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In Vitro Comparison of Marginal and Internal Fit of Zirconia Copings Fabricated by One CAD/CAM System with Two Different Scanners

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ABSTRACT

Objectives: Marginal and internal fit of restorations are two important clinical factors for assessing the quality and durability of computer-aided design/computer-aided manufacturing (CAD/CAM)-fabricated monolithic zirconia restorations. The purpose of this study was to evaluate the marginal and internal fit of CAD/CAM zirconia crowns with two different scanners (i3D scanner and 3Shape D700).

Materials and Methods: Twelve extracted sound human posterior teeth were prepared for full zirconia crowns. Two different extraoral scanners namely i3D scanner and 3Shape D700 were used to digitize type IV gypsum casts poured from impressions. The crowns were milled from presintered monolithic zirconia blocks by a 5-axis milling machine. The replica technique and MIP4 microscopic image analysis software were utilized to measure the marginal and internal fit by a stereomicroscope at ×40 magnification. The collected data were analyzed by paired t-test.

Results: The mean marginal gap was 203.62 µm with 3Shape D700 scanner and 241.07 µm with i3D scanner. The mean internal gap was 192.30 µm with 3Shape D700 scanner and 196.06 µm with i3D scanner. The results of paired t-test indicated that there was a statistically significant difference between the two scanners in marginal fit (P=0.04); while, there was no statistically significant difference in internal fit (P=0.761).

Conclusion: Within the limitations of this study, the results showed that type of extraoral scanner affected the marginal fit of CAD/CAM fabricated crowns; however, it did not have a significant effect on their internal fit.

Keywords: Computer-Aided Design; Dental Marginal Adaptation; Yttria Stabilized Tetragonal Zirconia

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INTRODUCTION

In dentistry, computer-aided designing/ computer-aided manufacturing (CAD/CAM) technology is used to fabricate inlays, onlays, crowns, laminates, fixed partial dentures, and implants since the 1980s [1-4]. The conventional CAD/CAM systems operate based on three steps of scanning, designing, and milling. Also, they are classified into chairside and laboratory models [5-7]. The flexibility, speed, accuracy, and efficiency of CAD/CAM laboratory systems have contributed to a wide range of applications in dentistry. Creating a virtual model of the gypsum cast made of conventional impression in a dental laboratory is the most common laboratory CAD/CAM procedure in dentistry, followed by CAD/CAM design and manufacturing steps. The cast surface is scanned and recorded by various tools in order to obtain digital information indicating the morphology of the desired tooth. These instruments are either called digitizers or scanners. Scanners may vary in different systems [8-13].

Marginal and internal fit of restorations are two important clinical factors in assessing the quality and durability of CAD/CAM ceramic restorations. The misfits between the restoration and the prepared tooth include internal gap, horizontal marginal discrepancy, vertical marginal discrepancy, overextended margins, and seating discrepancy [14]. The maximum acceptable marginal gap is 120 µm [1], and values between 50 and 180 µm have been determined as the acceptable range for clinical durability [14]. Marginal gap leads to microleakage, followed by periodontal disease, recurrent caries, tooth hypersensitivity, and eventual failure of restorations [15].

Moreover, internal fit is an important factor affecting the restoration seating and subsequently the marginal fit [16].

Advancements in extraoral and intraoral scanners for high-precision scanning, reliable software programs, and standard milling machines have led to a reduction in discrepancy of CAD/CAM restorations. Since the CAD/CAM technology is based on digital impressions, scanners are very important in accurate recording of the preparation dimensions. Digital impressions enable magnification of the scanned tooth on a computer and allow re-assessment of the insufficiently reproduced areas and may therefore improve the adaptation of restorations as such [17]. However, there is still controversy regarding the impact of type of CAD/CAM system and its components on restoration fit despite the advancements made in the fabrication of highly accurate restorations.

The laboratory Coritec Imes-Icore CAD/CAM systems are 5-axis systems. The 5-axis milling machines can enhance the success and accuracy of restorations by using additional axes of the machine. Considering the existing controversy regarding the effect of extraoral scanner type on the marginal and internal fit of zirconia restorations, the purpose of this study was to evaluate the marginal and internal fit of zirconia crowns fabricated with Imes-Icore CAD/CAM system with two types of scanners (i3D scanner and 3Shape D700). The null hypotheses of this study were: 1. There would be no difference in the marginal fit of the crowns fabricated by the two extraoral scanners. 2. There would be no difference in the internal fit of the crowns fabricated by the two extraoral scanners.

MATERIALS AND METHODS

After obtaining ethical approval (IR.UMSHA.REC.1396.615), 12 extracted sound human posterior teeth without caries or cracks were prepared for full crowns. Putty index of the teeth was made by polyvinylsiloxane impression material (Panasil, Kettenbach LP, Germany) to assess the amount of tooth reduction. The tooth preparation included 1.5 mm of occlusal reduction at the central groove and 1 mm of axial reduction to maintain an axial height of 4 mm. The total occlusal convergence of 10° was planned with 1 mm wide smooth continuous radial shoulder [18].

The teeth prepared without defects were duplicated by polyvinylsiloxane impression material (putty and light body; Panasil, kettenbach LP, Germany). The light body impression material was injected around the prepared tooth, and a prefabricated plastic tray containing putty was placed on it with no additional pressure and allowed to set according to the manufacturer’s instructions. The casts were poured with type IV dental stone (Hardstone, GC, Tokyo, Japan).

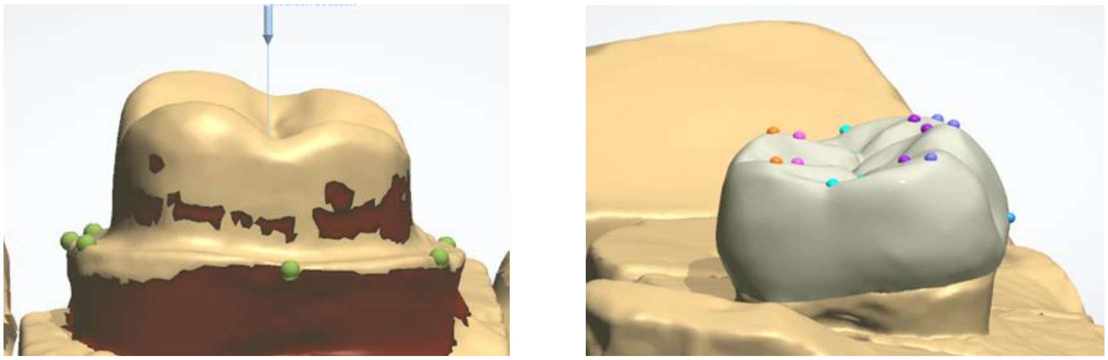

Fig. 1. (A) Scanned tooth on CAD software (detecting path of insertion); (B) virtual crown design (distal view on CAD software)

After 45 min, stone casts without voids were scanned by i3D scanner with CoriTEC 350i CAD/CAM system (Imes-Icore GmbH, Eiterfeld, Germany), and 3Shape D700 scanner (3Shape, Copenhagen, Denmark) with CoriTEC 250i CAD/CAM system (Imes-Icore GmbH, Eiterfeld, Germany), to obtain a virtual model. Then, the design was completed using CAD software (CoriTEC 4/6, Imes-Icore, Eiterfeld, Germany) by a skilled technician (Fig. 1). The restorations were milled with a 5-axis machine and 1-2.5 mm diameter diamonds (Diamond, Germany), respectively, from A2-shade zirconia blocks (Dental Direkt GmbH, Eiterfeld, Germany). The software, based on the standardized parameters, adjusted the 30 µm simulated cement space, starting 1 mm from the margin [14, 19]. The crowns were dried at 200°C for 15 min before sintering; then, they were sintered at 1510°C for 4h according to the manufacturer's instructions.

After the manufacturing process, a try-in phase was performed on the die and after complete seating on the cast, the crowns of each group were placed on the corresponding teeth, and the marginal fit was evaluated by silicone indicator paste (Fit Checker; GC, Tokyo, Japan) and an explorer. Adjustments were performed as required. The criteria for acceptable crowns included homogeneous thickness of the fit checker paste in the crowns without rupture and perforation. Then, the silicone replica technique was performed to measure the marginal and internal fit of the crowns.

Polyvinyl siloxane body impression material (Panasil, Kettenbach LP, Germany) was injected into the crowns and they were seated on their corresponding teeth. When the light body material was polymerized, the crowns with light body silicone inside them were removed from the teeth, and the residual space inside the restoration was filled with polyvinyl siloxane medium body impression material (Panasil, Kettenbach LP, Germany). Two silicone replicas were made from each crown; one was sectioned mesiodistally and the other buccolingually in order to achieve 2-mm thick sections with parallel walls for perpendicular positioning under the microscope.

The light body silicone thickness was measured under a stereomicroscope (Olympus, Tokyo, Japan) at x40 magnification. The stereomicroscope was equipped with a digital camera (Olympus, Tokyo, Japan) and MIP4 microscopic image analysis software (Nahamin Pardazan Asia, Mashhad, Iran). For each sample, the shortest distance between the crown margin and the finish line of the prepared tooth was measured at 8 points for marginal fit and 10 points along the axial walls and on the occlusal surface for the internal fit. All measurements were performed by MIP4 software by one operator. The mean value was calculated as the amount of gap representing the fit of each crown [14, 15, 20]. Data were analyzed by SPSS software version 21 (SPSS Inc., IL, USA). Paired t-test was used for the comparison of the two scanners. The significance level was 0.05%.

RESULTS

The mean and standard deviation of marginal gap were 203.62 ±47.38 μm in the 3Shape D700 group and 241.07 ±36.1 μm in the i3D scanner group. The mean and standard deviation of the internal gap were 192.30 ±32.30 μm in the 3Shape D700 group and 196.06 ±27.44 μm in the i3D scanner group (Fig. 2).

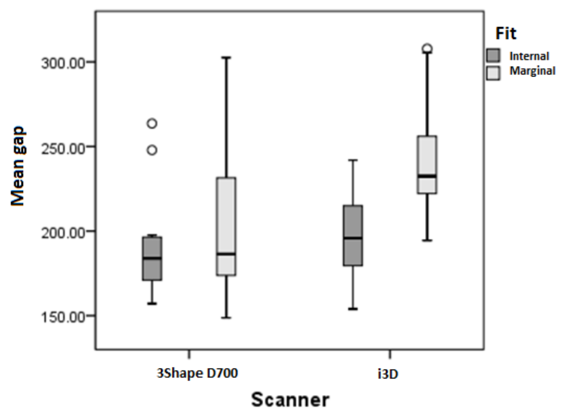

Fig. 2. Boxplot diagram of the mean and standard deviation of the internal and marginal fit of the groups

The results of paired t-test (Table 1) indicated a statistically significant difference between the two scanners for the marginal fit (P=0.04). Paired t-test showed no statistically significant difference in internal fit between the two scanners (P= 0.761, Table 1).

DISCUSSION

The results of the current study indicated that the marginal fit of zirconia crowns fabricated with two different scanners was significantly different; but there was no significant difference in internal fit.

Thus, the first null hypothesis was rejected; while, the second null hypothesis was accepted. Since the cement type, cementation process, and type of CAD/CAM system affect the fit of indirect restorations, all crowns were evaluated on the prepared teeth without cement and only one type of CAD/CAM system was used for both scanners [21, 22]. The difference between the two systems used in the present study was in the type of their scanners.

Many studies have agreed that a marginal gap below 120 μm is clinically acceptable [1, 15, 17]. However, higher values of marginal gap and cement space have also been reported in the range of 120 to 250 μm [14, 17].

In the current study, the silicone replica technique was used to measure the marginal and internal gap of restorations. For this purpose, the gap between the tooth and the crown was duplicated with low-viscosity polyvinyl siloxane and after sectioning, it was measured by a stereomicroscope. The use of microscopic image analysis software for measuring the sectioned silicone replica thickness is a non-destructive, rapid, easy, and suitable technique [23, 24].

In two-dimensional evaluation, the marginal fit of the restoration scanned with 3Shape D700 scanner was significantly higher. The 3Shape D700 scanner performs both impression and gypsum cast scanning, and has high potential for standard and advanced indications. Two cameras with decreased angle enable complete and precise scanning of impressions, full undercuts and deep inlays. The 3-axis motion system tilts, rotates and transfers the object, simplify scanning from any viewing point over 350° [25].

Table 1. Comparison of marginal and internal gap (μm) between the two scanners

Variable	Scanner	Mean±SD	Mean difference±SE	P*	95% CI of the difference	
					Lower	Upper
Marginal Gap	3Shape D700	203.62±47.38	-37.45±17.19	0.04	-73.11	-1.79
	i3D Scanner	241.07±36.1				
Internal Gap	3Shape D700	192.30±32.30	-3.76±12.23	0.761	-29.13	21.61
	i3D Scanner	196.06±27.44				

* Paired t-test; SD: Standard deviation; SE: Standard error; CI: Confidence interval

The results of the present study agreed with those of Marcel et al, [26] who reported that the marginal fit of CEREC CAD/CAM single restorations was significantly affected by the type of intraoral scanners. Conversely, the findings of a study by de Paula Silviera et al. [17] indicated that there was no significant difference between the marginal fit of CAD/CAM zirconia restorations fabricated by using different intraoral scanners. The difference between the results could be due to the type of material used (e.max and Lava Ultimate) and intraoral scanners because the restoration material may affect the marginal fit. The application of monolithic zirconia eliminates the need for the presence of the porcelain veneering layer on the zirconia core that can negatively affect the fit of zirconia restorations following thermal cycles [27,28]. In addition, since the intraoral space is limited, the intraoral scanners have a smaller measuring area than extraoral scanners, and they require more images of an area to produce a virtual model. The system software must combine the images with each other, and this process may lead to systemic errors [29,30]. In a study by Bosniac et al, [31] no significant difference was found between the marginal fit of zirconia copings scanned with two different intraoral scanners; nevertheless, the copings obtained by the 3Shape D700 extraoral scanner from the impression of the prepared tooth were significantly less fitted than those obtained by using intraoral scanners, and the marginal gap values were close to the results of this study.

The internal fit of zirconia restorations in the present study was not significantly different between the two groups. This finding was supported by the results of a study by Bohner et al, [32] who showed no significant difference between the fit of the acquired scans with different intraoral and extraoral scanners; the difference was not significant between the extraoral scanners either. Inversely, in another study, a significant difference was observed between the internal fit of restorations fabricated with different intraoral scanners [17]. Controversy between their results and those of the present study may be due to eliminating the need for conventional impression and thus, direct scanning of the prepared teeth by intraoral scanners, and using a different type of CAD/CAM system. Although the marginal fit of CAD/CAM restorations is more admissible, the internal fit is a challenge yet that depends on the CAD/CAM milling tools. In another study, the internal fit of e.max single crowns with different intraoral scanners was significantly different and was in the range of 16-230 µm [26]. The difference between the studies may be due to the use of intraoral scanners, and different cement space, and type of material.

The type and accuracy of the milling machine and the size of the milling tools can affect the accuracy of the marginal fit of CAD/CAM restorations. Therefore, for a proper review, the type of CAD/CAM system and its version, type of restoration, and its material must be considered [17,33]. In this study, the effects of proximal contacts of restorations and also the cementation factor on restoration fit were not evaluated. It is recommended to design a study considering the proximal contacts and cementation simulation. Since in vitro studies cannot well simulate the intraoral conditions, clinical studies are recommended to obtain more accurate and valid results.

The results of this study showed that all studied groups had internal and marginal fit within the clinically acceptable range, and the use of CAD/CAM system leads to an improvement in the efficacy and accuracy of restoration fabrication process.

CONCLUSION

Within the limitations of this in vitro study, the results indicated that the type of used extraoral scanners (3Shape D700 and I3D scanner) affected the marginal fit of CAD/CAM crowns; however, it did not have a significant effect on the internal fit.

CONFLICT OF INTEREST STATEMENT

None declared.

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