Marginal Vertical Discrepancies of Monolithic and Veneered Zirconia and Metal-Ceramic Three-Unit Posterior Fixed Dental Prostheses

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Purpose: The aim of this study was to investigate and compare the marginal fit of posterior fixed dental prostheses (FDPs) made of monolithic and veneered computer-aided design/computer-assisted manufacture (CAD/CAM) zirconia ceramic with metal-ceramic posterior FDPs. ***Materials and Methods:*** Thirty standardized steel dies were prepared to receive posterior three-unit FPDs. Specimens were randomly divided into three groups (n = 10): *(1)* metal-ceramic (control group), *(2)* veneered zirconia, and *(3)* monolithic zirconia. All FDPs were cemented using a glass-ionomer cement. The specimens were subjected to thermal cycling (5°C to 55°C). A scanning electron microscope (SEM) with a magnification of ×500 was used for measurements. The data were statistically analyzed using one-way analysis of variance and paired *t* test. ***Results:*** Both zirconia groups showed similar vertical marginal discrepancies, and no significant differences ($P = .661$) in marginal adaptation were observed among the groups. No differences were observed in either group in marginal discrepancies between surfaces or abutments. ***Conclusion:*** Monolithic zirconia posterior FDPs exhibit similar vertical marginal discrepancies to veneered zirconia posterior FDPs. No influence of localization measurements was observed. *Int J Prosthodont 2016;29:256–258. doi: 10.11607/ijp.4541*

The combination of zirconia-based material with computer-aided design/computer-assisted manufacture (CAD/CAM) technology has increased the range of application of these materials in dentistry. Zirconia ceramic has excellent mechanical properties[1] but is highly opaque, so the framework must be covered with veneering porcelain for a more acceptable esthetic outcome. However, failure of the veneering porcelain has been identified as a common complication.[2] Recently, monolithic zirconia restorations have been introduced as an alternative to zirconia veneered with feldspathic porcelain to eliminate chipping failures of veneer ceramics.

Although accuracy of fit has a considerable effect on the clinical success of the restorations,[3] to date no studies are available with regard to the marginal fit of monolithic zirconia in comparison with veneered zirconia in posterior fixed dental prostheses (FDPs).

The aim of this study was to investigate and to compare the marginal fit of posterior FDPs made of monolithic and veneered zirconia ceramics manufactured using CAD/CAM technology with that of metal-ceramic posterior FDPs, and to analyze the differences between abutments and between vestibular and lingual surfaces. The null hypothesis was that there would be no differences between the zirconia ceramic systems and metal-ceramic restorations, abutments, and surfaces.

Materials and Methods

Thirty standardized master steel dies with two abutments and a base were prepared to receive posterior three-unit FDPs. Abutments were prepared with a 1-mm-wide chamfer and a 6-degree angle of convergence of the axial walls. Specimens were randomly divided into three groups (n = 10): *(1)* metal-ceramic (control group), *(2)* veneered zirconia (Lava Zirconia, 3M ESPE), and *(3)* monolithic zirconia (Lava Plus, 3M ESPE). The metal-ceramic FDPs were fabricated using the conventional lost-wax technique and cast with a chromium-cobalt (Cr-Co) alloy (Ugirex C, Ugin Dentaire), using an induction vacuum/pressure casting machine. The zirconia restorations were prepared according to the manufacturer's specifications by the same experienced technician. The process of fabricating the zirconia CAD/CAM restorations consisted of scanning and digitizing the steel abutments with the

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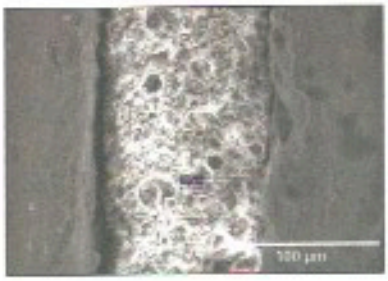

Fig 1 *(left)* Scanning electron microscopy image showing the marginal discrepancy of a Lava Zirconia specimen (×500 magnification).

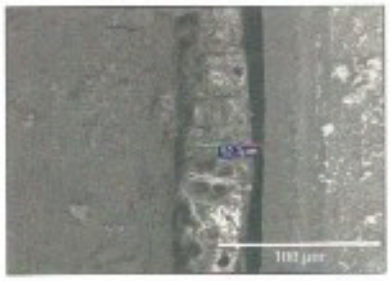

Fig 2 *(right)* Scanning electron microscopy image showing the marginal discrepancy of a Lava Plus specimen (×500 magnification).

Lava Scan (3M ESPE) and designing the structures using the system software (Lava CAD, 3M ESPE). Frameworks were milled from presintered yttria-stabilized zirconium oxide blanks in the Lava Form (3M ESPE) and sintered in the Lava Therm (3M ESPE). The Lava Zirconia specimens were veneered with the Lava Ceram ceramic (3M ESPE), and the Lava Plus specimens were not veneered. A digital caliper (Mitutoyo) was used to ensure that the porcelain thickness was correct in the metal-ceramic and veneered zirconia specimens. All FDPs were cemented using a glass-ionomer cement (Ketac Cem EasyMix, 3M ESPE). Each FDP was seated on the abutments with firm finger pressure, amounting to a uniformly distributed load of 10 N during 10 minutes, determined with a dynamometric key (USAG 820/70, Utensilerie). The specimens were subjected to 1,000 thermal cycles (Thermocycling TC-3, SD Mechatronik), at 5°C and 55°C with a 30-second dwell time to simulate aging of the restorations in vivo.

To standardize the marginal fit analysis, specific landmarks were traced with an indelible pen (Lumocolor Permanent, Staedtler) in the middle of the vestibular and lingual surfaces of each abutment, to ensure repeatable positions. The fit was assessed by measuring the distance between the crown margin and the preparation cavosurface angle.

A SEM (JSM-6400, Jeol) with a magnification of ×500 was used for measurements. A total of 60 measurements were recorded for each specimen (30 per abutment, 15 per each vestibular and lingual surface). Measurements were always taken at the same points, and each specimen was positioned in a base perpendicular to the optical axis of the microscope at a constant angle (25 degrees). To compare the marginal discrepancy on abutments, the measurement means obtained from both surfaces of the abutments were calculated for each specimen. Measurements for each FDP were averaged, and this was used to determine the mean marginal discrepancy of each group.

The data obtained were statistically analyzed using one-way analysis of variance for comparisons among the groups, and Student paired *t* test to compare surfaces and abutments for each group analyzed.

Table 1 Mean and Standard Deviation of the Marginal Discrepancies for Surfaces and Abutments in Each Group

Group	Surface	Mean (μm)	SD (μm)	Abutment (n)	Mean (μm)	SD (μm)
MC (n = 10)	V	73	46	1	64	25
	L	56	19	2	65	29
LZ (n = 10)	V	76	46	1	69	26
	L	76	31	2	84	55
LM (n = 10)	V	72	44	1	84	53
	L	83	63	2	71	32

SD = standard deviation; MC = metal-ceramic; LZ = Lava Zirconia; LM = Lava Plus; V = vestibular; L = lingual.

Statistical significance was set at $P < .05$. SAS 9.1 statistical software (SAS Institute) was used for the analysis.

Results

Table 1 shows the means and standard deviations for the groups and the variables analyzed. The marginal gaps for the experimental groups were within the clinically acceptable range. The Lava Zirconia and Lava Plus groups showed similar vertical marginal discrepancies (76.2 ± 36.3 μm and 77.4 ± 38.9 μm, respectively), and no significant differences ($P = .661$) in marginal discrepancies were observed among the groups (Figs 1 and 2).

When differences in marginal discrepancies between abutments were analyzed, the paired *t* test showed no differences for Lava Zirconia ($P = .3$), Lava Plus ($P = .3$), or metal-ceramic ($P = .9$). No significant differences were observed in marginal discrepancies between vestibular and lingual surfaces for the Lava Zirconia ($P = .9$), Lava Plus ($P = .6$), and metal-ceramic ($P = .2$) groups (Fig 3).

Discussion

This study evaluated the vertical marginal fit of monolithic, veneered zirconia-based ceramic and metal-ceramic posterior FDPs. The data obtained support the acceptance of the null hypothesis because no differences were observed among the groups or between surfaces or abutments.

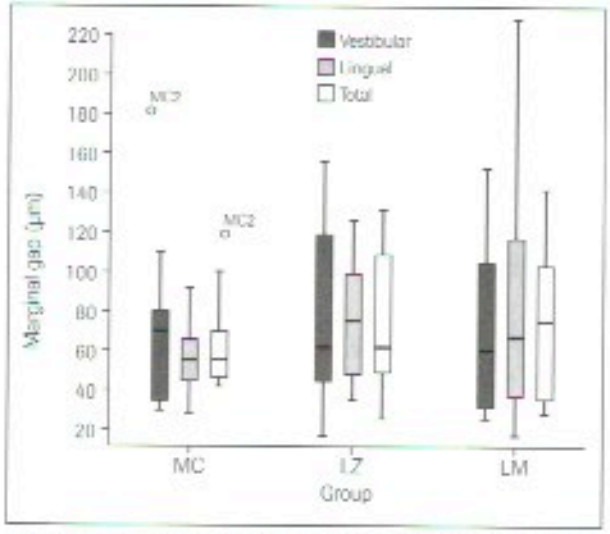

Fig 3 Box plot of the marginal gap measurements in the metal-ceramic (MC), Lava Zirconia (LZ), and Lava Plus (LM) groups.

Veneered zirconia restorations have several drawbacks. Chipping of the veneering ceramic is one of the main problems, with chipping rates higher than those of metal-ceramic restorations.[1,4] Several trials have been performed in an attempt to reinforce the veneering porcelain, but the obvious way to avoid the chipping is to replace the veneer/core bilayer with a monolithic ceramic, which consists of a single zirconia material without veneering. Monolithic zirconia restorations exhibit markedly superior chipping and fracture resistance relative to their porcelain-veneered counterparts, as previously reported.[5]

Although no studies have reported results with respect to monolithic zirconia FDPs, previous studies have evaluated the marginal fit of zirconia restorations.[3,4] In the present study, the measurements of marginal fit exhibited discrepancies in the range of clinical acceptance (< 100–120 µm) according to previous studies.[3]

In this study, no differences were observed between abutments and surfaces for the zirconia systems analyzed, in accordance with a previous study.[3] This could be explained by the fact that the same technician fabricated all the restorations, avoiding the possibility that different technicians involved in the fabrication of the restorations could influence the results.[3]

Although monolithic zirconia FDPs provided excellent fit of < 100 µm, this study had some limitations. One was that the restorations were fabricated under standardized conditions. Another limitation could be that today many CAD/CAM prostheses are made from digital impressions with no master die to refer back to for fit. To date digital impressions are not used routinely by all clinicians, and not all digital impressions systems have the same accuracy. Thus, in the present study digital impressions were not taken to avoid the inherent error that could be introduced by the intraoral scans. The study was focused on marginal discrepancies of monolithic and veneered zirconia FDPs, and only two CAD/CAM zirconia systems were analyzed. Certainly, the authors were aware that there are other zirconia systems that may provide different results. However, the zirconia systems analyzed in the study were provided by the same company, allowing comparison of the results between the two zirconia systems. Thermocycling was used to artificially age the specimens. However, there is a lack of standardization in that the parameters (ie, bath temperature, number of cycles, dwell times) and regimens used, with few exceptions, are proposed without reference to in vivo evaluations. Horizontal fit was not evaluated, and it is important to keep in mind the clinical implications of this discrepancy. Therefore, more studies on marginal discrepancy of monolithic zirconia, using thermocycling, with larger samples accompanied by long-term follow-up clinical trials are needed.

Conclusions

The results of this study show that monolithic zirconia posterior FDPs exhibit similar vertical marginal discrepancies to veneered zirconia posterior FDPs, and the accuracy of fit achieved by both zirconia systems analyzed and the metal-ceramic group was within the range of clinical acceptance. No influence of localization measurements was observed.

Acknowledgments

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References

1. Tinschert J, Natt G, Mautsch W, Augthun M, Spiekermann H. Fracture resistance of lithium disilicate-, alumina-, and zirconia-based three-unit fixed partial dentures: A laboratory study. Int J Prosthodont 2001;14:231–238.
2. Pelaez J, Cogolludo PG, Serrano B, Serrano JF, Suarez MJ. A four-year prospective clinical evaluation of zirconia and metal-ceramic posterior fixed dental prostheses. Int J Prosthodont 2012;25:451–458.
3. Gonzalo E, Suárez MJ, Serrano B, Lozano JF. Marginal fit of posterior Zirconia FPDs. Int J Prosthodont 2008;21:398–399.
4. Heintze SD, Rousson V. Survival of zirconia- and metal-supported fixed dental prostheses: A systematic review. Int J Prosthodont 2010;23:493–502.
5. Zhang Y, Lee JJ, Srikanth R, Lawn BR. Edge chipping and flexural resistance of monolithic ceramics. Dent Mater 2013;29:1201–1208.