All-ceramics works

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_**The Society for Dental Ceramics** (SDC) has followed the development of all-ceramic materials and CAD/CAM technology for the last ten years, reviewing and commenting on the clinical results in the professional community, supported by experience from its own field studies in private practices. During this period, the number of inserted all-ceramic inlays, onlays, crowns and bridges has increased steadily to over 5.5 million restorations per year, thus attaining 20 % share of the treatment volume indicated for long-term restorations.

At the 9th Ceramics Symposium *All-Ceramics at a glance*, which was held from 4 to 5 November 2009 in Munich in Germany, the moderator Dr Bernd Reiss (Germany) called attention to the results of the Tele-Dialog Survey, which demonstrated that 87 % of the symposium attendees judged the quality of polycrystalline oxide ceramic frameworks to be better than or at least equal to that of porcelain-fused-to-gold. Prof Sven Reich (RWTH Aachen University, Germany) supported this assessment and presented a thematic tour of millable CAD/CAM ceramics.

Thanks to a combination of different properties, today there is a suitable ceramic for every indication. Silicate ceramic, known for its translucent chameleon effect, has established itself for inlays, partial crowns, veneers, and crowns, chiefly in the anterior-tooth and premolar regions. For extended aesthetic demands, as well as crowns and three-unit fixed dental prosthesis (FDP) up to the second premolar, lithium disilicate (LS_2) ceramic is available in graded opacities for press and CAD/CAM techniques. Framework ceramics of aluminium oxide (Al_2O_3) and zirconium dioxide

Fig. 1a–f_Cusp overlay, indicated for weakened cusps. (Photographs courtesy of Prof Karl-Heinz Kunzelmann, Germany)

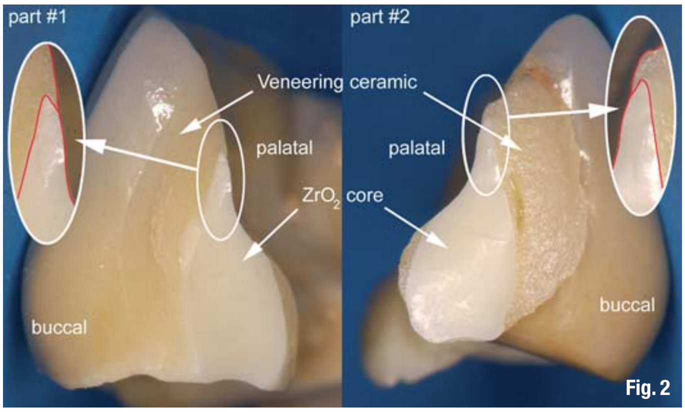

Fig. 2

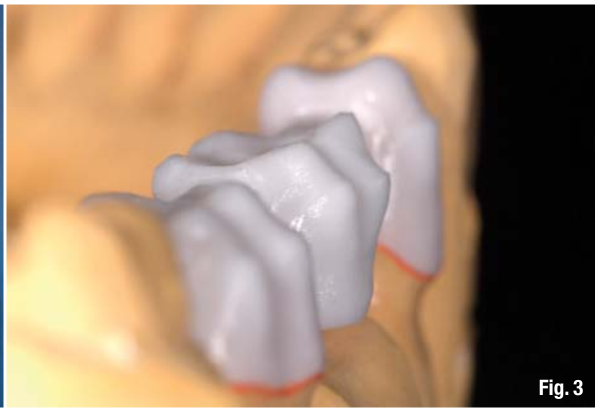
Fig. 3

(ZrO_2) have an opaque structure and require veneering. Owing to its partial translucency, Al_2O_3 is especially suitable for crown and FDP frameworks in the anterior and premolar regions. ZrO_2 is indicated for use not only in the posterior dentition, but also as a framework with wings for adhesive FDPs. Prof Reich discussed the veneering fractures on ZrO_2 frameworks, which have been under discussion in the professional community for some time. The underlying problem is that up until a few years ago, thin-walled crown copings were covered with thick veneer layers, and the bridges lacked anatomically designed frameworks with cusp support.

_Substance conservation as the goal

Prof Karl-Heinz Kunzelmann (Ludwig Maximilian University of Munich, Germany) lectured on *Ceramic inlays and partial crowns: New preparation concepts*, pointing out that current preparation criteria are still heavily influenced by—the limitations of early ceramic materials and CAD/CAM systems. Today, given the good fitting accuracy of ceramic restorations, the enlarged divergence angles of the gold era are no longer necessary (Figs. 1a–f). Thus, classical divergence angles of 6 to 10° are to be avoided, owing to the risk of the cavity margin ending in the area of the cusp tips or contact points. Occlusal surface veneers of pressable ceramic, suitable for the treatment of occlusal defects and vertically increasing occlusion, do not require a chamfer and conserve considerable substance. In partial crowns with cusp reconstruction, a substance-conserving supporting area in the enamel-dentine region is preferable to a supporting shoulder. An overlay is indicated when cusps are very thin (<2 mm cusp thickness). According to Prof Kunzelmann, the reimbursement for overlaying cusps should be adjusted because the statutory health insurance criteria for the partial-crown indication require that all cusps be sacrificed. However, this contradicts the principle of substance conservation.

Dr Andreas Kurbad (Germany) covered the range from *Classical crown to minimally invasive*. In the preparation of a fully anatomical ceramic crown with a circular chamfer, up to 64 % of the hard dental tissue can be conserved.[1] In contrast, metal-supported full crowns consume at least 70 % in preparing the necessary retention surfaces.[2]

A sure positioning of the crown is facilitated by clear margins. It should be tactilely perceptible when the ceramic body has reached its correct position. Further, the advantage of adhesive

Fig. 2_Fracture of a veneered ZrO_2 bridge. The framework was ground in palatinally (pointed droplet shape) and did not support the veneer adequately. The over-dimensioned veneering layer became subject to tensile forces.
(Photograph courtesy of Prof Ulrich Lohbauer, Germany)

Fig. 3_Cusp-supporting coping form prevents veneering fractures.
(Photograph courtesy of Prof Joachim Tinschert, Germany)

Fig. 4_Embedding the CAD/CAM-milled wax-up in order to obtain a pressed veneer.
(Photograph courtesy of Volker Brosch, Germany)

Fig. 5_Pressed veneers (IPS e.max Press) with final firing on ZrO_2 framework.
(Photograph courtesy of Volker Brosch, Germany)


Fig. 4


Fig. 5

Table I _Failure rates of all-ceramic bridges. ZrO_2 frameworks remained largely fracture-free; chipping interfered with clinical success. (Table courtesy of Prof Matthias Kern, Germany)

Failure rates of all-ceramic fixed dental prosthesis

FIRST AUTHOR	N	CERAMIC	TIME (IN MONTHS)	FAILURE RATES (IN %) ANT.	PM	M
Pospiech 2004[c]	35	Lava	36	–	–	0°
Suárez 2004[c]	10	In-Ceram Zr	36	0°	5.5	
Raigrodski 2006[c]	20	Lava	31	–	0*	0*
Sailer 2007[a]	33	DCM	53	–	26.1°*	
Molin 2008[a/c]	19	Denzir	60	0	0	0
Tinschert 2008[a/c]	65	DSC	37	0°	0*	
Wolfart 2008[c]	24	Cercon	45	–	4*	
Wolfart 2008[c]	37	Cercon ext-br.	46	–	8.1°*	
Beuer 2009[c]	21	Cercon	40	–	9.5	
Eschbach 2009[c]	60	In-Ceram Zr	60	–	–	3.2*
Wolfart 2009[a/c]	36	e.max Press	86	0°	6.7*	

[a] adhesive luting [c] conventional luting ° up to 25 % additional fractures * 2.2–4.8 % structural fractures

luting is that no retention forms are necessary whatsoever. Depending on the type of material, ceramics have translucent properties; thus, according to Dr Kurbad, dark fillings can be a difficult foundation. Pronounced discolouration of the crown stump requires greater substance removal, in order to allow the ceramic a greater thickness.

_Toughness versus resistance

"The fracture toughness of the ceramic is more important than its resistance," explained Prof Ulrich Lohbauer (University of Erlangen-Nürnberg, Germany) in his talk on *Fracture mechanics of all-ceramic restorations*. Hence, it is an important accomplishment that in the structure of zirconium dioxide ceramic (ZrO_2), volume-expanding compressive forces block the propagation of micro-cracks. The fracture toughness explains the high survival probability of crown and FDP frameworks of ZrO_2 in clinical long-term studies. However, there has been recent discussion about veneering fractures on ZrO_2 frameworks[3] because the veneer ceramic (feldspar) has a much lower crack toughness than ZrO_2. In designing the crown copings, it is therefore important to ensure that cusps support the veneering layer (Figs. 2 & 3). After grinding (fine diamond), Prof Lohbauer recommended polishing the restoration's surface (check with loupes) during insertion or, better yet, sending it back to the dental laboratory for final firing. In selecting the ZrO_2 blank, Prof Lohbauer advised using only original materials from quality-conscious ceramic manufacturers and with proven clinical suitability, and adhering to the procedure for the veneers. This is to ensure that framework and veneering materials match.

_From wax knife to mouse

Master Dental Technician Volker Brosch (Germany) demonstrated the switch from wax knife to electronic framework design, comparing the workflow in conventional dental engineering with the CAD/CAM technique. The digitally constructed datasets can be used to construct both the temporary and definitive restorations. Fully anatomical anterior and posterior crowns can be made from the millable LS_2 blanks, and multi-unit bridges up to the second premolar can also be manufactured from this pressable ceramic of increased strength. Where aesthetic demands are particularly high, the cut-back procedure is used—the fully anatomical crown is anatomically ground down by the thickness of the enamel layer and then fuse-on veneered. Recently, Brosch has made singly designed veneers of fluorapatite pressable ceramic, digitally modelled and then sintered onto the ZrO_2 frameworks (Figs. 4 & 5).

Unique in dentistry is the multi-centre field study by the SDC, in which dentists in private practice can compare their findings/results on all-ceramic restorations anonymously and individually with other participating practices. At the time, over 5,700 restorations from more than 200 practices constituted the basis of the results. After evaluating over 3,000 follow-up examinations, Dr Reiss, who heads this quality-control study, recapitulated that the survival rate of inlays, onlays, partial crowns, and crowns of silicate ceramic lies at 83 % after 13 years of observation, putting them on par with cast restorations as described in the literature.[4] He explained that participating dentists enter their results online on the platform www.csa-online.net and receive an individual, graphic treatment profile.

_ZrO_2 not always necessary

Speaking on the *Clinical testing of all-ceramic restorations*, Prof Matthias Kern (University of Kiel, Germany) made it clear that ceramics must measure up to the survival rates of metal-supported restorations. The literature demonstrates that ceramic inlays and onlays have a clinical durability similar to that of cast restorations. CAD/CAM restorations demonstrate a longer service life than pressed or laboratory-constructed restorations.[5] Owing to its semi-translucency, Al_2O_3 is particularly well suited for crowns in the aesthetically sensitive anterior dentition. According to Prof Kern, it is thus not necessary to manufacture single crowns from ZrO_2. FDPs with ZrO_2 frameworks have demonstrated encouraging results; in observation periods of up to five years, framework fractures occurred rarely, even in multi-unit FDPs. However, some studies described veneering fractures (chipping; Table I). The reason for this is that originally, trusting in the high fracture-flexural strength of the material, ZrO_2 frameworks were delicate constructions, milled out with thin walls onto which thick veneering layers were applied, which became subject to tensile force. Prof Kern recommended wall thicknesses of no less than 0.8 mm for ZrO_2 frameworks and advised designing them anatomically, so that the veneering is supported by the cusps.

From the papers submitted for this year's Research Award in All-Ceramics, the jury selected three studies of equal merit. The presenter of the award thus decided to recognise all three researchers: Dr Frank Nothdurft (Germany) for his study *Clinical testing of a prefabricated all-ceramic implant build-up of zirconium dioxide in the posterior dentition*, Dr Andreas Rathke (Germany) for his *In vitro examination of the effectiveness of the dentin bond of ceramic inlays using different luting concepts*, and Falk Becker (Germany) for his study *Press-on and layering technique, chipping behaviour of all-ceramic anterior crowns.*

_CAD/CAM workshop reflects practical experience

During the concluding CAD/CAM workshop at the Clinic for Dental Prosthetics in Munich, Prof Daniel Edelhoff, Dr Florian Beuer, dentist Peter Neumeier, dental technician Marlis Eichberger and dental technician Josef Schweiger helped familiarise participants with the functioning of CAD/CAM systems. The clinic is equipped with representative CAD/CAM systems (C.O.S., 3M ESPE; Cercon, DeguDent; DigiDent, Girrbach-Amann; etkon, Straumann; Everest, KaVo; inLab, Sirona Dental Systems; Lava, 3M ESPE; Procera, Nobel Biocare; ZENOTEC, Wieland), which are used in scientific projects and for practical work in patient treatment.

In terms of the achievable quality and precision of fit of the milled all-ceramic frame-works, Prof Edelhoff emphasised that these are of a high level in every respect. Schweiger pointed out that the computerised milling systems for all-ceramic restorations employ various grinding strategies that are especially designed for the original blanks of the manufacturer. ZrO_2 frameworks that were manufactured in manual copy-milling processes (pantograph) had a worse fit and a critical structure, according to Schweiger. Prof Beuer and Schweiger demonstrated a new way to avoid veneering fractures: sinter veneering (Fig. 6). In this, single veneer structures of feldspathic ceramic are computer milled and sintered onto the ZrO_2 framework._

Editorial note: A complete list of references is available from the publisher.

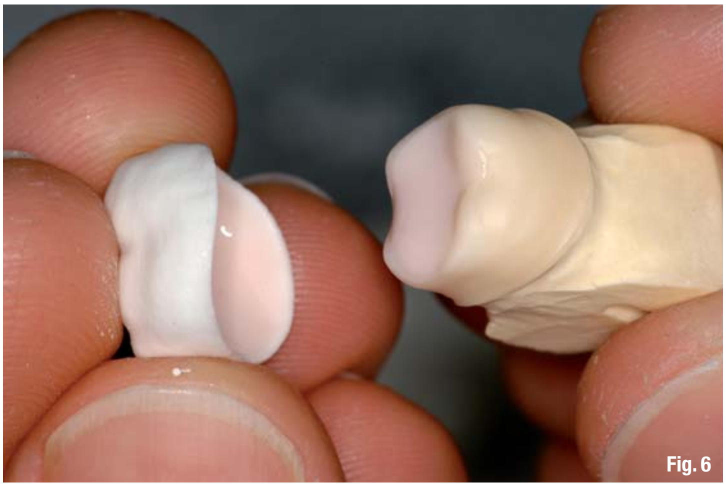

Fig. 6

Fig. 6_The feldspathic veneer, ground with CAD/CAM, was ceramic sintered to the ZrO_2 crown framework. (Photograph courtesy of Josef Schweiger, Germany)

_contact cosmetic dentistry

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