

**FEDERAL UNIVERSITY OF UBERLANDIA**

**FACULTY OF DENTISTRY**

**BÁRBARA INÁCIO DE MELO**

**Evaluation of scanning time and CAD/CAM crowns fit using different intraoral  
scanning systems**

Uberlandia - MG

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Course completion work presented to the Faculty  
of Dentistry of the Federal University of  
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## RESUMO

**Declaração do problema** Os novos sistemas de digitalização intraoral (IOS) disponíveis no mercado odontológico permitem melhor qualidade de imagem e tempo de digitalização mais rápido. Contudo, a precisão destes IOS deve ser avaliada.

**Objetivo** O objetivo deste estudo in vitro foi avaliar o tempo de escaneamento e o ajuste marginal de coroas CAD/CAM obtidas com diferentes IOS (O1- Ominican 1.0, O2- Ominican 2.0, PS- Primescan).

**Material e métodos** Um troquel de resina padronizado impresso em impressora 3D com preparação dentária de coroa total foi digitalizada dez vezes com cada IOS, seguida pelo desenho e fresagem de coroas cerâmicas de dissilicato de lítio. Em seguida, as coroas foram fixadas com material polivinilsiloxano no troquel e escaneadas por meio de tomografia microcomputadorizada, obtendo-se as imagens utilizadas para mensuração do ajuste marginal das coroas. Foram realizadas 52 medidas em cada imagem e após análise do desajuste marginal, também foi avaliado o tempo de cada varredura. Os dados foram analisados quanto à homogeneidade e foram realizados testes ANOVA e Tukey ( $\alpha=0,05$ ).

**Resultados** Os valores médios ( $\pm$  desvio padrão) do desajuste vertical foram: O1-  $46,7 \pm 16,4 \mu\text{m}$ ; O2-  $33,8 \pm 21,4 \mu\text{m}$  ( $p=0,041$ ); e PS-  $12,3 \pm 6,6 \mu\text{m}$  ( $p<0,001$ ). Os percentuais de desajustes verticais verificados abaixo de  $75 \mu\text{m}$  foram: O1- 76,5%; O2- 77,9%; e PS- 98,1%. Os valores médios ( $\pm$ DP) para desajuste horizontal foram: O1-  $104,2 \pm 20,1 \mu\text{m}$ ; O2-  $96,1 \pm 16,9 \mu\text{m}$ ; e PS-  $89,0 \pm 14,2 \mu\text{m}$  ( $p=0,098$ ). Os tempos médios de varredura ( $\pm$ DP) foram: O1-  $37,4 \pm 3,1 \text{s}$ ; O2-  $34,8 \pm 2,7 \text{s}$ ; PS-  $27,8 \pm 1,9 \text{s}$ ; com tempo semelhante para O1 e O2, que diferiu do PS.

**Conclusões** Foram observadas diferenças significativas no tempo de escaneamento e no ajuste marginal das coroas cerâmicas CAD/CAM obtidas com diferentes IOS, sendo que o PS apresentou os melhores resultados. As melhorias de hardware e software no IOS desempenham um papel fundamental na influência desses resultados.

**Palavras-chave** CAD/CAM, cerâmica, coroa, ajuste marginal.

**Implicações clínicas** O sistema Primescan IOS proporcionou coroas cerâmicas com ajuste marginal mais preciso, além de tempos de escaneamento mais curtos em comparação aos sistemas Omnicam 1.0 e Omnicam 2.0 ao usar a mesma unidade de fresagem.

## ABSTRACT

**Problem statement** New intraoral scanning systems (IOS) available on the dental market allow best image quality and fast scanning time. However, the accuracy of these IOS should be evaluated.

**Purpose** The aim of this in vitro study was to evaluate the scanning time and marginal fit of CAD/CAM crowns obtained with different IOS (O1- Ominican 1.0, O2- Ominican 2.0, PS- Primescan).

**Material and methods** A 3D-printed standardized composite resin die with full-crown tooth preparation was scanned ten times with each IOS, followed by designing and milling of lithium disilicate ceramic crowns. Then, the crowns were fixed with polyvinylsiloxane material on the die and scanned using microcomputed tomography, obtaining the images used to measure the marginal fit of the crowns. Fifty-two measurements were performed on each image and after analyzing the marginal misfit, the time of each scan was also evaluated. Data were analyzed for homogeneity, and ANOVA and Tukey tests were performed ( $\alpha=.05$ ).

**Results** The mean values ( $\pm$  standard deviation) for vertical misfit, were: O1-  $46.7\pm16.4\mu\text{m}$ ; O2-  $33.8\pm21.4\mu\text{m}$  ( $p=.041$ ); and PS-  $12.3\pm6.6\mu\text{m}$  ( $p<.001$ ). The percentage of vertical misfits verified under  $75\mu\text{m}$  were: O1- 76.5%; O2- 77.9%; and PS- 98.1%. The mean values ( $\pm$ SD) for horizontal misfit were: O1-  $104.2\pm20.1\mu\text{m}$ ; O2-  $96.1\pm16.9\mu\text{m}$ ; and PS-  $89.0\pm14.2\mu\text{m}$  ( $p=.098$ ). Mean scanning times ( $\pm$ SD) were: O1-  $37.4\pm3.1\text{s}$ ; O2-  $34.8\pm2.7\text{s}$ ; PS-  $27.8\pm1.9\text{s}$ ; with similar time for O1 and O2, which differed from PS.

**Conclusions** Significant differences were observed in the scanning time and marginal fit of the CAD/CAM ceramic crowns obtained using distinct IOS, with PS presenting the best

results. Hardware and software enhancements in IOS play a pivotal role in influencing these results.

**Keywords:** CAD/CAM, ceramics, crown, marginal fit.

**Clinical Implications** The Primescan IOS system provided ceramic crowns with more accurate marginal fit, besides shorter scanning times as compared to Omnicam 1.0 and Omnicam 2.0 systems when using the same milling unit.

## SUMMARY

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## INTRODUCTION

The increasing emphasis on aesthetics in dentistry has driven the widespread adoption of all-ceramic restorations<sup>1</sup>. Accurate manufacturing of ceramic crowns is an important step for treatment survival<sup>2</sup>. Inaccurate impressions may result in restorations with incompatible marginal fit<sup>2,3</sup>. Digital impression methods offer advantages, such as the direct visualization of three-dimensional (3D) models, correction of scanning procedure<sup>2</sup>, time optimization, and the possibility of chair-side production for indirect restorations using computer-assisted design/computer-aided manufacturing (CAD/CAM)<sup>4-8</sup>. This procedure is normally performed using intraoral scanning systems (IOS), which have received software and hardware updates to improve the definitive fit of restorations<sup>4</sup>.

The CEREC intraoral scanning system has undergone substantial updates over the years, particularly in image capture technology<sup>9,10</sup>. These updates minimize errors and reduce marginal discrepancies<sup>9,10</sup>. The Omnicam system generates a 3D model using a video sequence with active triangulation and striplight projection technology<sup>11,12</sup>. Active techniques use light projected from the camera onto an object, relying less on the real texture and color of tissues for reconstruction<sup>13,14</sup>. In active techniques, a luminous point is projected onto an object and the distance to the object is calculated by triangulation. The new Primescan system presents a video sequence and confocal microscopy technology<sup>15</sup>. This is based on the acquisition of focused and defocused images from selected depths<sup>14</sup> and the use of structured light<sup>5</sup>. Additionally, CEREC Primescan has a larger field of view than CEREC Omnicam, which is faster and more accurate<sup>16,5</sup>.

The first CEREC chair-side system was developed in 1984. Since then, this system has improved intraoral scanner technologies<sup>10</sup>. Bluecam emerged as a 3D system with blue image capture technology, followed by the video capture scanners Omnicam and Primescam<sup>10</sup>. Cameras with new technologies should provide similar or better results than existing technologies in terms of scanning time, fit, and accuracy of restorations<sup>10,16</sup>. Marginal fit is an important aspect of clinical longevity and success of indirect restorations. However, poor adaptation of crowns can result in microleakage, cement solubility, plaque accumulation, secondary caries, periodontal tissue inflammation, and endodontic complications<sup>8,9,17-19</sup>. Several factors, such as software, hardware<sup>3</sup>, operator experience<sup>20</sup>, and tooth preparation design have been shown to influence the marginal fit of crowns<sup>21,22</sup>. There is no consensus regarding clinically acceptable marginal discrepancies in indirect restorations<sup>9,10,23-25</sup>. Clinically, a fit is considered acceptable when the margin interface is not detectable by the explorer<sup>23</sup>. Some studies suggest a marginal fit below 120  $\mu\text{m}$  as acceptable<sup>24,26,27</sup>, while others advocate values below 100  $\mu\text{m}$ <sup>28,29</sup>. However, others assert that the acceptable fit should be under 75 $\mu\text{m}$ <sup>30</sup>. Ideally, the clinically perfect marginal fit for cemented restorations falls within the range of 25  $\mu\text{m}$  to 40  $\mu\text{m}$ <sup>9,31</sup>, although achieving these values remains a challenge<sup>32</sup>.

The comparison of marginal fit data from various studies can be problematic because of the use of different assessment methods<sup>20, 27</sup>. Some of these methods are destructive, such as sectioning crowns with a diamond disc, measuring the marginal gap with stereomicroscopy, or scanning electron microscopy<sup>33-35</sup>. However, non-destructive approaches are also available, such as the superimposition of 3D techniques, measurement of cement thickness using polyvinylsiloxane (PVS) paste, and microcomputed tomography (micro-CT)<sup>9,32,36,37</sup>. micro-CT allows a 3-dimensional (3D)

investigation of marginal fit with a range of a few micrometers at different sites and directions<sup>38</sup>. While this method offers qualitative and quantitative analyses of the vertical, horizontal, and even internal fit of crowns in both the coronal and sagittal axes, it has certain challenges, such as high acquisition costs, extended scanning times, and complex data analysis<sup>10</sup>.

To the best of our knowledge, there is currently no evaluation of the marginal fit of ceramic crowns obtained with Omnicam 1.0, Ominican 2.0, or Primescan IOS using micro-CT. Therefore, the purpose of this study was to investigate the differences between these distinct technologies of intraoral optical scanners, considering the scanning time and marginal fit of the fabricated crowns. The null hypothesis was that the scanning time and marginal fit of the ceramic crowns would be similar when using different IOS.

## **MATERIAL AND METHODS**

### **Manufacturing the crowns**

A standardized die with a full-crown preparation was obtained by 3D modeling<sup>39</sup> using CAD software (Rhinoceros 4.0) and NURBS lines, and then printed in a photocured resin composite using a 3D LCD printer (Anycubic). The die represented a full-crown preparation of the mandibular left first molar with rounded axiokingival angles and shoulder termination. Before the die was fixed on a full-arch typodont model, the preparation was partially scanned ten times using the following IOS systems; Ominican 1.0 (Sirona Dental GmbH), Omnicam 2.0, (Sirona Dental GmbH), and Primescan (Sirona Dental GmbH), as described in Table 1. The scanning process was automated by a software, which defined the insertion axis and preparation margin, and no modifications were made to this automatic delimitation. In addition, for the O1 and O2 systems, the

composite resin die was sprayed with a thin layer of opacifier powder (CEREC Optispray) to improve scanning<sup>10</sup>. The scanning time was recorded for each scan performed using the different IOS systems.

The Ominican 1.0 crowns were designed using the CEREC v. 4.2.5 software and the luting space for adhesive cementation was set at 80  $\mu\text{m}$ , according to the manufacturer's instructions. The Omnicam 2.0 and Primescan crowns were designed using the CEREC 3D v. 5.0 software, and the luting space was set at 120  $\mu\text{m}$ , according to the manufacturer's instructions. The margins of the restorations were manually adjusted. All crowns were designed and the ceramic blocks were milled in an MCXL computer-controlled milling unit (CEREC, Sirona Dental GmbH) using the veneer milling mode. Lithium disilicate ( $\text{LS}_2$ ) glass-reinforced ceramic CAD/CAM blocks (IPS e.max CAD; MT-A2 shade; Ivoclar Vivadent) were used in the three IOS systems to produce the crowns, as shown in Table 1. No internal adjustments were made, and crystallization of the crowns was performed according to the manufacturer's instructions using the same firing program (Program P91, Programat P300, Ivoclar Vivadent).

### **Micro computed tomography and measurement**

Each crown was fixed on a standardized die with a PVS-based material (GC Fit Checker, GC Dental Industrial Corp.) using custom equipment to uniformly apply 20 N of pressure for crown setting (digital pressure). The crown-die sets were digitized using microcomputed tomography (Micro-CT Scanco CT40, Scanco Medical AG) to obtain images for marginal fit measurements. Micro-CT scans were performed at 100 Kv and 100  $\mu\text{A}$ , with a pixel size of 9.4  $\mu\text{m}$ , Cu filter of 0.11 mm, and resolution of 1632 $\times$ 1092 pixels. Selected scanning was performed in rotation steps from 0.6–to 360 degrees, and

two frames with random movements of 20 pixels were collected, resulting in a scanning time of 38 min per specimen.

Subsequently, the micro-CT images were reconstructed and the existing artifacts were reduced. NRecon software (v. 1.1.8.0., SkyScan) was used with the following parameters: 5% smoothing, 4% ring artifact correction, and 5% beam-hardening correction. Next, the Dataviewer software (v. 1.5.0.2; SkyScan) was used to obtain the sagittal and coronal image sets. Then, 13 images each were selected for the sagittal and the coronal sets, showing the entire specimen length in two different dimensions (mesiodistal and buccolingual). The images were chosen from the same spatial division between the first and last images where the cervical margins appear<sup>9</sup>.

The measurements for marginal fit were made in each of the selected images, with two readings each for vertical and horizontal adaptation at 600x magnification, using CTAN processing software (v. 1.12.0.0, SkyScan). Fifty-two measurements were performed per specimen according to previous investigations<sup>10,23</sup> and these measurements were assigned to their respective surfaces to assess any relationship of the misfit per surface. The measurements were performed by three previously calibrated examiners and the average values of the three evaluations were considered (Kappa =0.80).

### **Statistical analysis**

Statistical analyses were performed using GraphPad Prism 8 software (GraphPad Software, San Diego, CA, USA). The average misfit values for the vertical, horizontal, and standard deviations were calculated for each group. Data were analyzed for homogeneity, and one-way analysis of variance (ANOVA), followed by Tukey HSD test ( $\alpha=.05$ ) was used to compare the groups.

## RESULTS

The mean values of the vertical and horizontal fits for the experimental groups are listed in Table 2. For vertical misfit, the mean values ( $\pm$ SD) were: O1-  $48.8 \pm 41.9$   $\mu$ m; O2-  $41.7 \pm 34.7$   $\mu$ m; and PS-  $12.3 \pm 6.6$   $\mu$ m. For horizontal misfit, the mean values ( $\pm$ SD) were: O1-  $103.8 \pm 112.0$   $\mu$ m; O2-  $94.6 \pm 17.2$   $\mu$ m; and PS-  $88.9 \pm 14.2$   $\mu$ m. Figures 1 and 2 show the mean misfit values and their limits for the vertical and horizontal assessments, respectively.

Considering the vertical fit, the results were significantly different for PS compared to O2 ( $p < .0001$ ) and O1 ( $p < .0001$ ). O1 also differed from O2 in terms of vertical fit ( $p < .0406$ ). Considering the horizontal fit, there was no statistical difference between the groups. In this study, clinically acceptable values of vertical marginal adaptation  $\leq 75 \mu$ m were considered, and Table 2 also shows the percentages of the values that are within this limit. The percentage of vertical misfits under  $75 \mu$ m were as follows: O1- 76.5%; O2- 77.9%; and PS- 98.1%. Considering the scatterplot (Fig. 3) we have more variation of vertical and horizontal fit measurements for group O1 (4.2.5 software) when compared to O2 (software 5.0), The mean scanning times ( $\pm$ SD) were: O1-  $37.4 \pm 3.1$  s; O2-  $34.8 \pm 2.7$  s; PS-  $27.8 \pm 1.9$  s and are presented in Table 3. PS showed the shortest scanning time among the IOS ( $p < .0001$ ), significantly differing from O1 and O2, which presented similar scanning times ( $p = .054$ ).

## DISCUSSION

Since the scanning time and marginal fit of ceramic crowns produced with the different intraoral optical scanner (IOS) technologies were not similar among the systems, the null hypothesis proposed was rejected. New technologies tend to present better results<sup>16</sup>, and the PS system camera hardware and software offered a fast scanning

time and better vertical marginal fit for ceramic crowns produced with the same milling unit compared with the other IOS systems in this study. The blue light and confocal microscopy technology present in the PS system, along with improved software (CEREC 3D v. 5.0), enhanced the 3D model acquisition and crown design, optimizing the milling step and marginal fit of the ceramic crowns. Moreover, the PS system can easily detect sharp areas in the image to infer the distance to the object, which is correlated to the focal length of the lens<sup>15</sup>. These facts may justify why 98.1% of the crowns produced using the PS system presented vertical marginal fit values below  $75\mu\text{m}^{10,30}$ .

Marginal fit is an important factor in the clinical success of indirect restorations<sup>8,17</sup>. Well-fitting restorations reduce the risk of complications, such as microleakage, plaque accumulation, caries, periodontal inflammation, and endodontic lesions, which influence the clinical longevity of rehabilitation with single crowns<sup>8,9,17-19</sup>. Investigations have shown improvements in the marginal discrepancy after updates in the hardware (scanning technologies) and software of IOS systems<sup>3,6,10,16</sup>. When comparing the same IOS hardware with upgraded software (O1 vs. O2) and computer hardware evolution, the use of improved scanning technology for the O2 system resulted in better values for the vertical marginal discrepancy of ceramic crowns with CEREC 3D v. 5.0, compared to O1 with CEREC v. 4.2.5.

The findings of this study indicate that not only the hardware, but newer software versions of IOS systems offer the best fit for the restorations produced, in addition to improving the performance of the digital flow<sup>5</sup>. These findings should be justified based on the easier marginal detection presented by the new software (CEREC 3D v. 5.0) compared to the earlier version (CEREC v. 4.2.5). In addition, the surface quality of the 3D model images produced by the previous software (version 4.2.5) may

present more reconstruction errors than the newer version (version 5.0), which may have negatively affected the vertical marginal fit for the O1 system. The surface aspect irregularities observed in the digital models from O1 may have influenced the dimensions of the ceramic crowns, resulting in the highest vertical marginal discrepancies. Furthermore, when analyzing the overlay images, we observed that the hardware could also influence these values based on the results obtained in the scanning file (STL file).

This study evaluated the marginal fit of ceramic LS<sub>2</sub> crowns produced using CAD/CAM technology with different IOS systems using micro-CT. This method is non-destructive and allows the investigation of marginal and internal fit without affecting the marginal fit area. In the literature, the Primescan group presented better results than the Omnicam group with respect to the trueness and precision of the scan<sup>7</sup>. Micro-CT evaluations allowed the evaluation of the marginal fit of CAD/CAM crowns in different areas of tooth preparation.

Scanning time is an important topic that needs to be verified to provide a more comfortable experience for patients<sup>14</sup>. New hardware and software technologies have significantly reduced the chair-side time required to perform scans. A short scanning time is important to reduce the influence of crevicular fluid, ambient lighting, breathing, saliva, patient movements, limited mouth access on the quality of the 3D model, and the restoration of marginal fit. More experienced professionals were shown to influence the accuracy of scans performed with IOS, and repeated clinical experience also affected the trueness of the virtual models, significantly reducing deviations between the scans achieved<sup>20</sup>. This study obtained a 3D model with sextant scans of a typodont model, eliminating intraoral influences and facilitating result standardization.

According to ISO 5625-1, the term “precision” refers to the proximity between results obtained under standardized conditions, which can be expressed through standard deviation<sup>15</sup>. In the present study, we observed smaller SD in the PS group. This factor can also be observed in the scatter plots, where there is less variability in measurements with smaller SDs. Thus, the PS group had the most accurate IOS, followed by the O2 and O1 groups, which can be explained by the new technology related to image capture and the software used to generate the crowns.

In this study, two versions of the Omnicam camera and Primescan were evaluated using video camera technology<sup>5</sup>. However, the IOS of group PS used blue light (presented in the Bluecam system) and confocal technology to perform scanning, whereas the IOS of groups O1 and O2 used white light and triangulation technology<sup>15</sup>. This evolution in hardware image capture technology may be a crucial factor in the results obtained by the PS group, the camera with the most recent update among those highlighted.

The IOS in this study uses active object capture technology, which means that the cameras emit structured light onto the object that will be scanned<sup>14</sup>. This light can have different colors, in this study, we have the white light used in Omnicam and the blue light, which was originally used in the Bluecam, and is used again in PrimeScan. The return of blue light can be explained by the shorter and more intense wavelength, which improved the precision of the equipment<sup>9</sup>. In a previous study<sup>25</sup> comparing Omnicam cameras with Bluecam, the adaptation of crowns to Bluecam technology was found to be better. However, faster video scanning technology reduces the scanning time compared to image capture. In this study, the PS group obtained better results, which can be explained by the association between blue light and confocal technology.

Hence, showing the relevance of understanding the technology involved in each piece of the equipment.

In this study, the marginal fit of ceramic crowns produced using CAD/CAM with different IOS was evaluated using an in vitro test setup, which had some intrinsic limitations. Factors such as subgingival preparation margins, crevicular fluid, ambient lighting, breathing, saliva, patient movement and limited access to structures can influence the result<sup>5</sup>, and were controlled under the laboratory conditions used. Clinical investigations should be conducted to demonstrate the impact of these limitations on the results. The composite resin die used had similar characteristics to coronal resin composite reconstructions made in severely destroyed teeth requiring full-crown preparation and provided a valid comparison among IOS systems with standard preparation. Further studies should be conducted to evaluate the influence of internal adjustments on the marginal fit compared with other IOS systems.

## **CONCLUSION**

Within the limitations of this in vitro study, it is concluded that (1) The Primescan system resulted in a better marginal fit for ceramic crowns and reduced scanning time than Omnicam systems, and (2) hardware and software enhancements of the IOS systems played a pivotal role in influencing the marginal fit of ceramic crowns produced through CAD/CAM technology.

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## TABLES

Table 1. Description of experimental groups (n=10).

| <b>IOS system</b> | <b>Software</b> | <b>Milling<br/>unit</b> | <b>Groups</b> | <b>Ceramic</b>     |
|-------------------|-----------------|-------------------------|---------------|--------------------|
| Omnicam 1.0       | v4.2.5          | MCXL                    | O1            | Lithium disilicate |
| Omnicam 2.0       | v5.0            | MCXL                    | O2            | Lithium disilicate |
| Primescan         | v5.0            | MCXL                    | PS            | Lithium disilicate |

Table 2. Mean ( $\pm$ SD) vertical, and horizontal marginal fit (n=10) and scanning time for the IOS systems.

| <b>IOS<br/>system</b> | <b>Vertical<br/>(<math>\mu\text{m}</math>)</b> | <b>Percentage <math>\leq 75</math><br/><math>\mu\text{m}</math></b> | <b>Horizontal<br/>(<math>\mu\text{m}</math>)</b> | <b>Scanning time<br/>(s)</b> |
|-----------------------|------------------------------------------------|---------------------------------------------------------------------|--------------------------------------------------|------------------------------|
| O1                    | 46.7 $\pm$ 16.4 <sup>a</sup>                   | 76.5 %                                                              | 104.2 $\pm$ 20.1 <sup>a</sup>                    | 37.4. $\pm$ 3.1 <sup>a</sup> |
| O2                    | 33.8 $\pm$ 21.4 <sup>b</sup>                   | 77.9%                                                               | 96.1 $\pm$ 16.9 <sup>a</sup>                     | 34.8 $\pm$ 2.7 <sup>a</sup>  |
| PS                    | 12.3 $\pm$ 6.6 <sup>c</sup>                    | 98.1%                                                               | 89.0 $\pm$ 14.2 <sup>a</sup>                     | 27.8 $\pm$ 1.9 <sup>b</sup>  |

\*Values with same superscript letter are not significantly different (columns) based on paired *Tukey's test* ( $p < .05$ ).

## LEGENDS FOR ILLUSTRATIONS

Fig. 1. Mean marginal vertical misfit values and limits ( $\mu\text{m}$ ) of the ceramic crowns according to the IOS systems.

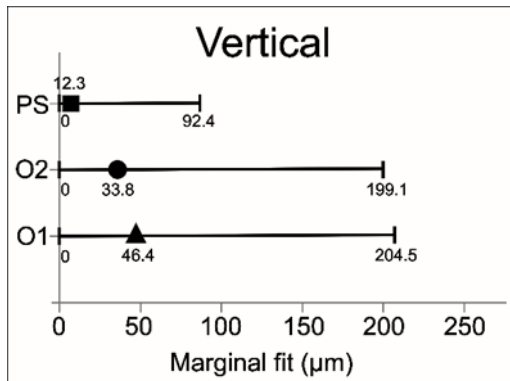


Fig. 2. Mean marginal horizontal misfit values and limits ( $\mu\text{m}$ ) of the ceramic crowns according to the IOS systems.

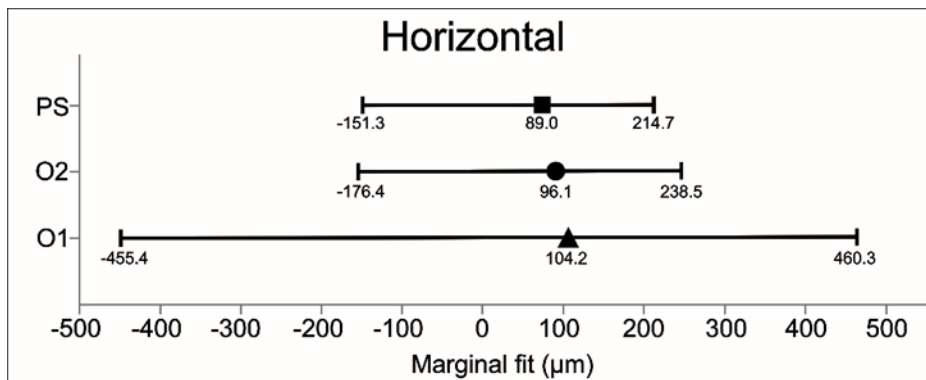


Fig 3-a. Vertical measurements – O1 system.

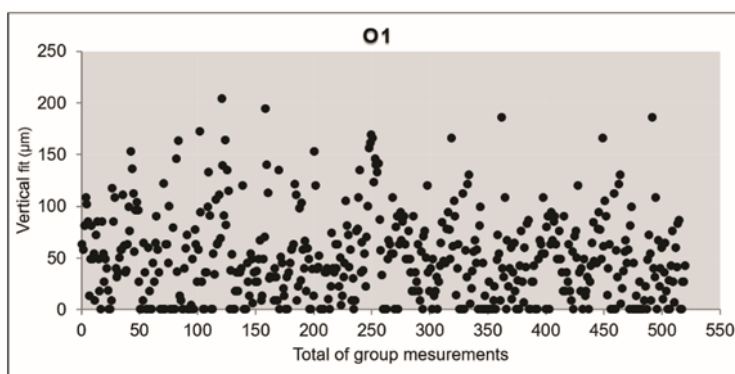


Fig 3-b. Vertical measurements – O2 system.

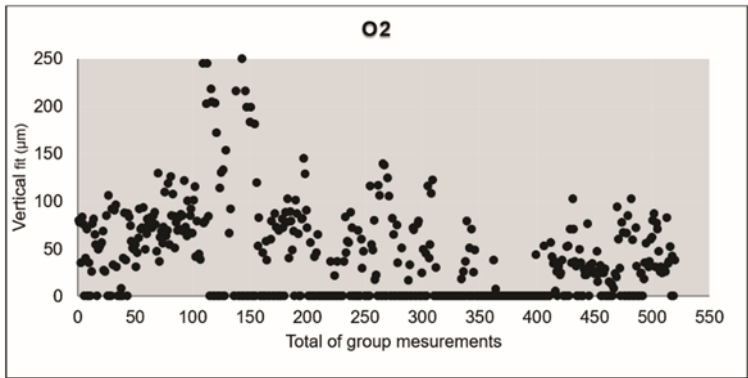


Fig 3-c. Vertical measurements – PS system.

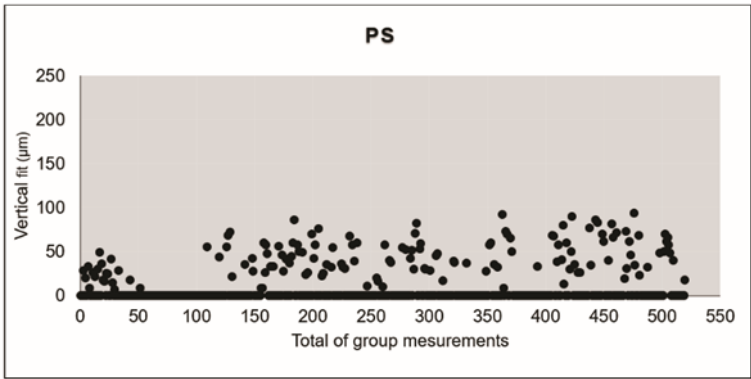


Fig 3-d. Horizontal measurements – O1 system.

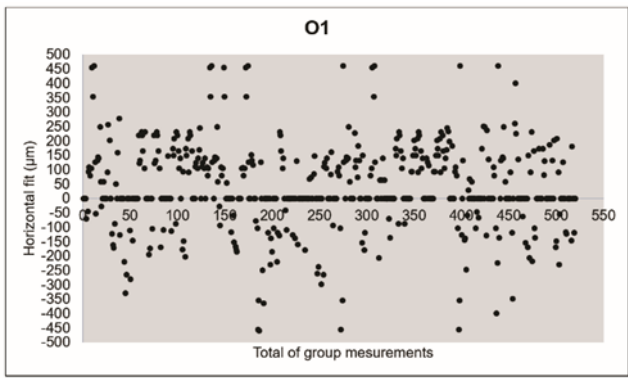


Fig 3-e. Horizontal measurements – O2 system.

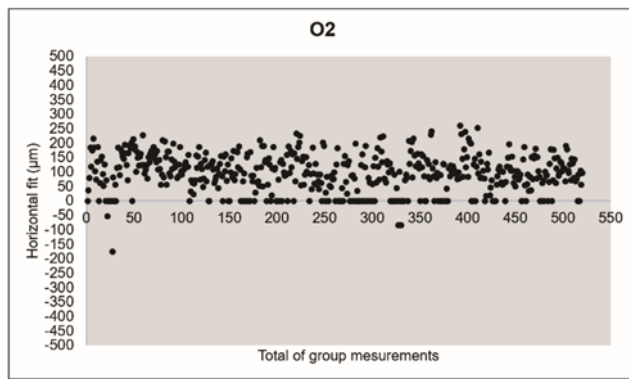


Fig 3-f. Horizontal measurements – PS system.

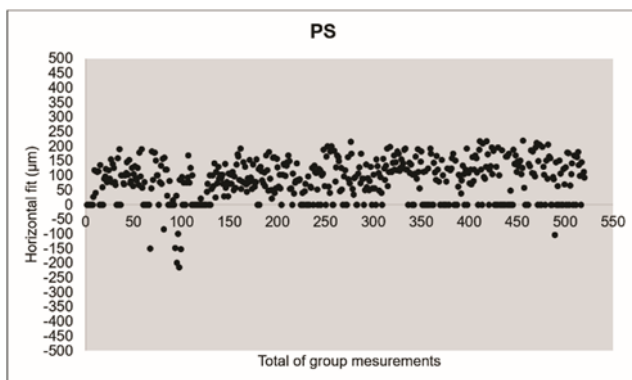
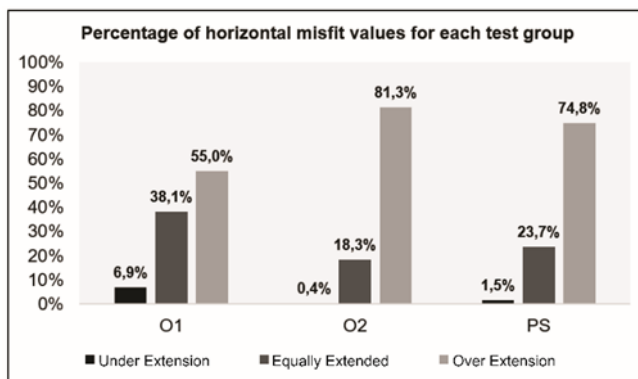


Fig 4. Percentage of horizontal misfit values for each test group.



## The Journal of Prosthetic Dentistry: norms submission

The study complies with the standards of *The Journal of Prosthetic Dentistry*.



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#### Some Elements of Effective Style

Short words. Short words are preferable to long ones if shorter word is equally precise. Familiar words. Readers want information that they can grasp easily and quickly. Simple, familiar words provide clarity and impact. Specific rather than general words. Specific terms pinpoint meaning and create word pictures; general terms may be fuzzy and open to varied interpretations. Brisk opening. Plunge into your subject in the first paragraph of the article. Limited use of modifying words and phrases. Check your adjectives, adverbs, and prepositional phrases. If they are not needed, strike them out. No unnecessary repetition. An idea may be repeated for emphasis—so long as that repetition is effective. Short sentence length. Twenty words or less is recommended. Rambling sentences cluttered with subordinate clauses and other modifiers are hard to read and may cause readers to lose their train of thought. Short sentences should, however, be balanced with somewhat longer ones to avoid monotony. Paragraphs. Break up long sections into paragraphs but avoid the use of single sentence paragraphs. Restraint. Writers who use flamboyant words or overstate their proposition or conclusions discredit themselves. Facts speak for themselves. Clearly stated conclusions. Don't hedge. If you don't know something, say so.

#### Objectionable Terms

The following are selected objectionable terms and their proper substitutes. For a complete list of approved prosthodontic terminology, consult the eighth edition of the *Glossary of Prosthodontic Terms* (J Prosthet Dent 2005;94:10-92).

Or visit JPD <http://www.prosdent.org> and click on Collections/Glossary of Prosthodontic Terms.

Alginate *use* Irreversible hydrocolloid Bite *use* Occlusion Bridge *use* Partial fixed dental prosthesis Case *use* Patient, situation, or treatment as appropriate Cure *use* Polymerize Final *use* Definitive Freeway space *use* Interocclusal distance Full denture *use* Complete denture Lower (teeth, arch) *use* Mandibular Model *use* Cast Modeling compound *use* Modeling plastic impression compound Muscle trimming *use* Border molding Overbite, overjet *use* Vertical overlap, horizontal overlap Periphery *use* Border Post dam, postpalatal seal *use* Posterior palatal seal Prematurity *use* Interceptive occlusal contact Saddle *use* Denture base Study model *use* Diagnostic cast Take impressions, photographs, radiographs *use* Make Upper (teeth, arch) *use* Maxillary X-ray, roentgenogram *use* Radiograph

In addition, *specimen* should be used rather than *sample* when referring to an example regarded as typical of its class.

### **Additional Terminology Guidelines**

#### **Acrylic**

An adjective form that requires a noun, as in acrylic resin.

#### **Affect, effect**

Affect is a verb; effect is a noun.

#### **African American**

Spelled thus and preferred over Negro and black in both adjective (African American patients) and noun (... of whom 20% were African Americans) forms.

#### **Average, mean, median**

Mean and average are synonyms. Median refers to the midpoint in a range of items; the midpoint has many items above as below it.

#### **Basic**

Like fundamental, this word is often unnecessary. An example of unnecessary use: Dental implants consist of two basic types: subperiosteal and endosteal.

#### **Between, among**

Use between when 2 things are involved and among when there are more than 2.

#### **Biopsy**

This noun should NOT be used as a verb. A biopsy was performed on the Tissue, rather than: The tissue was biopsied.

#### **Centric**

An adjective that requires a noun, as in centric relation.

#### **Currently, now, at present, etc.**

These expressions are often unnecessary, as in: This technique is currently being used...

#### **Data**

Use as a plural, as in: The data were...

#### **Employ**

Should not become an elegant variation of use, as in This method is employed ...

#### **Ensure**

Preferred over insure in the sense of to make certain.

#### **Fewer, less**

Use fewer with nouns that can be counted (fewer patients were seen) and less with nouns that cannot be counted (less material was used).

#### **Following**

After is preferred.

#### **Imply, infer**

The speaker implies; the listener infers.

**Incidence**

The rate at which a disease occurs in a given time; sometimes confused with prevalence (the total number of cases of a disease in a given region).

**Majority**

Means more than half; use most when you mean almost all. **Male, female**

For adult humans, use men and women. For children, use boys and girls.

**Must, should**

Must means that the course of action is essential. Should is less strong and means that the course of action is recommended.

**Numbers**

Spell out numbers used in titles or headings and numbers at the beginning of a sentence. The spelled version may also be preferable in a series of consecutive numbers that may confuse the reader (eg, 2 3.5-inch disks should be written two 3.5-inch disks). In all other cases, use Arabic numerals.

**Orient**

Proper form; avoid orientate.

**Pathologic**

Use instead of pathological. Other words in which the suffix -al has been dropped include biologic, histologic, and physiologic.

**Pathology**

The study of disease; often mistaken for pathosis (the condition of disease)

**Percent**

Use the percent sign in the text, as in The distribution of scores was as follows: adequate, 8%; oversized, 23%; and undersized, 69%. But spell out when the percent opens a sentence, as in Twenty percent of the castings ...

**Prior to**

Before is preferred.

**Rare, infrequent, often not, etc.**

Whenever possible, these vague terms should be backed up with a specific number.

**Rather**

Like very, this word should be avoided.

**Regimen**

A planned program for taking medication, dieting, exercising, etc. Not to be confused with regime, meaning a system of government or management.

**Sex**

Use "sex" rather than "gender" unless you are referring to the socially constructed roles, behaviors, activities, and attributes that a given society considers appropriate for men and women.

**Symptomatology**

The science or study of symptoms; this word is not a synonym for the word symptoms.

**Technique**

Preferred over technic.

**Using**

Avoid the dangling modifier in sentences such as "The impression was made using vinyl polysiloxane impression material." Write "with" or "by using" instead.

**Utilize**

Use is preferred.

**Vertical**

An adjective that needs a noun, as in vertical relation.

**Via**

Use through, with, or by means of.

**White**

Preferred over Caucasian. This is true only if the patient is from the Caucasus region of Eastern Europe. If not, use the term, white to describe the patient.

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