Short Communication

Comparative Analysis of Two Measurement Methods for Marginal Fit in Metal-Ceramic and Zirconia Posterior FPDs

Esther Gonzalo, DDS, Dr Odont[a]/María J. Suárez, MD, Dr Med, DDS, Dr Odont[b]/
Benjamín Serrano, MD, DDS, Dr Odont[c]/José F. L. Lozano, MD, Dr Med, DDS[d]

The purpose of this study was to compare two measurement methods for the external marginal fit of zirconia posterior fixed partial dentures (FPDs) fabricated using computer-aided design/manufacturing technology and metal-ceramic posterior FPDs fabricated using the conventional lost-wax technique. The null hypothesis was that there would be no differences between the measurement methods. Forty standardized steel specimens were prepared to receive posterior three-unit FPDs. Specimens were divided into four groups (n = 10): *(1)* metal-ceramic, *(2)* Procera Bridge Zirconia, *(3)* Lava AllCeramic System, and *(4)* Vita In-Ceram YZ 2000. All FPDs were luted with glass-ionomer cement (Ketac Cem EasyMix, 3M ESPE). Two measurement methods were used to analyze marginal fit: an image analysis (IA) program and a scanning electron microscope (SEM) (JEOL JSM-6400) with magnifications of ×40 and ×1,000, respectively. Marginal fit was measured at the same point on each abutment. Significant interaction was observed between measurement method and material (P = .0019). Therefore, the measurement method is not independent of the restoration material. Differences among groups were observed for IA (P = .0001) and SEM (P = .0013). Significant differences were observed for the Procera (P = .0050) and metal-ceramic (P = .0039) specimen groups when both measurement methods were evaluated separately. Accuracy of fit achieved by the four groups analyzed was within the range of clinical acceptance, yielding Procera Bridge Zirconia to have the best marginal fit using both measurement methods. *Int J Prosthodont 2009;22:374–377.*

Over the last 2 decades, interest in more esthetically pleasing and metal-free restorations has increased the demand for all-ceramic restorations, and several systems are currently available that employ sophisticated computer-aided design/manufacturing (CAD/CAM) technology. Furthermore, in an attempt to meet the requirements for dental materials and improve strength and toughness, several new ceramic materials have been developed, zirconium oxide being the one considered to fulfill all the criteria for an ideal dental restorative material. Thus, recent progress in material technology and manufacturing procedures has extended the indications not only for single-crown restorations, but also for fixed partial dentures (FPDs).

In addition to esthetics and fracture resistance, good marginal fit is one of the most important criteria for the long-term success of all-ceramic restorations. Previous studies have demonstrated wide variations in marginal fit for different all-ceramic systems,[1] one of the reasons being the different measurement methodologies used among them. Because of the large variations in the results and the limited studies about the new zirconium oxide ceramics, especially in posterior FPDs, the authors considered it important to evaluate the marginal discrepancies of these restorations.

[a]*Research Student, Department of Buccofacial Prosthesis, Faculty of Odontology, University Complutense, Madrid, Spain.*
[b]*Professor and Vicerrector, Department of Buccofacial Prosthesis, Faculty of Odontology, University Complutense, Madrid, Spain.*
[c]*Associate Professor, Department of Buccofacial Prosthesis, Faculty of Odontology, University Complutense, Madrid, Spain.*
[d]*Chairman, Department of Buccofacial Prosthesis, Faculty of Odontology, University Complutense, Madrid, Spain.*

Correspondence to: *Dr María J. Suárez, Department of Buccofacial Prosthesis, University Complutense, Pza Ramón y Cajal s/n, 28040 Madrid, Spain. Fax: +34 913941910. Email: mjsuarez@odon.ucm.es*

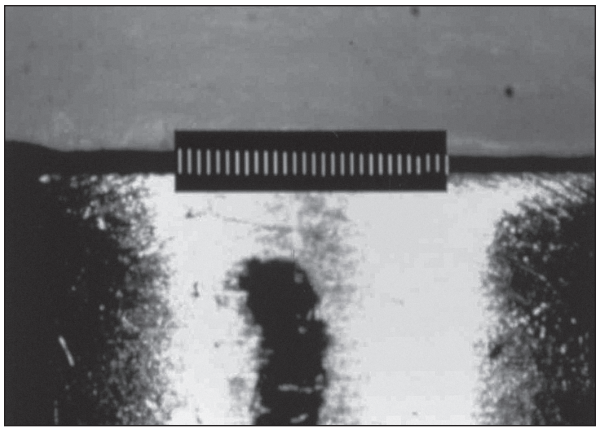

Fig 1 IA photograph showing the window (1,500 × 300 μm) with 30 measures (white lines) in a Lava specimen; magnification ×40.

The purpose of this study was to compare the in vitro marginal fit data obtained with two measurement methods in zirconia posterior FPDs fabricated using CAD/CAM technology and metal-ceramic posterior FPDs fabricated using the conventional lost-wax technique. The null hypothesis was that there would be no differences in marginal adaptation between the measurement methods.

Materials and Methods

Forty standardized steel specimens with two abutments screwed onto a base (30 mm long, 17 mm wide, 4.5 mm thick) were prepared to receive posterior three-unit FPDs. All FPDs were constructed with one pontic and two abutments, one on each side of the pontic. The finish line of the abutments was a chamfer 1 mm deep circumferentially. The angle of convergence was 6 degrees, simulating clinical conditions. Specimens were divided into four groups (n = 10): *(1)* metal-ceramic, *(2)* Procera Bridge Zirconia, *(3)* Lava AllCeramic System, and *(4)* Vita In-Ceram YZ 2000. Each zirconia FPD was fabricated according to the manufacturer's instructions by an experienced technician, and metal-ceramic restorations were fabricated following the traditional lost-wax technique. All FPDs were luted with glass-ionomer cement (Ketac Cem EasyMix, 3M ESPE) and a standardized load of 10 N/cm^2 was applied for 10 minutes with a dynamometric key (USAG 820/70, Utensilerie SpA).

Two measurement methods were used for analyzing marginal fit: *(1)* an image analysis (IA) system, consisting of IA software (OPTIMAS 6.1, Optimas Corporation) in combination with an Olympus microscope with a magnification of ×40 and a charge-coupled device Sony camera that captured the zone to be analyzed, and *(2)* a scanning electron microscope (SEM) (JEOL JSM-6400) with a magnification of ×1,000, in conjunction with the software INCA Suite 4.04 (Oxford Instruments). The marginal fit was measured for every abutment on each restoration at the same point in the middle of the buccal and lingual surfaces, marked with an indelible marking pen. Fit was assessed by measuring the vertical distance between the crown margin and preparation cavosurface angle. Measurements were always taken at the same points in both measurement systems. Each specimen was positioned leaning on a base (that served as orientation of the marginal discrepancy measuring points) at an angle of 25 degrees so that the interface was positioned perpendicular to the optic axis of both microscopes. In the IA method, the software analyzed an area of 30 points for each selected area (Fig 1). Therefore, 120 measurements (60 per abutment) were recorded for each specimen. In the SEM method, 60 measurements for each specimen were recorded (30 per abutment).

The data obtained were statistically analyzed using two-way repeated measures analysis of variance (ANOVA). One-way ANOVA and the Duncan multiple range post-hoc test were performed for a multicomparison analysis among the groups for each measurement method. One-way repeated measures ANOVA was used for evaluating both measurement methods in each group.

Results

The Procera group showed lower discrepancies than the other groups with both methods (IA = 12 ± 9 μm; SEM = 26 ± 19 μm) and significant differences were demonstrated ($P = .0001$ and $P = .0013$, respectively). The Lava and metal-ceramic groups showed similar discrepancies with IA (71 ± 45 μm and 76 ± 29 μm, respectively), but SEM revealed lower values for the metal-ceramic group (65 ± 26 μm) compared with the Lava group (76 ± 37 μm). No significant differences were observed between both groups. Measurements obtained using IA were lower than with SEM except for those of the metal-ceramic group (Fig 2). The accuracy of fit achieved for the three all-ceramic groups analyzed was within the range of clinical acceptance (< 100 μm) (Fig 3).

Two-way repeated measures ANOVA showed significant interaction ($P = .0019$) between measurement method and material. Thus, the method of measurement is not independent of the material used (Fig 4).

As a consequence of this interaction, differences among groups were evaluated separately for each measurement method. Significant differences were observed for IA ($P = .0001$), showing Duncan test differences between Procera and the other groups and

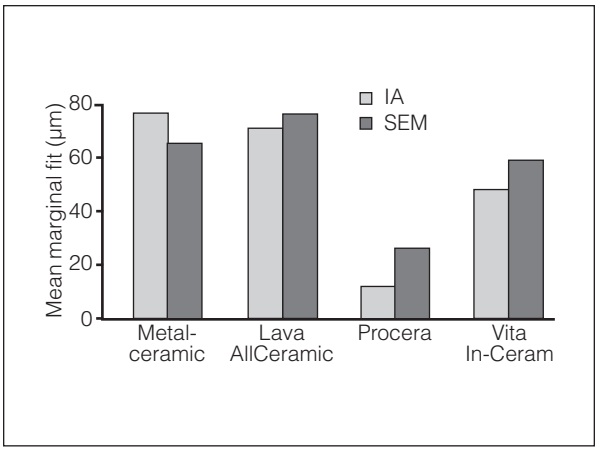

Fig 2 Mean value of the marginal fit for both measurement methods (IA and SEM) in all groups.

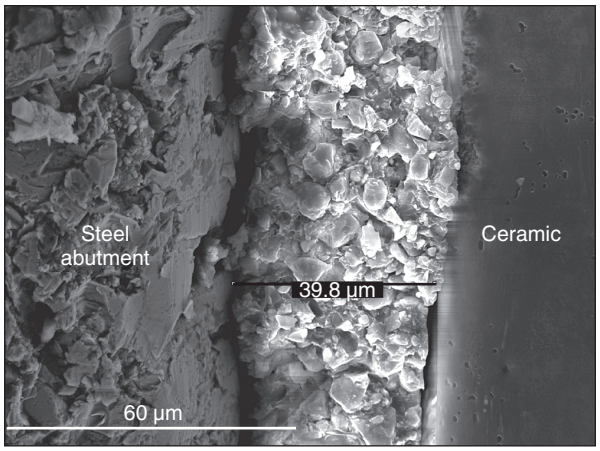

Fig 3 SEM photograph showing the marginal gap of an In-Ceram YZ specimen; magnification ×1,000.

between the In-Ceram YZ and metal-ceramic groups. Significant differences were also observed for SEM between Procera and the other groups ($P = .0013$).

In the same way, differences between both measurement methods were evaluated separately for each of the four groups, showing one-way ANOVA significant differences for the Procera ($P = .0050$) and metal-ceramic ($P = .0039$) groups.

Discussion

An important factor that ensures the long-term success of fixed prosthodontic restorations is the precision of the margins. Inadequate adaptation of the restoration may be detrimental for the tooth and the periodontal supporting tissue. Two significant internal and external precise methods are used to analyze marginal fit of the restoration. Studies investigating the internal marginal fit are mostly based on measurements of sectioned teeth. Although extremely accurate, these measurements result in the destruction of the restoration and consequently are of little use in clinical practice.[2] Other authors have used cross-sectional measurements with an impression material instead of a luting cement. This type of in vitro evaluation has inherent errors, such as a cut being oblique and resulting in the introduction of error into the measurement.[3] Recently, an innovative method for evaluation of the internal three-dimensional fit of crowns was developed, based on the registration of point clouds of duplicate gypsum dies on a CAD surface model that was identical to the metal master die. The results were shown to be suitable for this purpose.[4] Direct viewing with external measurements has the advantage of being noninvasive and is therefore useful in clinical practice to determine the precision of the marginal fit. However, it is difficult to repeat the measurements from an identical angle.[2]

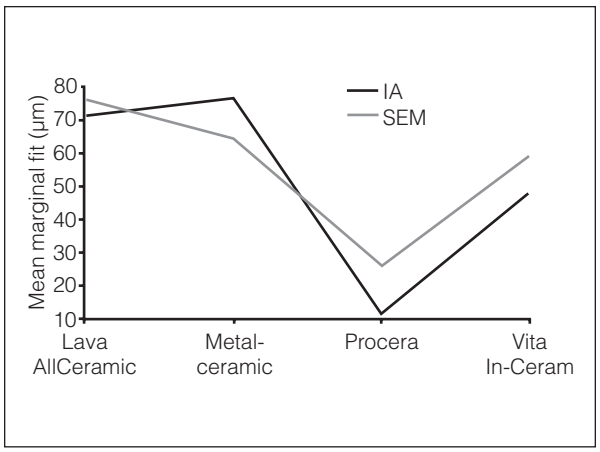

Fig 4 Interaction between materials and measurement method.

Although various protocols have been proposed to analyze marginal precision, no general guideline exists on how to perform gap measurements.[2,4]

For this in vitro study, vertical marginal fit was evaluated. Although it is difficult to be certain that only this marginal gap has been measured and to repeat the measurements from an identical angle, these aspects could be minimized by two factors: the use of experimental restorations, which had a better-defined and more regular margin and were thus easier to align with the focal plane of the microscope, and the positioning of the restorations in a base to ensure that the measurements were always taken at the same points. In this study, horizontal, absolute, or internal marginal discrepancies were not taken into consideration, and it is necessary to keep in mind the important clinical implications of these discrepancies. Further studies will be necessary to confirm the results obtained concerning these topics.

Opinions on the clinical relevance of the size of marginal discrepancies are controversial. Most authors agree that marginal discrepancies in the range of 100 µm seem to be clinically acceptable with regard to longevity of the restorations.[1,2,4] According to these authors, the results of this study are within acceptable standards. Previous studies were taken into consideration regarding the minimum number of measurements to ensure relevant results,[2] and all measurements were performed by the same technician to avoid statistical variance as much as possible.

In the present study, differences were observed between both measurement methods for the metal-ceramic and Procera groups, but it could not be demonstrated which was best. All three zirconia CAD/CAM systems had similar trends with regard to measuring techniques; the measurements with IA were lower than those with SEM. It was thought that the operator measurements would be influenced similarly, but measurements for the metal-ceramic group were higher with IA when compared to SEM. The results revealed that measurement method is not independent of the material analyzed. Furthermore, it should be taken into consideration that the manufacturing processes of the restorations were different, so this could be another factor that may have contributed to the results.

The study comparing measurement methods was first performed by Groten et al[5] and their results are not in agreement with the present ones. They could not demonstrate differences between the two analyzing systems employed since they only analyzed one material. However, differences between methods observed in their study were less than ± 15 µm, similar to in the present study.

Conclusion

The results of this study show that the two measurement methods analyzed showed differences for each material analyzed. Therefore, measurement method is not independent of the material composing the restoration. It is important to establish a standardized method to analyze marginal fit of fixed prosthodontic restorations.

Acknowledgments

This study is part of a larger experimental study on fracture strength and marginal fit of zirconia posterior FPDs and was supported by a Research Project between the University Complutense and 3M España (no. 26-2005) and Nobel Biocare Ibérica (no. 322-2005) through the second author.

The authors would like to thank Vita Zahnfabrik for the contribution of the ceramic material; the dental laboratories Dident, Poveda, and Prótesis for their technical advice and for manufacturing the FPDs; Dr Guillermo Caruana, National Centre for Metallurgical Research, for his assistance with the image analysis program; and Dr Ricardo García, Centre of Data Processing, Computing Service for Research Support, University Complutense of Madrid, for his assistance with the statistical analysis.

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