Radiopacity of Zirconia-Based All-Ceramic Crown Systems

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The aim of this study was to evaluate the radiopacity of the core and veneer ceramics in four zirconia-based crown systems: In-Ceram Zirconia, In-Ceram YZ, Procera Zirconia, and Cercon. Two-millimeter-thick restoration slices were prepared and digitally radiographed alongside an aluminum stepwedge. The grayscale data were converted into millimeters of aluminum by an image analysis program. The two-way analysis of variance test detected significant differences with respect to all-ceramic system, layer ceramic, and the interaction of the two factors (P = .0001). All materials presented radiopacity values above the minimum recommended by the International Organization for Standardization. *Int J Prosthodont 2011;24:144–146.*

The demand for all-ceramic restorations has increased substantially because of their esthetics and biocompatibility. One of the most significant advances in this field has been the introduction of zirconia-based ceramic materials. These systems use the concept of computer-aided design/computer-assisted manufacturing to fabricate all-ceramic crowns and fixed partial dentures composed of a zirconium oxide ceramic framework combined with a compatible veneering feldspathic porcelain.[1,2]

Radiopacity is a valuable property that allows the clinician to assess the adequacy of the restorations, distinguish secondary caries, and evaluate marginal adaptation, voids, and interfacial gaps. In addition, adequate radiopacity plays an important role in detecting aspirated or dislocated restorations. It thus serves as an important diagnostic tool when evaluating the long-term success of restorations. However, only limited information is available on the radiographic properties of current all-ceramic restorative materials. The aim of this study was to evaluate the radiopacity of the core and veneer ceramics in four zirconia-based crown systems: In-Ceram Zirconia (Vita Zahnfabrik), In-Ceram YZ (Vita Zahnfabrik), Procera Zirconia (Nobel Biocare), and Cercon (Dentsply). The null hypothesis to be tested was that there would be no difference in radiopacity among the tested systems.

Materials and Methods

Twenty standardized liquid crystal polymer (Vectra B950, Ticona) specimens were prepared to receive all-ceramic crowns. Liquid crystal polymer was chosen as the abutment material because it allows for the preparation of identical artificial teeth and provides a suitable radiolucency to analyze the radiopacity of the restorative materials. All restorations were fabricated according to their respective manufacturers' recommendations. For the In-Ceram Zirconia group, five cores were produced and veneered with Vita VM 7 (Vita Zahnfabrik). For the In-Ceram YZ group, five copings were fabricated and veneered with Vita VM 9 (Vita Zahnfabrik). For the Cercon group, five cores were produced and veneered with Cercon Ceram S (Dentsply). For the Procera group, five copings were industrially manufactured and veneered with Nobel Rondo Zirconia (Nobel Biocare). All crowns were cemented onto their respective abutments using resin cement (Panavia 21, Kuraray). A special cementing device connected to a manual torque wrench (Astra Tech) was used to ensure that the crown was loaded axially at a constant pressure of 10 N/cm^2 until complete seating of the material. The specimens were sectioned mesiodistally with a rotary cutting machine (Isomet, Buehler). Slices were wet-polished, and 2-mm-thick specimens were prepared.

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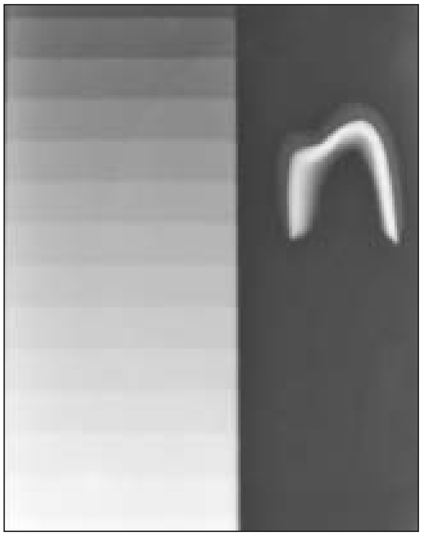

Fig 1 Radiographic image of the aluminum stepwedge and a Cercon specimen slice.

Table 1 Radiopacity Values of the Materials Tested (mm Al)

All-ceramic system	Mean ± SD
In-Ceram Zirconia	
Core material	6.93 ± 0.21
Vita VM 7	1.47 ± 0.73
In-Ceram YZ	
Core material	8.67 ± 0.19
Vita VM 9	1.66 ± 0.39
Cercon	
Core material	8.73 ± 0.14
Cercon Ceram S	1.71 ± 0.36
Procera Zirconia	
Core material	8.89 ± 0.12
Nobel Rondo Zirconia	1.73 ± 0.15

SD = standard deviation.

Each specimen was then digitally radiographed alongside an aluminum stepwedge graduated from 1 to 16 mm Al (in 1-mm increments). Radiographs were taken using a photostimulable phosphor image plate system (Digora Optime, Soredex) and a dental x-ray machine (Oralix AC Densomat, Gendex) operating at 70 kVp, 10 mA, the exposure set at 0.3 seconds, and a focus-film distance of 30 cm (Fig 1). The digital images were analyzed using MetaMorph 7.0 software (MDS Analytical Technologies). For every radiograph, the average grayscale values of the core/veneer ceramics were converted into absorbance notation and compared with that of the reference stepwedge to determine the equivalent radiopacity in terms of millimeters of aluminum per millimeters of material. The data obtained were analyzed statistically using two-way analysis of variance (ANOVA).

Results

The means and standard deviations for the radiopacity values (in mm Al) are shown in Table 1. Two-way ANOVA detected significant differences with respect to all-ceramic system, layer ceramic, and the interaction of the two factors ($P = .0001$). In-Ceram crowns presented the lowest radiopacity, revealing significant differences with respect to the other systems ($P = .0001$). In-Ceram YZ, Cercon, and Procera restorations showed statistically similar radiopacity values ($P > .05$). All core materials tested were more radiopaque than their respective veneering porcelains ($P = .0001$).

Discussion

The radiopacity of restorative materials against the tooth structure allows the diagnosis of secondary caries and detection of voids, gaps, and excess material in the cervical area. The evaluation of the proximal contours of the restoration and their contacts with adjacent teeth can also be evaluated using radiographs. The molecular structure and the thickness of a material have a major effect on the radiopacity. The International Organization for Standardization (ISO) 4049:2000 specification established that the radiopacity of restorative materials should be equal to or greater than that of aluminum alloy 1100 at the same thickness.[3] In the present study, Procera, Cercon, and In-Ceram YZ copings presented the highest radiopacity values. Considering that these ceramics contain yttrium-stabilized tetragonal zirconia polycrystals (Y-TZP), their superior radiopacity is probably derived from the high atomic number and molecular weight of zirconium.[4] However, excessively radiopaque restorations may hinder a clinician's ability to spot marginal defects by the Mach effect.[5] This phenomenon is a visual illusion that enhances the contrast between two areas of different radiopacities, making the dark border area darker. The effect might be misinterpreted as pathosis in certain situations (Fig 2).

In-Ceram Zirconia demonstrated lower radiopacity than the other core materials evaluated. This may be because of the presence of only 33% zirconium oxide in the glass-infiltrated alumina matrix. Hence, core

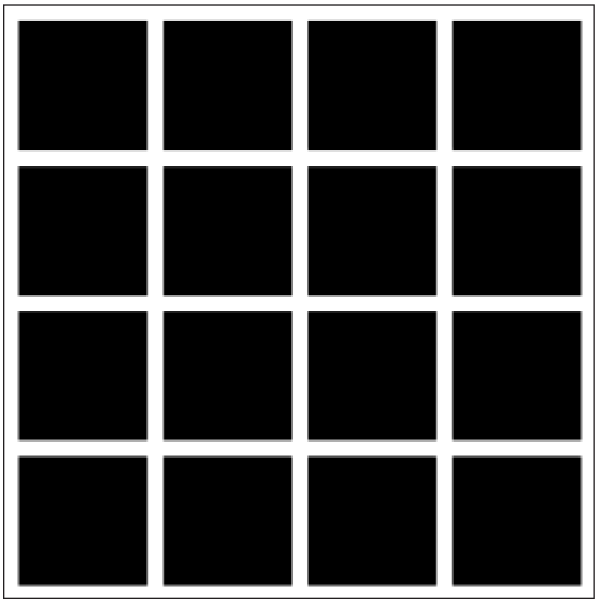

Fig 2 Hermann grid. In the image, there are iridescent gray spots located at the intersections between the black squares. However, those spots disappear when looked at directly. The Mach effect is a phenomenon that plays an important role when a defect is to be diagnosed in connection with a very radiopaque restoration.

materials with a moderate degree of radiopacity are preferable to those with a high degree of radiopacity, such as the Y-TZP ceramics.

Although all veneering porcelains tested met the ISO minimums, they showed the lowest radiopacity values. This could be explained by the small percentage of radiopacifying agents in their formulation (5% zirconia and bismuth oxide).

Conclusion

All ceramic materials investigated in this study exceeded the minimum required radiopacity stipulated by the ISO. However, the use of high-value radiopaque copings may mask imperfections in marginal adaptation, especially when restorations are cemented using radiopaque luting agents.

Acknowledgments

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