

CLINICAL REPORT

Ceramic implant fracture: A clinical report



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Advancements in the science and technology of biomaterials have steadily improved the success rate of dental implant treatment over the past decades.¹⁻³ From the 16th to early 20th century, dental implants were made of ivory, gold, lead, iridium, tantalum, stainless steel, and cobalt alloys.⁴ Since the 1960s, commercially pure titanium and its alloys have been used successfully for fabrication of dental implants because of their excellent biocompatibility and mechanical properties.^{2,3} However, titanium and its alloys have certain disadvantages as dental implant materials. These include the grayish appearance of the peri-implant soft tissue,⁵ occasional allergy,⁶ and potential contribution by titanium particles to the development of peri-implantitis.⁷ These concerns have driven a search for alternative dental implant materials, such as ceramics.^{2,8}

Ceramic dental implants were first introduced approximately 40 years ago and were made of aluminum oxide (single crystal or polycrystal), including the Tübingen implant system and a few other systems.⁹⁻²⁸ Alumina is prone to fracture due to its high hardness and modulus of elasticity but relatively low bend strength and fracture toughness.²⁹ Implant fracture is a frustrating problem for both patients and clinicians because it typically results in the loss of implants and prostheses.³⁰⁻³⁵ The fracture of alumina implants has rarely been reported as a form of implant loss.^{27,36-41} Nevertheless, the fear of fracture might have prevented dentists from using alumina implants.

ABSTRACT

This clinical report describes the presentation of a fractured ceramic dental implant. The fractured implant segment was examined by scanning electron microscopy and energy dispersive spectroscopy. Energy dispersive spectroscopy confirmed that the fractured implant was made of alumina. Although alumina implants were withdrawn from the market because of poor survival rates, clinical reports of their complications are rare. (J Prosthet Dent 2019;122:425-9)

The purpose of this clinical report was to present a case of fractured ceramic dental implant, together with microscopic evaluation by scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS).

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A 52-year-old woman who was born in Germany presented to a periodontics office in Seattle, WA, for an examination of her maxillary anterior teeth (Fig. 1). The patient was concerned that the gap between her maxillary right anterior teeth had been widening. She stated that she had had a dental implant placed in her maxillary right anterior area approximately 30 years earlier in Germany. Oral examination revealed that the patient's maxillary right canine and lateral incisor were splinted with metal-ceramic crowns and that the 2 maxillary central incisors were also splinted with metal-ceramic crowns. A 2-mm diastema was present between the maxillary right lateral and central incisors. A periapical radiograph showed that the maxillary right lateral incisor had a nonmetal cylindrical implant with a horizontal fracture line in the middle of the implant (Fig. 2). The radiodensity of the implant was similar to that of adjacent roots. A metal post was inserted in the

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Figure 1. Frontal view of maxillary right lateral incisor implant/crown.

center canal of the coronal half of the implant. The rest of the center canal was filled with radio-opaque cement.

A diagnosis of implant fracture at the maxillary right lateral incisor was made. The patient was encouraged to contact the dentist who placed this implant, but she was unable to find this dentist in Germany. The prognosis for the implant was hopeless due to fracture. Extraction was recommended, and the patient agreed. Both pieces of the fractured implant were successfully extracted without complications (Fig. 3). Ridge preservation was performed after extraction. After healing, a root-form titanium endosseous implant was placed and later restored with a titanium custom abutment and cement-retained metal-ceramic crown.

The fractured implant was cleaned and assessed by light microscopy, SEM, and energy-dispersive X-ray spectroscopy (EDS). Under light microscopy, it was confirmed that the crown was cemented over a core material retained with a metal post inserted into the coronal half of the implant. No bone was visualized on the surface of the implant. The color of the fractured implant was ivory (Fig. 4). The fractured implant was approximately 14 mm long: the coronal portion was 5 mm long, the root portion was 8 mm long, and these were separated by a 1-mm shoulder or collar. The root portion of the implant was 3.8 mm in diameter and had 3 parallel macroscopic grooves, each 0.8-mm wide and 0.8-mm deep, as well as several 0.3-mm-deep circular rings. The outer diameter of the rings was 1 mm, and the inner diameter was 0.4 mm. SEM observation (Fig. 5) showed that the implant had a uniformly microroughened surface and typical isotropic irregular indentations. EDS revealed that the implant was made of alumina (Fig. 6). Putting all the information together, the fixture was likely a variation of the Tubingen implant.



Figure 2. Periapical radiograph of fractured implant/crown and adjacent teeth.

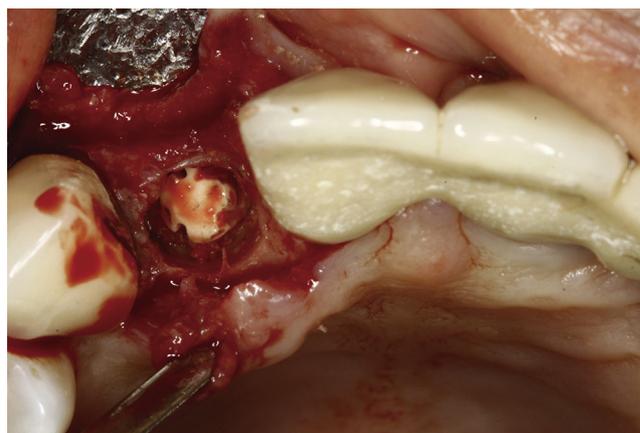


Figure 3. Extraction of fractured implant and crown.

DISCUSSION

Dental implants have been successfully used to restore completely and partially edentulous patients. However, complications and failures do occur. Depending on timing, they are generally divided into an early or late category. Early failures are typically due to lack of osseointegration after implants are placed. Late failures

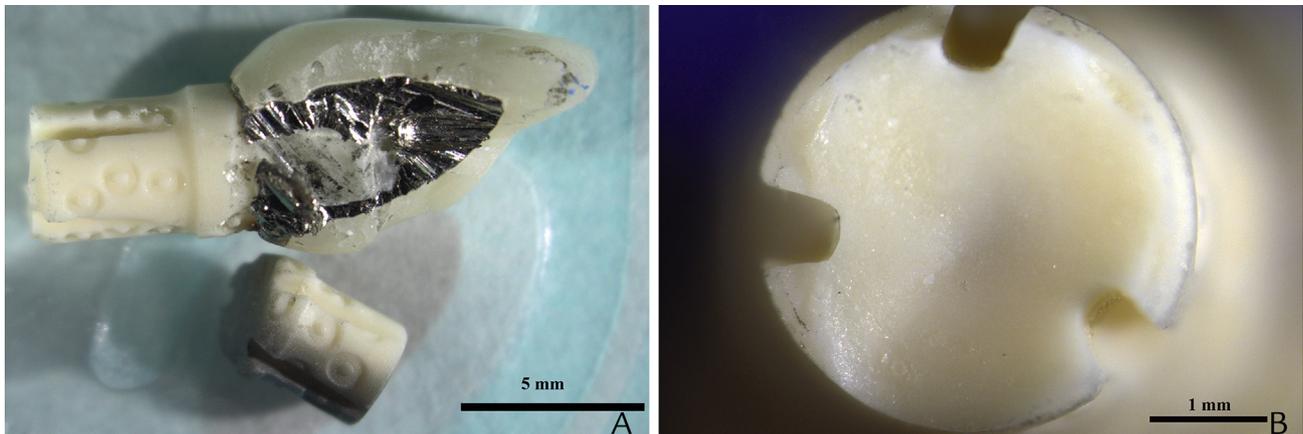


Figure 4. A, Extracted implant and crown (bar=5 mm). B, Fractured surface (bar=1 mm).

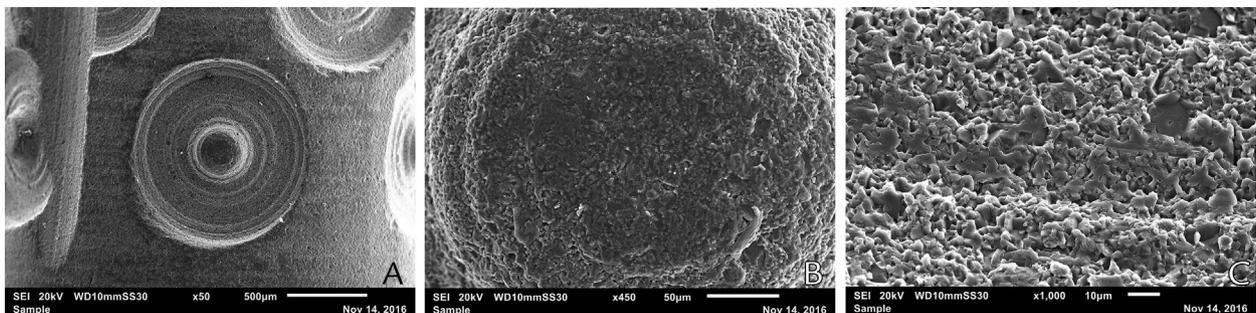


Figure 5. Scanning electron microscope images of surfaces of ceramic implant. A, Ring-like structures on surface of implant (bar=500 μm). B, Depression in center of ring-like structure (bar=50 μm). C, Rough surface on rim of ring-like structure (bar=10 μm).

occur after prosthetic restoration has been fabricated and functioning for a time.³⁰ The fracture described in this clinical report is a late failure.

According to Balshi,³³ the causes of implant fracture may be divided into 3 categories: implant design and manufacturing defects, nonpassive fit of the prosthetic structure, and biomechanical or physiologic overload. Other possible reasons of fracture include defective dental implants, bruxism or large occlusal forces, superstructure design, implant localization, implant diameter, metal fatigue, and bone resorption around the implant.^{30,34} Biomechanical overload was suspected in the present patient.

Many ceramic dental implant materials cannot withstand the extreme load experienced during some functional and parafunctional oral conditions. The physical properties of alumina include $\sim 4 \text{ g/cm}^3$ density, 2300 Vickers hardness, 4400 MPa compressive strength, 500 MPa bend strength, 420 GPa modulus of elasticity, and $4 \text{ MPa} \cdot \text{m}^{1/2}$ fracture toughness.³⁶ Therefore, alumina is a brittle material because of its high hardness and modulus of elasticity. In addition, it has relatively low bend strength and fracture toughness. Combining all these factors, alumina is prone to fracture in the oral

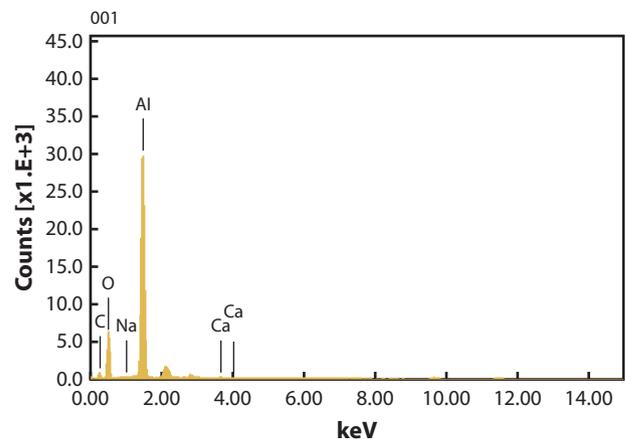


Figure 6. Energy dispersive spectroscopy result of ceramic implant surface revealing that implant made of alumina.

environment under unfavorable loading conditions. This might explain why alumina implant systems are no longer commercially available. Nevertheless, few implant fracture incidents have been reported in the literature.^{27,36,37}

A number of studies have evaluated the success rates of ceramic dental implants. An implant survival rate of

84% was reported after more than 2 years using different alumina ceramic implants, without any fractures.¹⁹ Koth et al²⁶ and Steflik et al³⁸ reported cumulative success rates of 77.7% (5 years) and 65.4% (10 years) in patients who received single-crystal sapphire (Al₂O₃) Bioceram implants, without any losses due to fracture. Brose et al³⁹ reported an implant survival rate of 23% after up to 8 years. De Wijs et al⁴⁰ followed up 101 patients and 127 Tübingen alumina implants for a mean period of 4.5 years. They reported a survival rate of 87%. Fartash et al⁴¹ followed up 86 patients and 324 Bioceram sapphire implants for mandibular overdentures. After 3, 5, 10, and 12 years, the cumulative success rates were 95.2%, 91.3%, 91.3%, and 91.3%, respectively. In all these studies, implants failed for biological reasons and no fractures were reported.

One Bioceram sapphire implant was reported as fractured in an edentulous mandible after 6 years of function.²⁷ Another study evaluated 33 patients with 99 crystalline bone screw implants in edentulous mandibles to retain overdentures for 2 to 3 years. An accumulative success rate of 78.1% was reported. Five implants fractured.³⁷

Limited success with alumina implants ultimately led to trials with zirconia materials. Presently, yttria-stabilized tetragonal zirconia polycrystal, because of its tooth-like color, low-temperature conductance, high flexural strength, and high fracture toughness, has become established as a viable alternative not only to alumina but also to titanium alloys for fabrication of endosseous dental implants.^{42,43} Most of the current studies on zirconia implants have been short term, and evidence of success in long-term clinical trials is lacking.^{44,45}

SUMMARY

Implant fracture has rarely been reported in the literature. This clinical report describes a fractured ceramic dental implant. Although dental implant fracture does not occur frequently, it is an important cause of implant therapy failure. Dental practitioners should be aware of the factors that contribute to implant fracture.

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Noteworthy Abstracts of the Current Literature

Thermal induced deflection of a porcelain zirconia bilayer: Influence of cooling rate

Swain MV, Mercurio V, Tibballs JE, Tholey M

Dent Mater 2019 Apr;35:574-84

Objective. To determine the thermal expansion of a porcelain (VM9) and tetragonal zirconia (Y-TZP) as well as the deflection upon re-heating and cooling of a bilayer fabricated from these two materials after slow and rapid cooling during initial fabrication.

Methods. The coefficient of thermal expansion (CTE) of bulk porcelain and Y-TZP as well as bilayer beam deflection was measured with a novel non-contact optical dilatometer. The influence of cooling rate during initial fabrication of the porcelain-zirconia bilayer and the bulk porcelain during subsequent heating and cooling is investigated. Specimens were heated to 900°C in the dilatometer, well in excess of the glass transition temperature (T_g) and softening temperature (T_s) of the porcelain.

Results. The thermal expansion of the porcelain above T_g exhibits a threefold increase in CTE over that observed below T_g . Observations of the bilayer deflection reflect the difference in the CTE of the component materials and enable T_g and T_s temperatures for the porcelain to be estimated. Initial cooling rate of the porcelain and porcelain-YTZP bilayer was found to have a profound influence on the subsequent response to slow reheating and cooling as well as the resultant residual deflection.

Significance. The estimation of the residual stress and potential for chipping of porcelain-zirconia dental restorative systems should not be based solely on thermal expansion data measured below T_g .

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