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Evaluation of Different Methods of Optical Impression Making on the Marginal Gap of Onlays Created with CEREC 3D

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Clinical Relevance

The marginal gap of ceramic onlays manufactured by Cerec 3D present a similar marginal gap whether the optical impression is taken intraorally using the Cerec powder or extraorally using a stone model.

SUMMARY

Objectives: This study evaluated the marginal gaps on several surfaces of onlays created with the Cerec 3D system using one intraoral and two extraoral optical impression methods. Methods: A human molar (#19) was mounted with its adjacent teeth on a typodont (Frasaco) and prepared for a MODL onlay. The typodont was assembled in the mannequin head in order to simulate clinical conditions. The same operator took 36 individual optical impressions using a CEREC 3D camera. For group 1 (IP), a thin layer of titanium dioxide powder (CEREC powder-VITA) was applied directly onto the surface of the preparation for imaging (n=12). For group 2 (EP), a sectional impression was taken with hydrocolloid Identic Syringable (Dux Dental), a die made with polyvinylsiloxane KwikkModel Scan (R-dental Dentalerzeugnisse GmbH) and powdered with titanium dioxide for imaging (n=12). For group 3 (ES), a sectional impression was taken with PVS and a sectional stock tray, a die fabricated in stone (Diamond die- HI-TEC Dental Products) and the die being imaged without powdering

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(n=12). One operator designed and machined the onlays in VitaBlocks Mark II for Cerec (VITA) using a CEREC 3D. The marginal gaps (µm) were measured with an optical microscope (50x) at 12 points, three on each surface of the MODL. The results were analyzed by two-way ANOVA/ Tukey's (p=0.05). Results: The overall mean marginal gaps (µm) for the three methods were: IP=111.6 (± 34.0); EP=161.4 (± 37.6) and ES=116.8 (± 42.3). IP and ES were equal, but both were significantly less than EP. The pooled mean marginal gaps (µm) for the occlusal = 110.5 (± 39) and lingual = 111.5 (± 30.5) surfaces were equivalent and significantly less than the distal = 136.5 (± 42.5) and mesial = 161.1 (± 43.3). Conclusion: The marginal gap of CEREC 3D onlay restorations was not different when the optical impression was taken intraorally vs extraorally using a stone cast that does not require powdering. The lingual and occlusal surfaces showed the lowest gaps.

INTRODUCTION

The first Cerec (Sirona Dental Systems, Bensheim, Germany) was introduced in 1984 as a computer-assisted design/computer-assisted manufacturing (CAD/CAM) system designed for the fabrication of indirect dental restorations.[1-3] Since its introduction, the Cerec system has undergone several technical modifications. The first generation system, Cerec 1, was designed for chairside fabrication of intracoronal restorations, such as inlays, onlays and/or veneers. In 1994, the Cerec 2 system was introduced with redesigned software and hardware to fabricate not only intracoronal restorations but also complete crowns.[3-4] In 2000, the Cerec 3 system was introduced to the dental profession and featured several improvements over the Cerec 2 system, including an enhanced intraoral optical camera capable of reproducing finer detail and depth of scale and improved software capable of more rapid recording of the preparation.[4-5] Additionally, the Cerec 3 system allows for more flexible and better true-to-detail grinding than the Cerec 2 system, which, in turn, should lead to a better fitting crown with improved occlusal morphology and design.[3-4] The Cerec 3D software was built on the existing Cerec 3 hardware platform, with new design tools and features added, making it easier to operate, design and visualize the restoration.[6]

Although the accuracy of adaptation to the cavity preparation of Cerec indirect restorations has been improved with modifications to the Cerec system, concerns still exist. The possible sources of dimensional error include imaging powder application,[7] camera misalignment and accuracy of the intraoral optical impression.[8] One way to overcome the problem of making optical impressions intraorally is by making a conventional impression, then producing a cast from which the optical impression can be made on the bench top. Prior to the introduction of Diamond die (HI-TEC Dental Products, Greenback, TN, USA), the cast needed to be powdered in order to be readable by the machine. This new stone is readable by the camera without powdering.

Recently, an extraoral model material for powderless optical impressions with CEREC Dental Systems, KwikkModel SCAN (R-dental Dentalerzeugnisse GmbH–Hamburg, Germany) was launched on the market. This material produces a die in less than five minutes, which does not require powdering; therefore, eliminating the problem of the intraoral powder application and the potential inaccuracy of the intraoral optical impression. However, the marginal accuracy of these different methods has not been compared.

The current study evaluated the marginal gap on several surfaces of Cerec 3D onlay restorations when using three methods of optical impressioning: one intraoral with tooth powder application and two extra oral using impression and cast materials.

The null hypothesis to be tested was that the onlay marginal gap would be similar, regardless of whether the impression was taken intraorally or extraorally, and the marginal gaps would be similar on every area evaluated.

METHODS AND MATERIALS

A human molar (#19) was mounted with its adjacent natural teeth on a typodont (Frasaco, Postfach, Tettnang, Germany) in a manikin head (Frasaco) and prepared for a MODL onlay with the following characteristics: occlusal reduction of ML (mesial-lingual) cusp: 2.0 mm, isthmus width of occlusal box: 3 mm, DL shoulder: 1.0-mm thick, pulpal floor depth: 2.0 mm from the cavosurface margin, axial wall of mesial: 1.5 mm, gingival floor width: 1.5 mm mesiodistally (Figure 1). The cavity preparation was free from undercuts, the internal line angles were rounded and the walls were tapered 6-8 degrees to the occlusal. The margins were prepared with 90-degree cavosurface angles for resistance of the ceramic. One experienced operator made the optical impressions and designed the restorations. After the pilot study, the sample size was determined using the ANOVA sample size test (α=0.05) and 12 optical impressions and restorations were fabricated per group for the study.

For group 1 (IP), a thin layer of titanium dioxide powder (Cerec powder; VITA-Zahnfabrik, Bad Säckingen, Germany) using an aerosol (ProCAD spray; Ivoclar Vivadent, Schaan, Liechtenstein) was applied onto the surface of the preparation, adjacent teeth and adjoining soft tissues to create a uniformly reflective surface.

Figure 1: *MODL onlay preparation.*

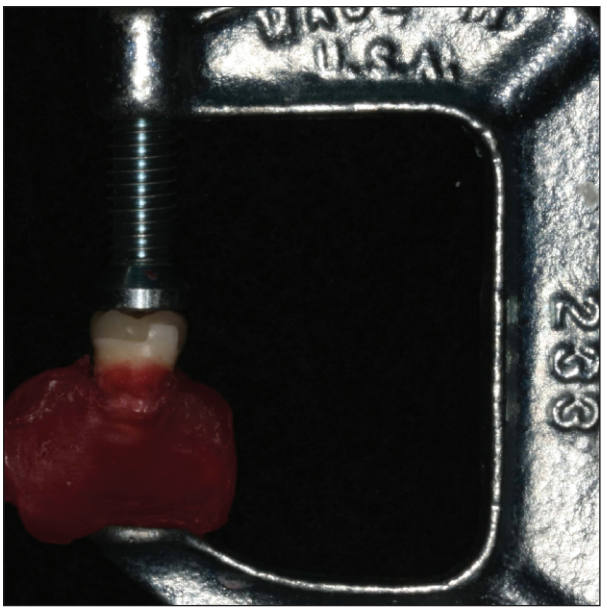

Figure 2: *Tooth and onlay positioned in the C-clamp.*

The camera of the CEREC 3D system was positioned over the cavity preparation in the path of insertion of the planned restoration and the optical image was taken. The camera projects an infrared grid onto the field of view to record the dimensions of the cavity preparation. The camera's field of view must have a uniform reflective surface to accurately record the height values of the cavity preparation. These procedures were done in the simulation clinic and, in order to simulate clinical conditions, the typodont was assembled in the mannequin head.

For group 2 (EP), the same operator made a sectional impression of the onlay preparation with hydrocolloid material (Identic Syringable; Dux Dental, Oxnard, CA, USA). Twelve different impressions and dies were made. The die was made using a polyvinylsiloxane material (KwikkModel Scan; R-dental Dentalerzeugnisse GmbH) and removed from the impression within five minutes. Though this silicone material does not require powdering, it was not possible to make high quality optical impressions without powdering. Without the powder application, the computer could not clearly read the image, resulting in a rough surface and model distortion. Therefore, the silicone dies were powdered with a thin layer of titanium dioxide powder. The operator made the extra-oral optical impression using the CEREC 3D system.

For group 3 (ES), a sectional impression was made with PVS (Aquasil medium body, Dentsply Caulk, York, PA, USA) and a sectional stock tray. Twelve different impressions and dies were made. The PVS material was used for this group, since it is the most common impression material used for making impressions of tooth preparations. The PVS material was not used for group 2, because the die was fabricated with KwikkModel Scan, which is a polyvinylsiloxane material; therefore, the die could not be separated from the impression. A cast was fabricated in stone (Diamond die; HI-TEC Dental Products) and it was imaged without powdering (n=12). One operator designed and machined the onlays in VitaBlocks Mark II for Cerec (Vita) using the CEREC 3D system. The luting space and adhesive gap were set at 50 µm.

The prepared tooth was taken off the Typodont model, and each restoration was fitted, adjusted with a diamond bur in order to achieve the best seating possible, and its position was carefully maintained for the marginal gap measurements by securing with a C-Clamp (Figure 2).[9] Boxing wax was placed around the roots of the tooth to stabilize its placement on the clamp and clamp movement was prevented by using a little PVS material under the clamp.

The marginal gaps were measured by one operator under an optical microscope visually at 50x magnification at 12 points, three on each surface of the MODL onlay (Figures 3 and 4).

Statistical Analyses

The results were analyzed by two-way analysis of variance (ANOVA) and Tukey's test ($p<0.05$) for the three different impressions and four surfaces (MODL).

RESULTS

The overall mean marginal gaps (µm) for the three methods were: IP=111.6(± 34.0); EP=161.4(± 37.6) and ES=116.8(± 42.3). IP and ES marginal gaps were equal, and both were significantly less than EP (Table 1).

There was no significant interaction between the method of impression and tooth surface. The pooled

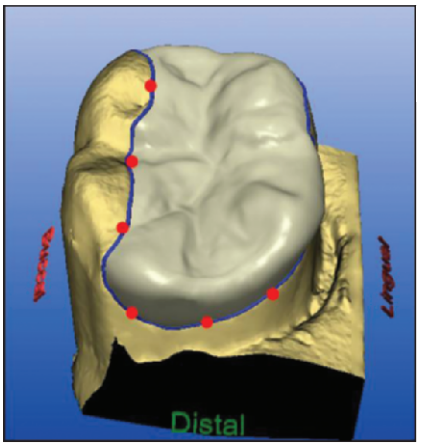

Figure 3: *Screenshot (distal view). The red dots represent the points of measurement on occlusal and distal surfaces.*

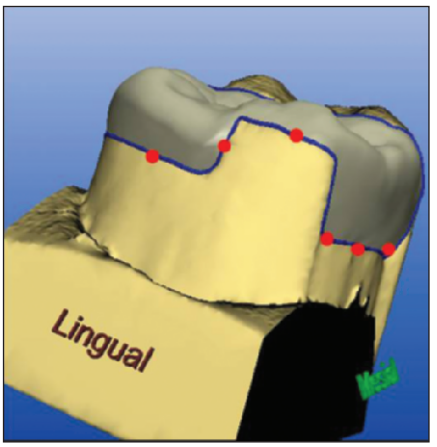

Figure 4: *Screenshot (lingual view). The red dots represent the points of measurement on lingual and mesial surfaces.*

mean marginal gaps (µm) for the occlusal=110.5(± 39) and lingual=111.5(± 30.5) surfaces were not significantly different and were significantly less than the distal=136.5(± 42.5) and mesial=161.1(± 43.3) (Table 2).

DISCUSSION

All ceramic restorations are recommended as an alternative to conventional metal ceramic restorations.[10-13] In addition to fracture resistance and esthetics, marginal fit is one of the most important criteria for the long-term success of all ceramic crowns.[14] *In vivo* studies have provided evidence that a large marginal discrepancy in a fixed restoration correlates with a higher plaque index and reduced periodontal conditions.[15-18] Therefore, achieving a gap width below 100 µm is desirable and considered clinically acceptable.[19] Some studies evaluated the marginal gap of Cerec 3[20-23] and Cerec 3D[24-25] restorations, and the mean marginal gaps varied widely. These variations may be due to different measurement techniques, the type of restoration (crowns,[21-22,24] inlays[20] or onlays[24-25]) and the restorative material (ceramic[20-21,23-25] or resin[22]). In order to make a fair comparison between the current study and other studies, only the two studies that evaluated the marginal gap of ceramic onlay restorations manufactured by Cerec 3 and 3D were included. The selected studies showed different marginal gap results for MOD onlay restorations made from Cerec 3 and Cerec 3D systems, 201.3 µm (± 78 µm)[23] and 70 µm (± 32 µm),[25] respectively. The current study showed average marginal gaps above the 100 µm threshold, whereas the IP and ES groups showed results very close to the clinically acceptable value, 111.6 µm and 116.78 µm, respectively. Evaluation of the marginal discrepancy among the studies was probably due to the method of gap measurements, location and quantity of measurements. Wang and others[23] evaluated the cement lute space thickness of the cerec onlays using Image Analysis Software at 44 paired points. Nine paired points were measured on each BL-D, BL-M and MD section and 17 paired points were measured on the BL-I section. Reich and others[25] evaluated the marginal gap of die replicas of the onlay placed on each preparation under SEM at 11 landmarks. Three points were measured on the occlusal, three points on the mesial, three points on the lingual and two points on the distal surface.

The null hypothesis that the onlay marginal gaps would be similar, regardless of whether the impression was taken intraorally or extraorally, was partially proved. There was no significant difference in the onlay

Table 1: *Results of the Mean Marginal Gap, Standard Deviation (SD) of the Impression Methods Evaluated at Each Surface and Overall Mean Marginal Gap and SD of Each Impression Method*

Impression	Onlay Surface	Mean Marginal Gap (µm)	SD	Overall Mean Marginal Gap	SD
IP	Occlusal	91	19.71	111.6[a]	34
	Lingual	92	20.74		
	Mesial	147.5	25.88		
	Distal	116.2	33.67		
EP	Occlusal	145	31.013	161.4[b]	37.6
	Lingual	134.83	19.21		
	Mesial	190.55	43.40		
	Distal	176.11	23.67		
ES	Occlusal	96.36	40.44	116.8[a]	42.3
	Lingual	107.77	33.51		
	Mesial	145.33	42		
	Distal	117.27	41.22		

Values with the same superscript letter are not significantly different.

margins when comparing groups IP and ES. The marginal gap was not significantly different when the optical impression was taken intraorally using the Cerec powder or extraorally using the stone die. Neither positioning of the camera in the simulator nor the powder application interfered with the marginal adaptation when compared to the extraoral and powderless optical impression.

Table 2: *Pooled Mean Marginal Gap at Each Surface and Standard Deviation (SD) of All Impression Methods*

Onlay Surface	Mean Marginal Gap (μm)	SD
Occlusal	110.5[a]	39
Lingual	111.5[a]	30.5
Mesial	161.12[c]	42.5
Distal	136.52[b]	43.3

Values with the same superscript letter are not significantly different.

One study evaluated the marginal gap of inlays produced with the Cerec 2 instrument using a stereoscopic microscope after each preparation had been coated with imaging powder applied with an aerosol, imaging powder applied with air from a dental unit and a water-soluble paint applied with a brush. The inlays fabricated on the two powder surfaces were not significantly different, but the painted surfaces were found to result in a significantly better-fitting inlay.[7] In the current study, the greatest marginal gap was shown when the optical impression was taken extraorally and the model was fabricated with polyvinylsiloxane KwikkModel Scan material. According to the manufacturer, this material does not require powdering; nonetheless, the Cerec camera could not capture the image adequately. Therefore, in order to capture the image, the authors of the current study applied the Vita powder to the PVS model. The results showed that this method was not as accurate as the others, likely due to poorer imaging quality. When time does not permit powdering of the tooth, or if there is difficulty in applying powder due to a lack of ideal isolation or depth of the preparation, a regular impression of the tooth could be taken and a stone cast could be made with Diamond die. The onlay should be tried-in and cemented at a second office visit. The null hypothesis that the marginal gaps would be similar on every area evaluated was rejected. Only the mean marginal gaps of the occlusal and lingual surfaces were not significantly different. The lingual and occlusal surfaces showed the lowest marginal gaps, probably because they are the most accessible areas of the tooth preparation to be read by the machine. The mesial and distal areas showed the greatest marginal gaps, the mesial being the greatest. In contrast to these results, Reich and others did not report any difference in marginal gap among the occlusal, lingual and proximal surfaces when evaluating the MODL marginal gap of Cerec 3D onlays. Moreover, they showed no significant difference in marginal gap between Cerec 3D onlays and IPS Empress onlay restorations.

This *in-vitro* study tried to simulate clinical conditions as realistically as possible. The prepared tooth was a natural human molar and the preparation design followed the Cerec 3D manual guidelines. The occlusal outline form was smooth and flowing; the internal walls had a single path of insertion with a 6˚-8˚ taper; the internal walls of the cavity preparation were well defined and smooth and the rounded shoulder margins were at least 1-mm thick. The preparation, powder application and optical impression were done with the typodont assembled in the mannequin head, simulating clinical conditions as close as possible. When impressioning was used, it also was accomplished in the mannequin's head. All the materials were used according to the manufacturer's instructions.

CONCLUSIONS

Within the limitations of the current study, the marginal gap of Cerec 3D onlay restorations was not different when the optical impression was taken intraorally vs extraorally using a stone cast that does not require powdering. The lingual and occlusal surfaces showed the lowest marginal gaps.

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