Long-lasting oxide ceramic bridges

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Fig. 1_Four-unit In-Ceram YZ bridge. *(Photo: Groten, Reichel)*

Fig. 2_Four-unit In-Ceram YZ bridge. CDA ranking: "excellent". *(Photo: Groten)*

_Launched at the beginning of the 1990s, the glass-infiltrated oxide materials In-Ceram Spinell, Alumina and Zirconia occupy a position between silicate ceramics on the one hand, and polycrystalline oxide ceramics on the other. They differ in terms of particle density and mechanical resilience. Spinell boasts a flexural strength of 400 MPa, Alumina 500 MPa, and Zirconia 600 MPa. The glass infiltration process gives the materials special visual characteristics–for example, translucency. Infiltration ceramics are suitable for sophisticated therapy applications, including anterior and posterior crown and bridge frameworks. In addition, these materials have the advantage that they are dimensionally stable–ie correspond exactly to the model–and do not shrink during the infiltration process. This makes it easier to place the restoration on the master model in order to check its proper fit.

_"Airbag" prevents cracking

The introduction of milling technology to dental laboratories spawned the development of industrially manufactured pre-sintered In-Ceram blocks. These blocks are subtractively machined on CNC milling systems (eg inLab) and then glass-infiltrated.

This was followed by the introduction of polycrystalline zirconium oxide (ZrO_2) blocks (In Ceram YZ) for high-strength anterior bridges with a flexural strength in excess of 900 MPa. The framework is milled to excess dimensions (approx. 20 percent). During the sintering process (at 1,530°C) the ceramic solidifies and the framework shrinks to the dimensions of the original model. The phase transition of the ZrO_2 crystals has a beneficial effect: the monoclinic particles expand by three to five percent and cushion any micro-cracks as soon as these occur. This 'airbag function' gives ZrO_2 its outstanding long-term mechanical toughness.

Polycrystalline aluminium oxide ceramics (In-Ceram AL, inCoris AL) achieve a flexural strength of up to 500 MPa and are suitable for anterior crowns and bridges. Like ZrO_2 this material requires shrink-sintering, which enhances its translucency. In combination with thin-layer veneers aluminium oxide frameworks offer outstanding dentine-like aesthetics. Aluminium oxide is superior to ZrO_2 in terms of colour shade, light transmission, translucency, and elasticity modulus (380 GPa as compared with 210 GPa). Unlike ZrO_2 workpieces, Al_2O_3 can be dry-milled after sintering has been completed.

_Conventional or adhesive bonding

Thanks to their high degree of flexural strength, the polycrystalline In-Ceram Al_2O_3 and ZrO_2 ceramics (AL, YZ) provide the basis for a conservative preparation approach. A circular wall thickness of 0.5 mm is sufficient for crown copings. A chamfer or shoulder preparation should be used for the crown margin. To minimize the risk of fractures in the ceramic veneering (a risk that is no higher than in the case of PFM crowns) the frameworks should be designed in such a way that the cusps are supported. In the interest of fracture resistance, the veneering thickness should not exceed 2 mm in the area of the cusps. The connector cross sections should range from 7 mm^2 to 12 mm^2, depending on the span length and the position of the framework (anterior, posterior). Al_2O_3 and ZrO_2 frameworks are pre-shaded. Alternatively, a dentine-like appearance can be created during the sintering process by means of a special shading fluid.

Clinical studies indicate that the bonding technique has a significant influence on the durability of all-ceramic restorations. Due to their inherent mechanical strength, In-Ceram crowns and bridges can be conventionally cemented with the aid of glass ionomer cement (Ketac) or zinc oxide phosphate cement (Harvard). New self-conditioning luting composites (Multilink) offer a credible alternative: they enhance the interlocking bond with the abutment tooth. Short-length crowns often have only a limited interface with the residual tooth. In this case it is advisable to sandblast the inner surfaces of the crown (Cojet; Al_2O_3; particle size: 50 µm; 2.5 bar pressure) in order to create a microretentive surface. Following this, a silicate coating and a silane coating (Rocatec) should be applied.

_CAD/CAM delivers optimum stability

All-ceramic crowns and bridges are a viable alternative only if they match the survival rates of PFM restorations. Against this background, various clinicians have carried out systematic studies of In-Ceram bridges, beginning in 1995. Initially the focus was on manually produced Al_2O_3 restorations. Attention then shifted to CAD/CAM restorations (Alumina, AL, YZ). Walton (2002) established an annual failure rate of between 1.0 and 1.3 percent for PFM crowns over a fifteen year period. The analysis revealed that the In Ceram crowns performed equally well. As from 2001 follow-up examinations of In-Ceram bridges were carried out. The success of three-unit Alumina bridges clearly depended on where they were placed in the jaw. Anterior bridges were virtually failure-free, whereas molar bridges (contraindicated by the manufacturer) displayed a significantly higher loss rate (Sorensen, 2002). Swedish scientists established a survival rate of 88 percent for anterior and posterior Alumina cantilever bridges after six years (Olsson, 2003).

The interim results of more recent studies indicate that CAD/CAM bridges made of Al_2O_3 and ZrO_2 are capable of withstanding higher chewing forces and hence are suitable for three-unit anterior bridges (In-Ceram AL), as well as for molar and cantilever restorations (In-Ceram YZ). Several long-term university studies confirm that computer-machined three and four-unit molar bridge frameworks made of ZrO_2 show no signs of fracturing after six years in situ (Tinschert, 2006; Kern/Pospiech, 2006). This substantiates the assertion that CAD/CAM oxide ceramic bridges are as durable as PFM crowns. These restorations have a greater probability of survival than an average marriage concluded in Germany in the last ten years. These initial findings—as well as those relating to In-Ceram YZ bridges—provide strong grounds for optimism._

Bridges al dente

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_Multiple unit bridges made of Zirconium Oxide are now entering the sixth year of scientific observation. So far no framework fractures have occurred.

Letters from private healthcare insurers are often an additional source of stress. In many cases insurance companies refuse to reimburse patients for all-ceramic bridges consisting of more than three units. They justify this on the grounds of 'insufficiently proven clinical performance' and refer to a statement issued by the German Society of Dental, Oral and Craniomandibular Sciences (DGZMK) back in 2001. At the time this organization recommended a cautious approach to long-span all-ceramic bridges. Instead, private insurers insist on PFM restoration and emphasize that they will not make any further reimbursements for a period of five years. Is this the expected survival time of a PFM restoration from the viewpoint of the insurance industry?

According to the German Ceramic Dentistry Working Party (AG Keramik), approx. 220,000 multiple-unit oxide ceramic bridges were placed in Germany in the course of 2006. Quality assurance records kept by

Fig. 1

Fig. 2

Fig. 1_Initial situation: Longitudinal fracture of bridge abutment 45. It was not worth conserving the fractured abutment tooth.

Fig. 2_Bridge restoration 45–47 with a ZrO_2 framework, no fractures after seven years in situ.

dental laboratories indicated an extremely small number of fractures (well under one percent over a period of four years). To update our readers on the latest research findings we asked Professor Dr Joachim Tinschert, a senior clinician at the Prosthetic Dentistry Department of Aachen University Hospital (RWTH), to evaluate the durability of ZrO_2 bridges.

_ZrO_2 bridges have stood up to the test of clinical practice

Aachen University Hospital (RWTH) commenced its experiments on multiple-unit ZrO_2 bridges in 1998. Initial in vitro stress tests showed that high-performance ZrO_2 ceramics achieve very high flexural strengths (Tinschert, 2000) compared with older types of framework ceramic. Further tests were performed on samples of yttrium-oxide reinforced ZrO_2 under realistic conditions (high humidity, 250 MPa). These tests likewise generated promising results. The probable failure rate was estimated at well under one percent after an assumed duration of ten years (Tinschert 2007). Cyclical stress tests (chewing simulator) were then conducted on three-unit zirconium oxide bridges. The fracture risk increased only marginally even at an average maximum chewing force of 500 N (= 50kg/mm^2) and an extrapolated service life of several decades (Tinschert 2006).

The Aachen researchers then evaluated the clinical reliability of ZrO_2. To this end, 65 three and four-unit bridges with yttrium-oxide reinforced frameworks were fitted to a total of 46 patients over the period 1998 to 2003. In all cases the abutment teeth were prepared with 0.6–0.8 mm chamfer. The wall thickness of the abutment cap was 0.6 mm. The bridge connectors had a cross-sectional area of 16 mm^2. The bridges were faced using VITA D. Phosphate monomer adhesive (Panavia 21) was used for the anterior bridges, and conventional zinc oxide phosphate cement (Harvard) for the anterior bridges. The maximum service period was 7.5 years (average observation period: 5 years). During this period four bridges needed to be re-cemented and five abutment teeth required endodontic treatment. One bridge framework fractured following the trepanation of an abutment crown. No other framework fractures occurred.

According to the scientific literature, PFM bridges display a survival rate of 96, 87 and 85 percent after 5, 10 and 15 years respectively. This corresponds to a failure rate of approximately one percent per year. By comparison, ZrO_2 is undoubtedly qualified for anterior and posterior bridge frameworks. In a separate study of free-end bridges, no fractures have so far occurred (Jenatschke, 2003).

Follow-up examinations of ZrO_2 bridges do not indicate any increased risk of fracture. There are likewise no problems with regard to tissue compatibility. The same abutment preparation and bonding techniques can be used as in the case of PFM restorations. Four cases of veneer spalling were observed during the first three years of the clinical ZrO_2 study (Tinschert, 2005). No further cases of spalling have been observed since the introduction of an improved framework design which provides added support for the cusps and stabilizes the veneer layer. To sum up, ZrO_2 frameworks with up to two pontics are suitable for application in day-to-day dental practice._

Further literature is available from the author.

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