

Evaluation of the Internal Fit of CAD-CAM Provisional Restorations Constructed After Using Two Intra Oral Scanners: An in-vitro Study

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Abstract—Aim: The purpose of this in vitro study is to evaluate two intraoral scanning accuracy regarding to internal fit of provisional restorations. **Methodology:** A maxillary acrylic cast will be used with two designs. Design1: Acrylic resin maxillary cast will be used after removal of right canine and then block their positions with wax. the abutments are maxillary central and lateral incisor and first premolar. The abutments will be prepared using the dental milling machine and then scanned by a laboratory scanner to make a virtual model, which will be used to make ten models by 3D printing. Design 2: Acrylic resin maxillary cast, the abutments are maxillary six anterior teeth from canine to canine. The abutments will be prepared using dental milling machine and then scanned by a laboratory scanner to make a virtual model, which will be used to make ten models by 3D printing. These ten models will be used to make single crowns using Omnicam and Prime scan. After scanning the abutments, provisional single crowns will be milled using Telio CAD blocks and adapted to the corresponding dies. Internal fit will be evaluated using a measuring microscope. **Results:** The results revealed that there were significant results between Primescan and Omnicam for all scanned teeth. **Conclusion:**The provisional restorations scanned with Primescan intra-oral scanner had better internal fit than restoration scanned with Omnicam intra-oral scanner.

Keywords: Internal fit, Primescan , omnicam, intraoral scanner.

Introduction:

The use of digital technology in dentistry has been increasing in recent years, with different computer-aided design and computer-aided manufacturing (CAD-CAM) systems being used to fabricate different types of prostheses. With CAD-CAM systems, a workflow starting with indirect or direct digitalization can be followed.(1)

The Digital scanning techniques with intraoral scanners (IOSs) have been reported to have clinically acceptable results compared with those of conventional impression methods in the fabrication of crowns and fixed partial dentures (FPDs), to provide time efficiency, eliminate potential error due to distortion of elastic impression materials and improve patient acceptance.(2)

Accuracy can be specified as trueness and precision. Trueness is the closeness between the test object and the reference object, whereas precision is the variability of repeated measurements of the object. In a completely digital workflow, an accurate digital scan is essential for a successful prosthesis.(3)

The accuracy of a digital scan depends on the ambient light, the head size of the IOS, the scanning technology, whether reflective powder is required, the scanner software program, the scanning protocol, limited spacing, and edentulous span length. Differences in digital scan accuracy have been reported depending on the scanners used.(4)

Therefore, the purpose of the present study was to evaluate the accuracy of two representative IOSs for single crowns and 3-unit FPD preparations regarding to marginal and internal fit of provisional restorations.

2. Methodology:

2.1 Model cast preparation:

Two ready-made acrylic resin maxillary cast¹ with acrylic teeth divided to:

-**Model (1):** cast was used after removal of right canine and then block their positions with wax². The abutments were maxillary central and lateral incisors and first premolars.

-**Model (2):** abutments were maxillary central, lateral incisors and canines in both sides.

The abutments teeth in both models in the present study were prepared using the dental surveyor with the same preparation protocol for the purpose of standardization of the preparation during the study.

The acrylic resin-tooth assembly was fixed on a specially modified dental surveyor³, Then a contra angle handpiece⁴ was fixed horizontally to the arm of the milling machine in such a way that allowed the attached tapered diamond stone with flat end⁵ to be vertically parallel to long axis of the tooth.

Tooth preparation:

Tooth preparation was done using tapered diamond stone with a flat end and 1 mm diameter head,⁶ so the preparation had 1 mm circumferential shoulder finish line and a 6-degree convergence angle which was achieved by the taper of the diamond stone. The occlusal reduction was using a cylindrical diamond stone with a diameter of 2 mm⁷ to make depth cut grooves of 2mm in the occlusal surface. Then the occlusal preparation was completed using flame stone and the preparation was finished with fine diamond stone at low speed. (Figure 1a,1b)



Figure (1b): Acrylic resin cast with missed right canine and prepared dies.

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Figure (1a): Acrylic resin cast for prepared six anterior dies

2.2 Standardization of models:

Both models with the prepared abutment were scanned by a laboratory scanner⁸, then the scanned file were transferred to computersoftware to make a virtual 3D models converted to STL files format and saved as an STL files that were used to transfer a virtual model from a computer screen to the 3D printing device⁹.

After scanning and making the virtual 3D model, the STL file of the designed models were transferred to the CAD/CAM specialized software and then the STL data sets were coordinated to reduce and/or eliminate any artifacts. Then, the resultant image created by the CAD/CAM specialized software is edited and corrected with the aid of computer-aided design (CAD) to generate a blueprint of the 3D printed of models.

After that, the finalized design was sliced digitally and transferred to a 3D printer for the construction of the 3D printed resin model. Twenty 3D resin models were fabricated by additive (layer by layer) manufacturing technique. This technique comprises pouring and curing of the fluid resin material layer by layer according to manufacturer instructions by light in a dark light-curing chamber on an ascending/descending platform.

Finally, the cured layers joined together in consecutive vertical layers to form the 3D printed resin model. This technique was used to construct a total of twenty 3D printed resin models.

Sample Grouping:

Twenty working 3D cast model were divided into 4 main groups according to the cast design (single abutment (model 1) and FPD (model 2) and types of intraoral scanner

(Omnicaam and Primescan), Five casts for each group (n=5), to receive standardized full-contour provisional restorations (single crown or FPD), which were made by two intraoral scanners as follows:

- **Group 1 (model 1 Omnicam):** Five model 1 were made using scanning by Omnicam scanner.

⁸ Edge 3d scanner, 77 Seongsuil-ro, Seongdong-gu, Seoul, 04790 Korea.

⁹Pharozen Tech Co LTD,Hinshu City 300,Taiwan.

- **Group 2 (model 1 Primescan):** Five model 1 were made using scanning by Primescan scanner.
- **Group 3 (model 2 Omnicam):** Five model 2 were made using scanning by Omnicam scanner.
- **Group 4 (model 2 Primescan):** Five model 2 were made using scanning by Primescan scanner.

Scanning:

The scans in this study were completed without anti reflective powder since the used scanners technologies does not require the powder to obtain accurate images. All of abutments of each group were made using their corresponding two intraoral scanners Omnicam and Primescan.

Fabrication of the provisional restorations:

After scanning the data files of each intraoral scanning system obtained from the master cast were transferred into an STL file and saved in an STL file format that is used to transfer a virtual 3D model from a computer screen to the CAD/ CAM milling machine¹⁰. All designs were created by using the individual design program of each scanner. Moreover, during designing the provisional crowns restoration, a cement gap was estimated as 50µm with the aid of the specialized CAD software.

Dentsply Sirona CEREC in lab MC X5 CAD/CAM milling machine was used to mill Wiessen CAD resin blocks to construct FPD and single crowns of the provisional restorations.

After the finished of FPD and single crowns restorations fabrication, all of the provisional restorations cemented were trayed and adapted to their corresponding abutments. (**Figure2**)



Figure (2):single crowns (Model 1) and FPD (Model 2) on resin model.

¹⁰CEREC In-Lab MC X5,Dentsply Sirona,Philadelphia Street Suite 60W York, USA

The single crowns (Model 1) and FPD design (Model 2), the prepared teeth were separated from the 3D printed casts with the aid of a sandpaper disc .

3.1 Measurement of the internal gap after cementation:

Half of the cemented crowns were sectioned in bucco – lingual direction and the other half of the crowns were sectioned in a mesio- distal direction using with the cutting milling machine to measure the internal fit of each provisional restoration along with their assigned group. (Figure 13)

Measurements of cement spaces between the restorations and the prepared tooth surface were performed at each half of the sectioned crown assembly at 24 points: 8 points at the incisal surface and 8 points at each axial wall of the crown fitting surface (Figure14).

All readings were averaged and the overall measuring of each crown was recorded and tabulated for the statistical analysis

Sample size calculation:

The sample size for this study was calculated according to Arkin (1984), using the following equation:

$$n = \frac{(Z_{\alpha})^2 * (S)^2}{(d)^2}$$

n = sample size
S = Standard diversion
Z_α = 1.96 at significant level 95%
d = different between factors

Z	S	d
1.96	0.56	0.2

4.Result of internal fit:

4.1 Result of internal fit of single-crown:

Comparison of internal fit of provisional restorations scanned Primescan and Omnicam:

The statistical analysis results of the internal fit between Primescan and Omnicam for both right and left sides were represented in (Table 1), and graphically illustrated in (Figure 3). Additionally, the statistical results showed that the Primescan device is more accurate with significantly better internal fit when compared with Omnicam.

However, the statistical results determined that there was no statistically significant difference in the internal fit between the right and left side for all scanned teeth with regard to the scanning device.

Among the groups; the Post-Hock’s Tukey test revealed thatthere is an overall significant difference between the sample means, except between the right and left scanned tooth with regard to the scanning device.

Table (1): Comparison of internal fi of single crowns scanned Primescan and Omnicam:

Variables	Primescan (mean± SD)		Omnicam (mean± SD)		P-value
	Right	Left	Right	Left	
Central incisor	58.17±1.46B	55.46±7.25B	66.51±1.01A	65.67±1.43A	0.00049*
Stat. Sign.	P1= 0.6794ns; P2=0.01503*; P3=0.03022*; P4=0.00153*; P5=0.00311*;				

among groups	P6=0.9847ns.				
Lateral incisor	35.30±1.39B	34.63±2.67B	50.38±1.13A	49.53±1.25A	<0.00001*
Stat. among groups	P1= 0.9256 ns; P2=0.00000*; P3=0.00000*; P4=0.00000*; P5=0.00000*; P6=0.8618ns.				
Canine	30.73±1.40B	30.73±1.04B	43.36±0.79A	43.51±0.83A	<0.00001*
Stat. among groups	P1= 0 ns; P2=0.00000*; P3=0.00000*; P4=0.00000*; P5=0.00000*; P6=0.9962ns.				

*; significant at P<0.05. ns; non-significant.

Different uppercase letters mean statistically significant.

P1; between Primescan right and left.

P2; between Primescan right and Omnicam right.

P3; between Primescan right and Omnicam left.

P4; between Primescan left and Omnicam right.

P5; between Primescan left and Omnicam left.

P6; between Omnicam right and left.

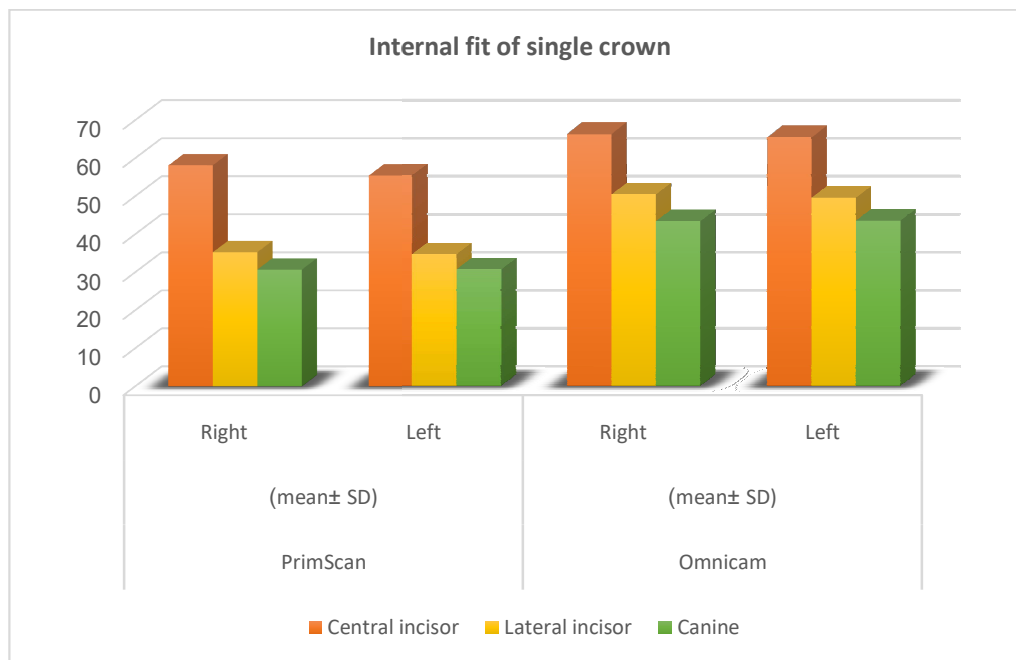


Figure (3): Comparison of internal fit of provisional restorations scanned Primescan and Omnicam

4.2 Result of the internal fit of the bridge:

Comparison between the internal fit of provisional restorations scanned Primescan and Omnicam:

The statistical analysis results of the internal fit between Primescan and Omnicam bridges were represented in (Table 2) and graphically illustrated in (Figure 3). The results revealed that there were significant results between Primescan and Omnicam for all scanned teeth as determined by an independent t-test. Additionally, the statistical results showed that the Primescan device is more accurate with a significantly better internal fit when compared with Omnicam for all scanned teeth.

Table (2): Comparison between the internal fit of Primescan and Omnicam:

Variables	FPD	t-value	P-value
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	Primescan (mean± SD)	Omniscam (mean± SD)		
Central	39.31±1.22	53.35±6.69	8.95	0.0017*
Lateral	35.02±0.37	50.02±0.77	13.75	<0.00001*
1st premolar	28.80±1.09	50.02±12.08	3.9	0.0045*

*; significant at P<0.05. ns; non-significant.

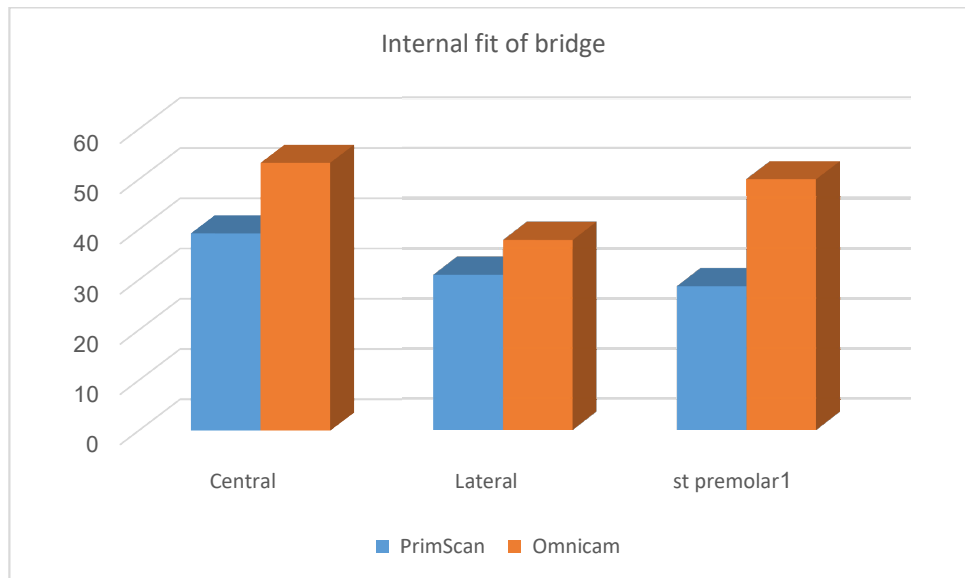


Figure (3): Comparison between the internal fit of provisional restorations scanned Primescan and Omnicam.

5. Discussion

internal gap result:

The results showed that the Primescan device is more accurate with significantly better internal gap when compared with Omnicam. These results might be attributed to the scanning technology that was applied by Omnicam as it operates with active triangulation and confocal microscopy optical scanning technology. The accuracy of intraoral scanners that apply this technology depends on the distance and the angle between the scanner head and the scanned surface. Regarding the angle, the curvatures and the inclinations of different abutments surfaces like incisal areas and axial surface slopes could affect the accessibility of the light to the scanned surface and also the direction of the reflected light toward the sensors even with hovering around the tooth. This consequently might affect the amount of information that are captured about each abutments surface thus affecting the accuracy of the 3D reconstruction. Two concomitant phenomena called “overshoot” and “rounded edges” occur during the scanning of these angled regions and could be responsible for the wider internal gaps. This might explain the relatively low occlusal and axial internal gap of Primescan scanner.

On the other hand, Omnicam can scan the relatively straight and flat surfaces like the finish line better than the inclined surfaces, while the Primescan can capture edge details better. This explanation came in accordance with (5)

The internal gap results of the current study were in agreement with: (6), (7), (8), (9), (10)

Because it is important to note the "in vivo" aspect of the practitioner when shifting from left to right in the jaws, the right and left sides of the mouth were compared in this study for single crowns and FPD provisional restorations. As a result, a scanning transit in such areas has been proposed and

tested. As it was previously stated, the need for a union of hemi arches (mainly of the vestibular surface) at particular sites (at the median line) has been cited as the reason for the interruptions in intraoral scanning, where continuous scanning would not be possible. **(11)**

Furthermore, the findings of this study revealed that, with regard to the scanning equipment, there was no statistically significant difference between the provisional restorations on the right and left sides. This might be connected to the capacity of the camera's tip in both iOS devices to resist moving while scanning in a transverse or apical direction. **(12)**

However, this study did not replicate an actual clinical situation and has several limitations. In most patients, multiple surfaces and materials are scanned, including various restorative materials, dentin, enamel, and soft tissues. Inherent anatomy-related changes in arch shape or jaw opening mean that this in vitro study is fundamentally limited, and in vivo studies using these scanners would be important to further illustrate the differences in accuracy. Further studies should be completed to determine whether these factors may affect full arch accuracy in this current generation scanners.

In the present study, only one clinician performed the scans on the master model to produce the data set for each scanner. This is important variation in scan strategy can affect the accuracy of stitching, which in turn would impact the significance of the results comparison.

A few limitations are suggested in our in vitro study, namely the in vivo complications, such as saliva, blood, patient interaction, etc. These need to be accounted for and may impact the results in an in vivo patient setting.

According to the results of the current study the hypothesis was rejected, because the Primescan intraoral scanner more accurate in digital scanning than Omnicam scanner.

The internal gap results of the current study agreed with:(13-16)

6. Conclusions

Within limitations of this present study it could be concluded that:

- 1) Primescan intra-oral scanner had better accuracy than Omnicam intra-oral scanner.
- 2) The provisional restorations scanned with Primescan intra-oral scanner had better internal fit than restoration scanned with Omnicam intra-oral scanner.

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