Catastrophic failure of a monolithic zirconia prosthesis

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ABSTRACT

Recently, monolithic zirconia restorations have received attention as an alternative to zirconia veneered with feldspathic porcelain to eliminate chipping failures of veneer ceramics. In this clinical report, a patient with mandibular edentulism received 4 dental implants in the interforaminal area, and a screw-retained monolithic zirconia prosthesis was fabricated. The patient also received a maxillary complete removable dental prosthesis over 4 anterior roots. At the 18-month follow-up, all of the zirconia cylinders were seen to be fractured, and the contacting abutment surfaces had lost structural integrity. The damaged abutments were replaced with new abutments, and a new prosthesis was delivered with a computer-assisted design and computer-assisted manufacturing fabricated titanium framework with denture teeth and denture base resins. At the 6-month recall, the patient did not have any problems. Dental zirconia has excellent physical properties; however, care should be taken to prevent excessive stresses on the zirconia cylinders when a screw-retained zirconia restoration is planned as a definitive prosthesis. (J Prosthet Dent 2015;113:86-90)
ISCFDP were planned. The possibility of progressive wear of the maxillary denture teeth against the mandibular zirconia ceramic material was a concern, although results of previous studies reported that well-polished zirconia ceramic causes minimal opposing material wear. Excessive wear of titanium also was expected at the zirconia ceramic–titanium abutment interface because of the hardness of zirconia ceramic; however, smooth titanium and zirconia ceramic surfaces reportedly do not show different amounts of wear. The maxillary right canine was endodontically treated, and its clinical crown was cut to support the planned overdenture. An immediate CRDP was placed after extraction of the maxillary posterior abutments.

On the day of implant surgery, the 1-piece, mandibular, narrow endosteal dental implant was removed, and 4 internal-connection endosteal dental implants of 4.3-mm diameter and 10-mm length (Implant; Warantec, Korea) were placed in the interforaminal area; the healing abutments then were placed. The tissue side of the mandibular CRDP was relieved and resurfaced with a resilient, autopolymerizing reline material (Coe-Soft; GC Intl) to avoid premature loading on the healing abutments. After 3 months of healing, 1-piece, titanium definitive abutments (Multiunit Abutment; Warantec) with flat platforms were placed at the appropriate gingival height. Type III dental stone (CrystalRock; Maruishi Gypsum) was used to fabricate the maxillary, and Type IV dental stone (Die-Keen; Heraeus Kulzer) was used for the mandibular definitive cast.

A verification jig was fabricated from the mandibular definitive cast by connecting the impression copings with an autopolymerizing acrylic resin (Pattern Resin; GC Intl). The 1-screw test was performed in the patient’s mouth to check the fit of the jig and then the jig was cut and rejoined.
to achieve a passive fit. Both right and left distal abutment analogs were removed from the definitive cast and repositioned by using the jig, and interim cylinders (Temporary Cylinder; Waranetc) were connected to both distal abutment analogs. A fixed resin record base with a wax occlusion rim was fabricated with the interim cylinders to obtain the maxillomandibular relationship record; the denture teeth then were arranged for the maxillary and mandibular prostheses. The cantilever length was set at 1.5 times the anteroposterior spread of the planned endosteal dental implants. During the evaluation procedure, the amount of soft tissue support, tooth exposure, and centric relation were reevaluated. The mandibular teeth and gingival contour were impressed by using a high-viscosity silicone elastomeric impression material (Exafl ex Putty; GC Intl) to form a mold. An autopolymerizing bis-acrylic composite resin (Luxatemp; DMG GmbH) was injected into the mold to fabricate a guide for copy milling a zirconia ceramic block (Prettau; Zirkonzahn GmbH). The milled zirconia framework was characterized with a metal-free brush to simulate tooth and gingival color and sintered in a special furnace (Zirkonofen 600; Zirkonzahn GmbH) to obtain its definitive mechanical and optical properties. The fit of the prosthesis was evaluated in the patient’s mouth and considered clinically acceptable, and both the maxillary overdenture and the mandibular ISCFDP were delivered (Fig. 2). A 24-hour follow-up examination was scheduled to identify any soft-tissue irritation or occlusal disharmony.

The patient revisited the clinic at 1, 3, 6, 12, and 18 months. At 12 months, he did not report any discomfort or pain. At the 18-month follow-up examination, slight dislodgment of the mandibular prosthesis was noted. When the 4 prosthetic screws were removed, the zirconia ceramic cylinders were found to be fractured (Fig. 3). The interfacial surfaces of the abutments, especially the distal abutments, had severely deteriorated. The 4 abutments were replaced, and an interim fixed dental prosthesis was fabricated from a bis-acrylic composite resin (Luxatemp; DMG America) by copying the zirconia ceramic prosthesis. The resin guide used for copy milling was converted into a replica by grinding the teeth and gingival portions. A titanium framework was designed and milled on the basis of the replica and the mandibular definitive cast by using a CAD/CAM system (MyPlant; RaphaBio). The patient returned with repeated fractures of the interim composite resin prosthesis at both the distal cylinder areas in spite of wire reinforcement and the addition of composite resin around the cylinders. Therefore, the length of the distal cantilever was reduced. The fit of the titanium framework was evaluated in the patient’s mouth and the denture teeth were arranged (Fig. 4). The mandibular prosthesis was placed in the patient’s mouth, and the patient resumed the regular follow-up visits (Fig. 5). Scanning electron microscopy was used to analyze the deteriorated abutments (Fig. 6).

**DISCUSSION**

This report presents the unexpected short-term failure of a monolithic, zirconia ceramic, screw-retained ISCFDP due to fracture of the zirconia ceramic cylinders and structural deterioration of the titanium abutments. The prosthetic failure could have been caused by inaccurate fit between the zirconia ceramic cylinders and the titanium abutments; inadequate cylinder dimensions, which could have accumulated tensile stresses; and excessive cantilever length, which could have produced excessive stress on the zirconia ceramic cylinders. The ISCFDP was fabricated by using a copy-milling technique; therefore, its accuracy depended on operator skill. Thin or irregular structures could have been introduced by the manual grinding process, and stress accumulation in such areas could have caused...
the fractures. Bonding or cementing metallic cylinders can compensate for machining errors and provide a passive fit (Fig. 7).

The hardness of zirconia ceramic produced excessive wear of the titanium abutments, although a previous study did not show different amounts of wear of smooth titanium and zirconia ceramic surfaces. The prosthesis had multiple fractured irregular surfaces with macro-roughness at the abutment contact area; therefore, structural deterioration of the titanium abutments was accelerated. Evidence of the continuous hammering of a zirconia ceramic cylinder onto the platform of an abutment is shown in Figure 7.

Until now, favorable short-term clinical results of zirconia ceramic, screw-retained frameworks with distal cantilever extensions have been reported. Both studies used between 5 and 8 implants in an arch to fabricate a zirconia prosthesis. Increased numbers of implants could prevent fracture of zirconia cylinders by reducing the amount of load on each zirconia cylinder. However, more implants also increased the difficulty of fabricating a passive fitting prosthesis. In addition, those clinical studies did not describe the cantilever length. Cantilevers of cast gold alloy screw-retained ISCFDPs should not be longer than 1.5 times the anteroposterior spread of the endosteal dental implants. Zirconia ceramic is more vulnerable to tensile stress than gold or titanium alloys; therefore, the maximum cantilever length should be reduced when zirconia ceramic is chosen as the framework material for such prostheses, even though increased numbers of implants could withstand longer cantilever length. Because of its excellent mechanical and biocompatible properties, monolithic zirconia ceramic is an attractive choice for ISCFDPs. However, prosthetic failure was encountered with this treatment. A CAD/CAM-fabricated titanium framework with denture teeth was chosen as the new prosthesis because of its predictable results and long-term clinical success.

SUMMARY

Clinicians should be careful when selecting a zirconia ceramic, screw-retained prosthesis. The accuracy of the prosthesis, stress accumulation around zirconia ceramic cylinders, and cantilever length should be thoroughly evaluated to prevent failure. An abutment-level prosthesis is a safe option for avoiding damage to the dental implant platform.

REFERENCES


Figure 6. Scanning electron microscopic image of deteriorated abutment. This abutment lost its entire structural integrity of platforms, and fin-like thin structure was noted at end of platform. Squashed surfaces also had vertical scratch lines, which represent amount of vertical dislodging movement of prosthesis. Hexagon tops represent dent marks that resulted from contact from prosthesis.

Figure 7. Metal cylinders. Intaglio surface with metal cylinders in monolithic zirconia prosthesis. Metal cylinders were cemented intraorally with resin cement.

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Noteworthy Abstracts of the Current Literature

Edge chipping and flexural resistance of monolithic ceramics

Zhang Y, Lee JJ, Srikanth R, Lawn BR
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Objective. Test the hypothesis that monolithic ceramics can be developed with combined esthetics and superior fracture resistance to circumvent processing and performance drawbacks of traditional all-ceramic crowns and fixed-dental-prostheses consisting of a hard and strong core with an esthetic porcelain veneer. Specifically, to demonstrate that monolithic prostheses can be produced with a much reduced susceptibility to fracture.

Methods. Protocols were applied for quantifying resistance to chipping as well as resistance to flexural failure in two classes of dental ceramic, microstructurally-modified zirconias and lithium disilicate glass-ceramics. A sharp indenter was used to induce chips near the edges of flat-layer specimens, and the results compared with predictions from a critical load equation. The critical loads required to produce cementation surface failure in monolithic specimens bonded to dentin were computed from established flexural strength relations and the predictions validated with experimental data.

Results. Monolithic zirconias have superior chipping and flexural fracture resistance relative to their veneered counterparts. While they have superior esthetics, glass-ceramics exhibit lower strength but higher chip fracture resistance relative to porcelain-veneered zirconias.

Significance. The study suggests a promising future for new and improved monolithic ceramic restorations, with combined durability and acceptable esthetics.

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