five measuring points in each region were chosen.

Statistical Analysis

Data were imported into a statistical program (SPSS 17.0, Munich, Germany). A 1-way analysis of variance (ANOVA) was used to detect significant differences between the sprays. The alpha level was set at .05% and the Bonferroni adjustment was used.



Slika 2. Triangulirana CAD površina – referentni model (CRM) s umjetnim zubom u području 24, zaobljena stepenica u području 25 te LEGO-kamen u području 26.
Figure 2 Triangulated surface CAD reference model (CRM) with artificial tooth in region 24, the chamfer preparation in region 25 and the LEGO stone in region 26.

Rezultati

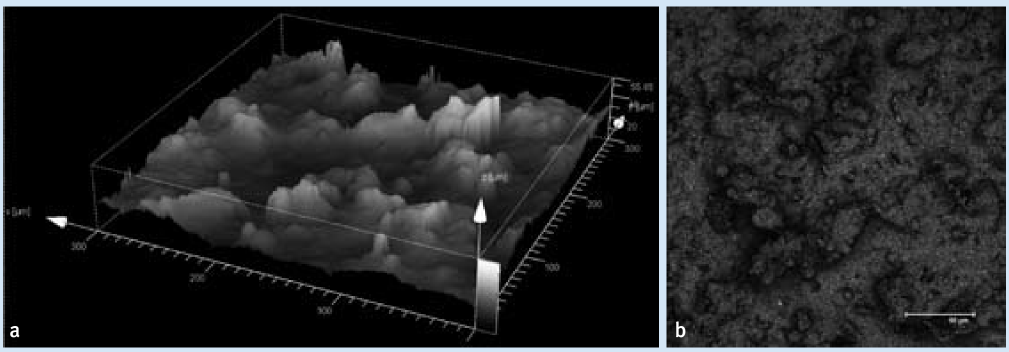
Sprej A

3D topografska vizualizacija predstavlja grubu i nepravilno oblikovanu površinu premaza (slika 3 a.). Maksimalna projekcija 2D pokazuje heterogenu površinu samo s nekoliko malih čestica spreja u području prekrivanja (slika 3 b.).

Results

Spray A

The 3 D topological visualization presents a rough and irregular formed coating surface (Fig. 3 a). The 2 D maximum projection exhibits also a heterogeneous shaped surface with only a few small spray particles within the coating zone (Fig. 3 b).



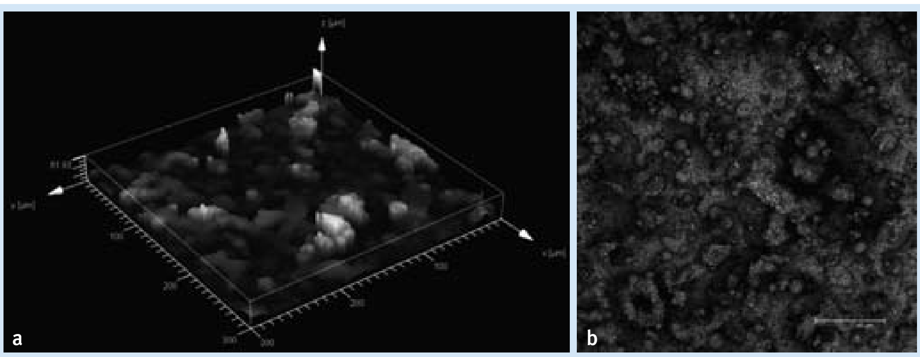
Slika 3. Morfologija površine prekrivene sprejem A (3D topografska vizualizacija (a), 2 D maksimalna projekcija (b)).
Figure 3 Surface morphology within the spray coating of spray A (3D topological visualization a), 2 D maximum projection b)).

Sprej B

Sprej B, kao i sprej A, pokazuje u 3D topografskoj vizualizaciji nepravilnu morfologiju (slika 4a.). U maksimalnoj projekciji 2D uočava se heterogenija morfologija površine s većim brojem malih čestica u odnosu prema spreju A (slika 4 b.).

Spray B

The spray B shows in the 3D topological visualization as well as the spray A an irregular shaped morphology (Fig. 4 a). However, the 2 D maximum projection exhibits a more heterogeneous shaped surface morphology with an increasing number of small particles compared to spray A (Fig. 4 b).



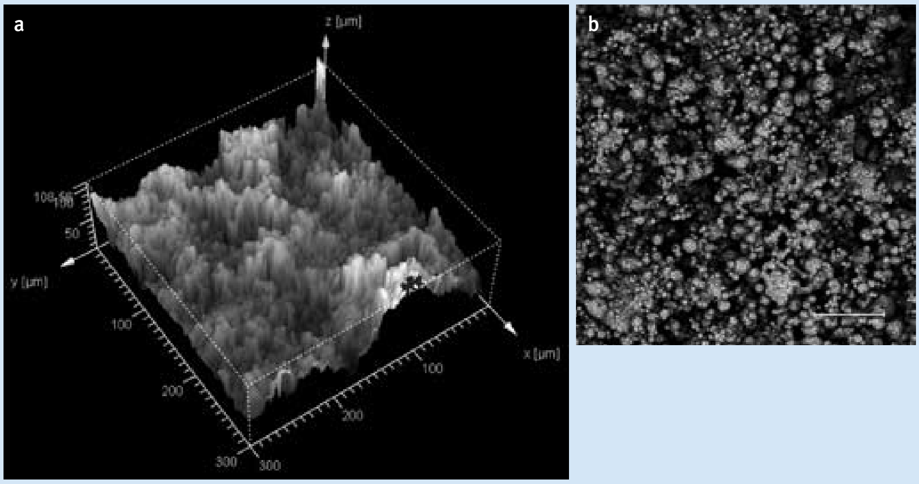
Slika 4. Morfologija površine prekrivene sprejem B (3D topografska vizualizacija (a), 2 D maksimalna projekcija (b)).
Figure 4 Surface morphology within the spray coating of spray B (3D topological visualization a), 2 D maximum projection b)).

Sprej C

Sprej C proizveo je, u usporedbi sa sprejevima A i B, u topografskoj vizualizaciji 3D heterogeniju površinu (slika 5a). U maksimalnoj projekciji 2D uočava se najviše malih čestica spreja u odnosu na sprejeve A i B (slika 5b.)

Spray C

In the 3D topological visualization, the spray C shows, compared to spray A and B, a more heterogeneous shaped surface (Fig. 5 a). The 2 D maximum projection clearly presents more small spray particles than spray A and B (Fig. 5 b).



Slika 5. Morfologija površine prekrivene sprejem C (3D topografska vizualizacija (a), 2 D maksimalna projekcija (b)).
Figure 5 Surface morphology within the spray coating of spray C (3D topological visualization a), 2 D maximum projection b)).

Debljina prekrivanja na ravnoj površini

Na staklenoj površini srednja debljina prekrivanja za sprej A iznosila je 25,3 µm, što je statistički značajna razlika (P = 0,017) u odnosu prema srednjoj debljini prekrivanja spreja B od 18,9 µm. Srednja debljina prekrivanja za sprej C bila je 19,2 µm (Tablica 1.).

Coating thicknesses on planar surface

On the glass plate, the mean coating thickness of 25.3 µm for spray A differs significantly (P = .017) from the mean coating thickness of spray B with 18.9 µm. The mean coating thickness of spray C was 19.2 µm (Table 1).

Tablica 1. Debljina prekrivanja na staklenoj pločici [Mm] za pojedine sprejeve za skeniranje
Table 1 Coating thicknesses on the glass plate [Mm] of scan sprays.

Sprej • Spray	n	Arit. sredina • Mean	SD	Min	Max
A	16	25.3	6.3	15.5	38.6
B	16	18.9	5.4	12.4	32.6
C	16	19.2	6.8	8.8	35.1

Debljina prekrivanja u simuliranim kliničkim uvjetima

Sprej A stvorio je srednju debljinu prekrivanja od 15,5 µm, sprej B 15,0µm te sprej C 13,µm (Tablica 2). ANOVA je upozorila na statistički značajne razlike samo između sprejeva A i C (p =0,033).

Coating thicknesses under simulated clinical conditions

The spray A showed a mean coating thickness of 15.5 µm, spray B showed 15.0 µm and spray C 13.3 µm (Table 2). The ANOVA indicated significant differences only between spray A and spray C (p = .033).

Tablica 2. Dentascope: debljina prekrivanja [Mm] u simuliranim kliničkim uvjetima za ispitivane sustave spreja za skeniranje
Table 2 Dentascope: Coating thicknesses [Mm] under simulated clinical conditions of scan spray systems.

Sprej • Spray	n	Arit. sredina • Mean	SD	Min	Max
A	260	15.5	7.2	0	40.5
B	260	15.0	5.9	0	62.2
C	260	13.3	6.6	0	55.7

Rasprava

Konfokalni laserski mikroskop (CLSM) uporabljen je zato što se njime može nedestruktivno procijeniti što je u namazu stvoreno sprejem. U ovom kontekstu, za razliku od optičkog mikroskopa, ta metoda otkriva mikrostrukture i trodimenzionalni prostorni raspored. Omogućuje izradu presjeka kroz premaz i, uz pomoć kompjutorske obrade podataka, stvaranje 3D prikaza iz mnogobrojnih pojedinačnih presjeka prema z-osovini ili kvantitativnom gradijentu površine (30). Za ocjenu hrapavosti koristili smo se profilometrom (31). Odabrali smo ga za procjenu debljine prekrivanja glatkih površina, ali za procjenu debljine prekrivanja slobodnih nepravilnih površina nije bio pogodan. Za slobodne nepravilne površine koristili smo se uređajem za 3D digitalizaciju. Uparivanjem trianguliranih točaka i izračunavanjem njihovih udaljenosti može se točno izračunati debljinu prekrivanja. Razlika u morfologiji površine u premazu prikazana 3D topografskom vizualizacijom (Slike 3–5a) i 2D projekcijom maksimuma (Slike 3–5b) može se pripisati vrsti pumpnog injektora. U skladu s tim pronađen je povećan broj malih čestica spreja kada se rabio tek razvijeni pumpni injektor (Slike 5a., b.). Male dimenzije čestica spreja vjerojatno omogućuju tanji sloj prekrivanja površine preparacije, a u skladu s tim ustanovljena je veća debljina prekrivanja kada je korištena konvencionalna injektorska pumpa. Činjenica je da primjena spreja za skeniranje utječe na preciznost konačne CAD/CAM restauracije. Izmjerene debljine prekrivanja malo su varirale i slažu se s rezultatima ostalih istraživanja (2, 32). Ograničenja u ovom istraživanju, kao u svim istraživanjima *in vitro*, bila su u tome da se nisu mogli potpuno simulirati svi uvjeti *in vivo* i prema tome nisu se mogli ekstrapolirati neposredno na kliničke situacije. Zbog toga su potrebna daljnja klinička istraživanja kako bi se procijenio učinak optičkoga kondicioniranja preparacije uz pomoć spreja za skeniranje na oblik preparacije, točnije na nakupljanje titanijeva dioksida u kutovima i posljedično na zaokruživanje preparacije. U skladu s ograničenjima u ovom istraživanju, dobiveni podaci podupiru našu nultu hipotezu o morfologiji površine i debljini prekrivanja ispitivanih sprejeva za skeniranje.

Zaključak

Prekrivanjem odabranim sprejevima postigle su se različite morfologije površina. Debljine tako nanesenih premaza za testirane sprejeve u prihvatljivim su kliničkim rasponima, utjecaj na oblik preparacije zadovoljava te su pogodni za kliničku primjenu.

Mogući sukob interesa

Nema ni financijskih ni bilo kakvih drugih sukoba interesa jer ni jedna organizacija nije financirala pisanje ovog članka.

Discussion

Confocal laser scanning microscopy (CLSM) was used because a non-destructive evaluation of IZ formation of spray coating is possible. In this context, and in contrast to light-optical microscopy, this method represents microstructures in all three spatial dimensions. It is thus possible to make optical cross-sections through the coating and, with the help of computer-assisted data processing, three-dimensional images from numerous individual cross-sections along the z-axis or the surface's quantitative structural gradient can be received (30). A profilometer is commonly used to define the roughness of surfaces (31). However, we used optical profilometry to evaluate the coating thicknesses on planar surfaces. This method permits an evaluation of coating thicknesses on a planar surface, but not on free formed surfaces. For this purpose, a 3D surface digitalization device was used. Matching of triangulated surfaces and calculation of distances between correlated points allows an accurate determination of coating thicknesses. The differences of surface morphology within the coating shown by the images of 3D topological visualization (Fig. 3 – 5 a) and 2 D maximum projection (Fig. 3 – 5 b) could be induced by the type of pump injector. In this way, an increasing number of small spray particles could be detected, when the newly developed pump injector was used (Fig. 5 a, b). The small size of spray particles probably permits the application of a reduced coating thickness. Thus, the increased thicknesses of coatings could be explained when the conventional pump injector was used. Consequently, it is a fact that the application of scan sprays influences the precision of the final CAD/CAM restorations. However, the detected coating thicknesses were in a small range and comparable to other study results (2, 32). A limitation of this study, as with any *in vitro* study, is that it could not simulate *in vivo* conditions completely and therefore cannot be extrapolated to the clinical situation. Further clinical research must evaluate the effect of optical conditioning of preparations with scan spray on preparation form, in particular the accumulation of titanium dioxide in corners and the rounding of preparations. Within the limitations of this study, these results partially support our null hypotheses of this study concerning the surface morphology and the coating thicknesses of the investigated scan sprays.

Conclusions

The coatings of the used scan sprays showed different surface morphologies. However, the coating thicknesses of the tested scan sprays were in an acceptable clinical range; and the effects on preparation form of the investigated scan sprays are satisfactory for clinical use.

Competing interests

There are not any financial or non-financial competing interests. There is no organization financing this manuscript.

Abstract

Objective: CAD/CAM systems require scan spray for chairside sampling of tooth surfaces. However, this leads to alterations of the sprayed preparation and may affect marginal and internal adaptation of the restoration. The aim of this study was to define the effect of scan spray on preparation form by evaluating the morphologies and the thicknesses of three different scan sprays. **Materials and Methods:** The surface morphology of the coatings of different scan sprays (A, B, C) was evaluated by use of a *confocal laser scanning* microscope. The thicknesses of spray coatings were measured on a glass plate as well as under simulated clinical conditions using a profilometer and a surface digitalisation device. The data were analysed by a 1-way ANOVA ($\alpha = .05$). **Results:** The confocal laser scanning microscopy showed rough and irregular formed coating surfaces of all sprays, whereas an increasing numbers of small spray particles were seen from spray A over spray B to spray C. Mean coating thicknesses on the glass plate were: spray A 25.3 Mm, spray B 18.9 Mm and spray C 19.2 Mm. Significant differences were detected between spray A and B (P = .017). Under simulated clinical conditions median coating thicknesses were: spray A 15.5 Mm, spray B 15.0 Mm and spray C 13.3 Mm. A statistically significant difference could be detected only between spray A and C (P = .033). **Conclusions:** The coatings of the used scan spray systems showed different surface morphologies and exhibited different thicknesses. Consequently, the application of scan sprays affects the precision of the final CAD/CAM restorations. However, the scan sprays under investigation showed acceptable coating thicknesses for clinical use.

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Key words
Computer-Aided Design; Computer simulation; Microscopy, Confocal; cad/cam; dental casting technique; dental impression technique

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