Original Article

Effect of Scanner Type on Marginal Adaptation of e.max CAD Crowns

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Abstract

Background and Aim: Marginal adaptation has a significant role in the success and longevity of indirect restorations. This experimental study compared the effect of intraoral and extraoral scanning on the marginal adaptation of the crowns which was made using the CEREC AC system.

Materials and Methods: A Typodont maxillary first molar was prepared and served as the master die for an all-ceramic restoration. In the first group, the model was scanned ten times directly by the intraoral scanner. In the second group, ten conventional impressions were made from Typodont, and the extraoral scanner scanned the resulting gypsum casts. The data was used to design and build crowns from IPS e.max CAD blocks. The crowns were placed on the prepared tooth, and the marginal gap was measured at 16 points by a stereomicroscope at ×35 magnification. Collected data were analyzed using t-test.

Results: The mean marginal gap for intraoral and extraoral groups were 74.83 ± 10.07 μm and 102.56 ± 6.89 μm respectively. The gap was significantly less in the intraoral group (P-value = 0.001).

Conclusion: Marginal adaptation was clinically acceptable in both groups, although the results of intraoral scanning showed significantly lower gap than extraoral scanning.

Key Words: Computer aided design/computer aided manufacturing, all-ceramic crowns, intraoral scanners, extraoral scanners, Dental Marginal Adaptation

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Introduction

Dental treatments based on all-ceramic restorations have increased in recent years due to the rise of esthetic demands, the exceptional ability of all-ceramics to match the color of natural teeth and their high tissue biocompatibility [1]. All-ceramic restorations are made by various techniques such as sintering, casting, slip casting, heat-pressing, and computer-aided design/computer-aided manufacturing [2]. Unlike feldspathic porcelains and glass ceramics, strong zirconium oxide restorations are exclusively manufactured by CAD/CAM technology [3]. The use of this technique is rising dramatically in recent years [4] because of the advantages like reduced risk of distortion during laboratory steps, better patient acceptance, and comfort, cost and time efficiency [5-7].

Three main steps of workflow in CAM/CAM systems are making digital impressions by direct scanning of dental and oral tissues or by indirect scanning of their stone cast, designing, and

manufacturing of the restoration [3,5,6].
There are two types of dental scanners: extraoral and intraoral; extraoral scanners are used in laboratories to scan stone casts [3]. Intraoral scanners are used for direct scanning of patient's dental arch, implant scan bodies, and oral tissues. Their use eliminates the need for conventional impression making, hence the potential risk of patient discomfort, gaging and unpleasant taste [8]. However, dimensional changes of impression materials, separation of impression material from the tray, need for disinfection of impression, distortion of tray or cast could be disadvantages of extraoral scanning methods [7,8]. Also, in the intraoral scanning method, there would be no need to block out severe undercuts on the unprepared teeth or between them [9]. Intraoral scanning makes a real-time evaluation of preparation and instant communication with laboratory possible [7].
However, saliva, blood, and any moisture contamination alongside the movement of patient and dentist, restricted space in the oral cavity, and smaller measuring area might negatively influence the quality of intraoral scanning [10].
In extraoral scanning, either the impression or the stone model of the dental arch is scanned [8,11]. The limitations of this method include patient discomfort if the impression has to be remade, distortion of impression material and dimensional changes of both impression material and the resultant cast [10].
Marginal adaptation is a prerequisite for success and longevity of any indirect restoration. Lack of marginal adaptation, in the long term, causes plaque accumulation and periodontal disease, as well as cement dissolution, and ultimately secondary caries [12,13]. Different factors might affect the fit of the restoration including the ceramic type and the CAD/CAM technique [14]. However, some factors are considered independent of the technique or material used to prepare final restoration, including tooth preparation design, adjustment of the intaglio surface of the restoration, and the cementation process [13].
Different studies have investigated the accuracy of intraoral and extraoral scanning methods by comparing the trueness and precision of the scanners [3,6,7,11,15]. However, a few studies concerned the effect of scanner type on the marginal adaptation of the CAD/CAM made crowns [9,14]. In these studies, scanners from different companies were used.
The aim of the present study was to compare the effect of data digitizing with intraoral or extraoral scanners on the marginal adaptation of CAD/CAM made crowns. CEREC (Dentsply Sirona Dental Systems, LLC, Charlotte, NC) is among a few systems which can produce a 3D model of dentition, with the same digitization technology, from the inside of the mouth by the dentist or the cast in the laboratory. The null hypothesis was the type of scanner has no effect on the marginal adaptation of the restorations.

Materials and Methods

In order to closely simulate clinical conditions, maxillary right first molar of a Typodont (Nissin, Dental Products Inc., Japan), mounted on a phantom head, prepared for a full ceramic crown by a prosthodontist. After placing depth-orientation grooves, the occlusal surface was reduced 2mm on the functional cusps and 1.5mm on the nonfunctional cusps. With a flat end tapered diamond bur (846 0.12, D+Z Diamant GmbH, Drendel+Zweiling, Berlin, Germany) axial surfaces were reduced to 1.5mm with 6° to 8° taper. Supragingival rounded shoulder finish line, 1mm deep, was formed and all the line angles were rounded (Figure 1).

Figure 1. The prepared tooth

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In group one, prior to intraoral scanning by CEREC AC Bluecam (Dentsply Sirona Dental Systems, LLC, Charlotte, NC), surfaces of the prepared tooth and its adjacent and opposite teeth was sprayed with a thin layer of titanium oxide powder (CEREC powder VITA-Zahnfabrik, Bad Säckingen, Germany). An expert performed the scanning and was repeated ten times. After each scan, the Typodont was cleaned entirely and powdered again for the next scan. Scanning started from the prepared tooth and continued to adjacent teeth in the maxillary arch, then to the opposite mandibular teeth in the occlusion. The data were transferred to Sirona software version SWA4.01.

In group two, ten conventional impressions of the prepared tooth were made by the same practitioner, using prefabricated plastic trays, additional polyvinyl siloxane putty (Panasil putty soft, Panasil, Kettenbach, Germany), and its compatible liner (X-light Panasil, Kettenbach, Germany) impression material. The incomplete, distorted impression, or with bubbles were discarded and remade. Type IV die stone (Fujirock EP, GC, Tokyo, Japan) was used for making casts. The stone was prepared according to the manufacturer's instructions. Casts were trimmed for scanning by MCXL in Lab scanner (Sirona Dental Systems, LLC, Charlotte, NC) (Figure 2). The data were transferred to SW4.01 Sirona software for designing the restoration. The technician who designed the crowns was blind to the source of data.

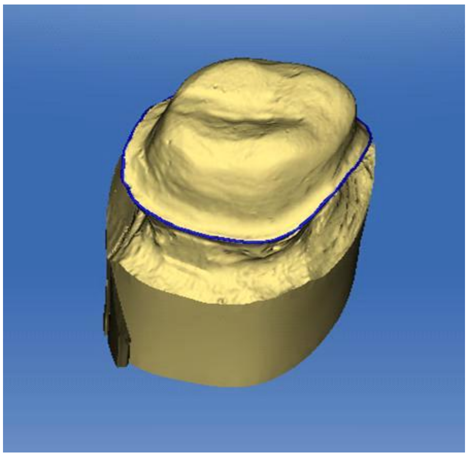

Figure 2. The 3D model of the prepared tooth

Designing of the restoration for each 3D model began with determining the finish line. The cement space was considered to be 50 µm based on the suggestion by Costa et al. [5]. After designing, restorations were milled (MCXL in Lab, Sirona Dental Systems, LLC, Charlotte, NC) from IPS e.max ceramic blocks (CAD LT A3/C14, Ivoclar Vivadent; Amherst, NY) (Figure 3). The intaglio surface of the crowns was cleaned, and any pressure spots disclosed by spraying powder (Arti-Spray Bausch, Germany) were removed with a diamond round bur.

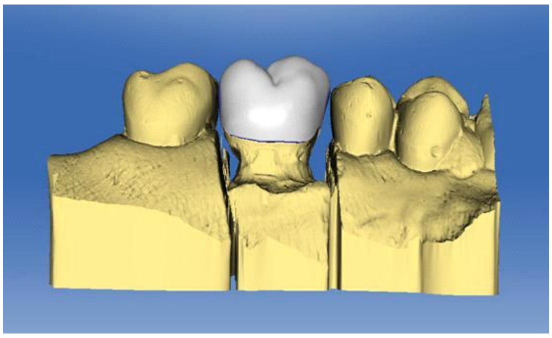

Figure 3. The designed crown using the CEREC system

On each axial surface of the tooth, four points were marked, 1mm below the finish line and 1mm apart from adjacent points. Since the crowns were not cemented to the tooth, a caliper was used to apply uniform force on the crowns during the measuring gaps and to prevent separation of the assembled crown from the tooth. A small amount of putty was put between the occlusal surface of the crown and the jaw of the caliper to prevent damage to the crown. The vertical distance between crown margin and the finish line of the tooth was measured as a vertical marginal gap by a stereomicroscope (Leica EZ4D, Leica Microsystems Inc., IL USA) at ×35 magnification (Figure 4). Collected data were analyzed by independent t-test at $P<0.05$ significance level (SPSS software version 11.6).

Results

The mean (SD) marginal gap for the intraoral group was 74.83 (10.07) µm, and for the extraoral group was 102.56 (6.89) µm. The difference between

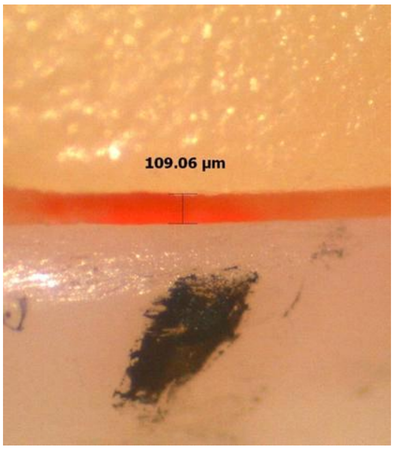

Figure 4. Gap measurement using stereomicroscope at ×35 magnification.

the two groups was statistically significant (P=0.001). Mean values of the marginal gap at different surfaces of each group are presented in (Table 1).

Table 1. Mean marginal gap of different surfaces of two groups (µm); values are presented as mean ± standard deviation

	Extraoral	**Intraoral**	**P-value**
Buccal	150.66±8.11	86.80±8.94	0.001
Mesial	96.88±12.55	86.79±13.26	0.252
Lingual	107.72±7.03	79.60±15.42	0.006
Distal	159.74±9.88	95.07±13.16	0.001

Discussion

In the CAD/CAM technology, a 3D model of dentition is made by digitizing dental arch data, using either intraoral or extraoral scanners. Each type of scanning has some advantages and disadvantages, and there is no consensus on the preference of any of them [17]. This study compared the effect of intraoral or extraoral scanners on the marginal adaptation of the crowns made using CAD/CAM. Intraoral scanners showed significantly better results so the null hypothesis is rejected. Several factors affect the marginal adaptation of indirect restorations made with CAD/CAM systems including margin configuration [13], cement type and cementing procedure [13,14], and die spacer thickness [14]. In order to prevent the effect of these factors on the results of the present study, all the crowns were examined on one prepared tooth without cementation.

The accuracy of the virtual model can be defined in terms of trueness and precision; trueness shows how much the dimension of digital model is close to the real object, and precision shows how much the repeated digitization values are close to each other [7,11]. Type of CAD/CAM system is an influential factor in the accuracy of the scanners [7,14]. In the present study, CEREC was used because it is one of the few CAD/CAM systems that have both type of scanners and the technology of data processing for both scanners is triangulation.

The accuracy of the 3D models is also affected by scanner access and movement, number and sequence of recorded images, the distance of the camera from preparation, and the reflectance of hard and soft tissues [18]. In order to standardize the conditions and to eliminate the effect of patient-related factors like patient movement and gag reflexes on the results, this study was designed as an in vitro experiment. However, this is one of the limitations of the study since the precision of intraoral scanning is negatively affected by limited intraoral space, patient movement, intraoral humidity, and saliva flow [10,11]. To eliminate the adverse effect of powdering on the accuracy of scanning [18], a thin layer of powder was applied for each intraoral scanning and was cleaned completely aftermath. Since the type of ceramic [14] might affect the marginal gap of crowns made with a CAD/CAM technique, same ceramic and manufacturing steps were used for both groups.

Two major methods for evaluating the accuracy of scanning techniques are: comparing the captured data from each technique with highly accurate reference dataset [8,17] or measuring the marginal discrepancy of restorations [8]. In the present study, the second method was used.

The marginal discrepancy can be measured directly

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by optical microscopes [9,18,19], by replication of space between the tooth and the crown using low viscosity silicon paste [9,12], and by sectioning the cemented crown on the tooth, either physically or by computerized tomography [20]. Direct measuring of the marginal gap is not feasible inside the mouth, so this study was performed in-vitro.

Since the intraoral space is restricted, intraoral scanners have smaller measuring area than extraoral scanners, so they need more images of an area for making the virtual model, and the system software should stitch the images together. This process is one of the sources of error in the system [10]. Therefore, extraoral scanners are preferred for full arch scanning. On the other hand, the potential risk of inaccuracy during different steps of extraoral scanning workflow, from making physical impressions to the pouring casts, justifies using intraoral scanners for crowns or short bridges [8]. The result of the present study is in accordance with the studies of Guth et al. [8] and Shembesh et al. [13]. Conversely, Costa et al. [16] did not find any difference in marginal gaps of onlay restorations when the optical impression was taken intraorally or extraorally.

In the study of Cook et al. [18], the marginal fit of crowns milled from IPS Empress CAD blocks was in the range of 61-66µm which are very close to the results of the present study; they used Cerec AC as an intraoral scanner. Hamza et al. [14] reported 40µm marginal gap for e.max CAD crowns made by Cerec inLab system which are much smaller than the results of the present study. In their study, they used a prepared mandibular stainless steel molar as a master die, and have not mentioned the type of scanner or making any physical impressions of the die. Therefore, they might have directly scanned the die by an extraoral scanner. Skipping the impression making steps may possibly explain the smaller gap size in their study compared to the present study. Brawek et al. [9] found 83µm marginal gap in crowns made from Vita In-Ceram YZ blanks after using CEREC AC intraoral scanner and CAD/CAM system. Their results were close to the results obtained in the present study. Costa et al. [16] examined the effect of intraoral and extraoral optical impression methods on the marginal gap of onlays built with the CEREC 3D system. There was no significant difference between the two methods; the mean value of the gaps reported in their study was about 112 µm for the direct method and 118 µm for the indirect method. While the values in the present study are 74.8 µm and 102.56 µm, respectively. The difference between the results of the two studies may be due to the difference in the materials used to fabricate the crowns, which was Vita Blocks Mark II in their study and lithium disilicate in the present study. As mentioned earlier, the restorative material could affect the marginal adaptation [14]. In the study of Lee et al. [17], the mean marginal gap of crowns made with the CEREC 3D system from Vita Blocs Mark II was 94 µm. As mentioned before, the use of different restorative material and their fabrication process could explain the differences in the results.

According to the study of Mclean and Fraunhofer [21] marginal gaps, less than or equal to 120µm are clinically acceptable. Therefore, it can be said that the marginal adaptation of both experimental groups in the present study is clinically acceptable.

There are some limitations to this research; the prepared tooth was acrylic, and its reflectance was different from natural teeth. Moreover, the marginal gaps were measured at 16 points not all around the tooth without cementation which could result in the different amount of the marginal gap.

Conclusion

Within the limitations of this study, it could be concluded that the marginal adaptation of crowns made with CEREC blue cam system is clinically acceptable, although intraoral scanning resulted in a significantly less marginal gap.

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