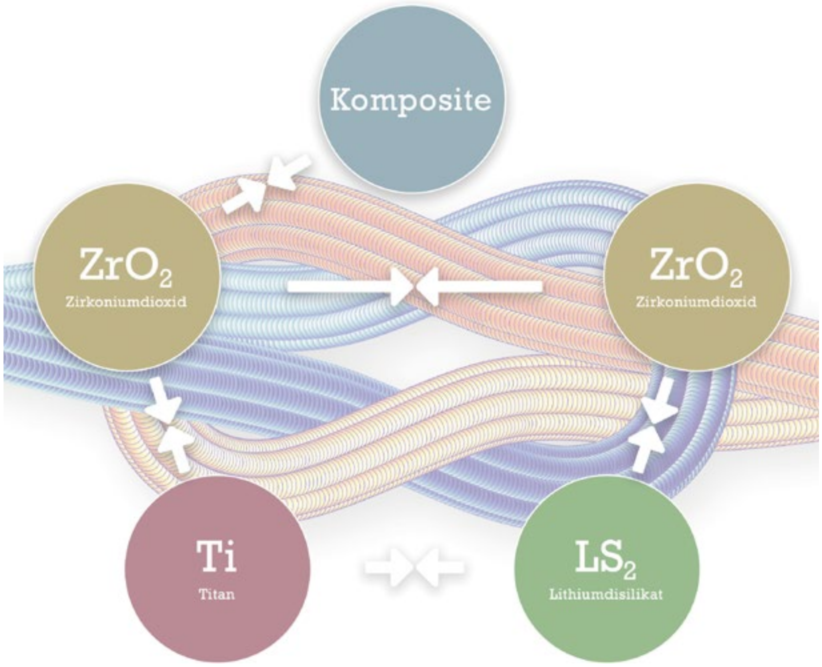
QUINTESSENZ DENTAL TECHNOLOGY



REPRINT

Success factors in the ceramic lithium disilicate zirconium oxide sintered composite

Jan Hajtó, Uwe Gehringer

Influence of joining on the stability of four-unit zirconium oxide bridges

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Occlusal modified zirconium oxide bridge

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Innovations and teamwork in implantation prosthetics

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3 41. Jahrgang März 2015

5 37. Jahrgang Mai 2011

3 39. Jahrgang März 2013

Discover the many application options of DCMhotbond products on the following pages in this issue:

DCM hotbond fusio

Success factors in the ceramic lithium disilicate zirconium sintered composite

Jan Hajtó, Uwe Gehringer

Page 258 – 266

Innovations and teamwork in implantation prosthetics

Bärbel Riemer-Krammer, Catrin Eilert, René Friedrich, Aurica Mitrovic, Michael Hopp, Reiner Biffar

Page 656 – 670

DCM hotbond zirconnect

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Page 656 – 670

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Page 352 – 367

DCM hotbond zircon

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Arvid Langschwager, René Friedrich, Aurica Mitrovic, Michael Hopp, Reiner Biffar

Page 352 – 367

Influence of joining on the stability of four-unit zirconium oxide bridges

Timea Wimmer, Jürg Hostettler, Florian Beuer, Bogna Stawarczyk

Page 306 – 316

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Bärbel Riemer-Krammer, Catrin Eilert, René Friedrich, Aurica Mitrovic, Michael Hopp, Reiner Biffar

Page 656 – 670

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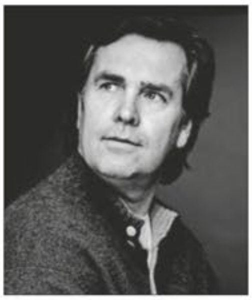
ZrO_2 → ← ZrO_2

Oliver Brix
innovative dentaldesign, Kisseleffstraße 1a, 61348 Bad Homburg, Germany

„DCMhotbond fusio uniquely combines stability and aesthetics with a durable bond between two different materials. Joining is easy to integrate into everyday laboratory work and enables reliable joining prior to individualisation."



ZTM Christian Moss *(Master dental technician)*
Moss Laboratorium für Zahn- und Implantattechnik GmbH, Sachsenfeld 3-5, 20097 Hamburg, Germany

„We use hotbond in 87 % of all patient jobs - and have done so for 7 years. There is no better added value I can have in the lab."

Achim Ludwig & Massimiliano Trombin GbR
DA VINCI DENTAL, Glockengasse 3, 53340 Meckenheim, Germany

„Thanks to the use of DCMhotbond, new application options have opened up for in the use of the Maryland bridge technique."

ZTM Andreas Klar *(Master dental technician)*
Rübeling + Klar Dental-Labor GmbH, Ruwersteig 43, 12681 Berlin, Germany

„hotbond products are novel materials for joining and layering that start where other materials finish. hotbond products will be hugely successful in the years to come."

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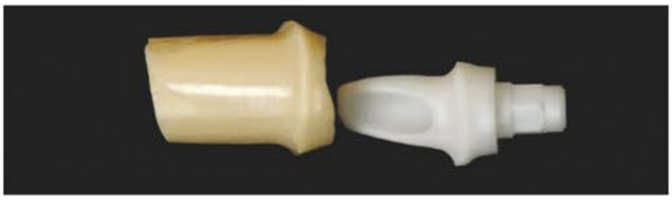
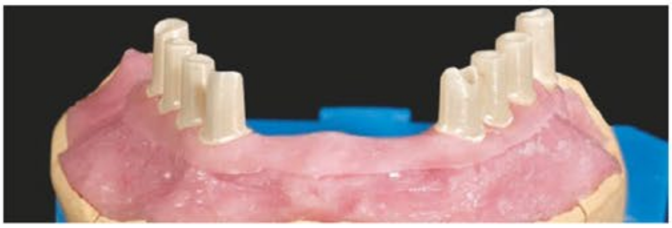
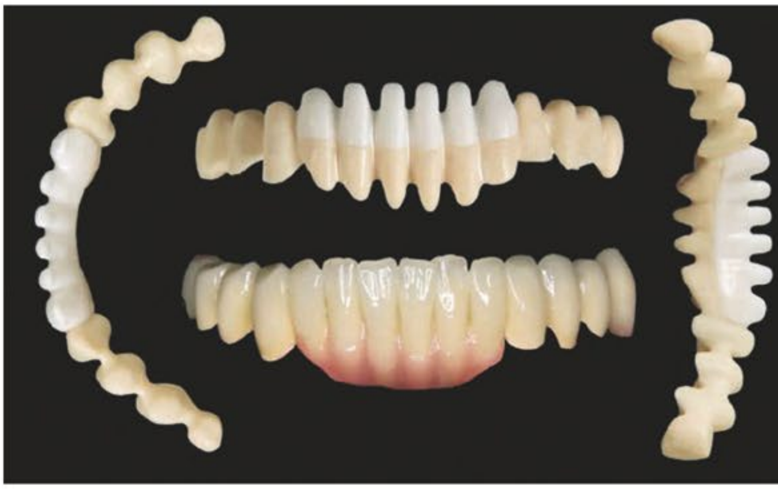
Study group at Dental Technology 2008







The final lecture of dentist Dr Michael Hopp from Berlin had been eagerly awaited by many, so the lecture hall was surprisingly full despite the late hour. Hopp reported on the joining of zirconium dioxide ceramics using ceramic solder and arousedgreat interest with this procedure among the audience, as the system he presented gives the dental technician or surgeon the option of producing mechanically and thermally stable connections using ceramic solder specifically matched to zirconium dioxide, similar to glass and ceramic soldering used in industry. These solders are used for horizontal and vertical expansions of framework structures, repairs, abutment optimisations and much more (image column on the right). For example, milling machines with limited blank size can still create highly stable, circular framework structures by combining several segments. Due to the increased working temperature of the solder, these have the advantage of a later ceramic veneer through layering or pressing. This ceramic joining technique allows the joining of hiped zirconium dioxide as well as sintered green material. The use of available furnaces and devices for ceramic soldering in the dental lab is advantageous, the investment in implementing the technology is very low but the possibilities are great.

Quintessenz Zahntech 2008;34(8):1043

Summary

Sintered composite technology enables the production of permanently resilient aesthetic all-ceramic crowns and bridges, which can be cemented in a conventional way due to the zirconium oxide framework. This article provides an overview of the most important factors that should be observed to apply this technology effectively in the dental lab.

Indices

Sintered composite, glass solder, zirconium oxide,

Success factors in the ceramic lithium disilicate zirconium oxide sintered composite

Jan Hajtó, Uwe Gehringer

Introduction

All-ceramic restorations made from zirconium oxide and lithium disilicate in the sintered composite process have been a tried and trusted, reliable and resilient method of treatment for several years. The functioning composite of lithium disilicate and zirconium oxide using a ceramic was described by Beuer and Schweiger for IPS E.Max CAD (Ivoclar Vivadent, Ellwangen) in 2007.6 Since 2009, sintered composite crowns and bridges have been available as Infix®-CAD products manufactured at their main plant by Biodentis (Leipzig) and by Ivoclar Vivadent for Chairside and In-Lab systems under the Cad-On® name since 2010. Both in-vitro studies [1,7,8] as well as the clinical outcome confirm the effective firmness and absence of chipping of these crowns and bridges. In particular on implants, occlusally screwed or cemented zirconium oxide lithium disilicate composite crowns and bridges constitute a reliable functional and aesthetic option in contrast to manually veneered zirconium oxide.5 For the dental surgeon, sintered composite work provides a major advantage of being easy to cement using conventional cements. In addition, an excellent colour match to the adhesively inserted IPS E.Max crowns, partial crowns, inlays or veneers is possible, as the surface veneering of the sintered composite crowns and bridges is made of the same material.

Despite the high level of reliability and its advantages, sintered composite technology has still not become generally well established in everyday lab work. The initial manufacturing costs may be somewhat higher but the authors believe the effort and unpleasantness for the patient, dentist and dental technician are still justified compared with the new production of firmly inserted and fractured work in the mouth. With the appropriate experience and routine as well as the use of CAD/CAM technology for milling of not only the zirconium oxide frameworks but also the wax veneers using the lost wax process or directly ground lithium disilicate veneers, the time and effort can be reduced. The sintered composite technique using DCMhotbond Fusio is generally possible both with IPS E.Max Press as well as with IPS E.Max CAD. The authors have been providing all patients for the most part with sintered composite restorations for the last five years and have observed virtually no complications since then.3 The intention of this article is to explain several major points that should be considered when manufacturing the Infix Press crowns and bridges using glass solder (DCMhotbond Fusio, DCM GmbH Rostock), in order to achieve the best possible result.

1. Sufficient occlusal free space

The dentist's primary task when preparing is to ensure there is sufficient space for a crown to be produced. With sintered composite, the space is particularly relevant occlusally and buccally, as it has proven effective to leave the lingual cervical parts completely unveneered (see also point 2). However, the dental technician is also not completely free of the obligation to report any lack of space to the dental surgeon, in order to discuss further options together. These include, for example, a reduction on the antagonist, undercutting of layer thicknesses, the selection of another material or another type of restoration, complete or partial omission of the veneer, reduction of the stump on the plaster and preparation of an abrasive cap, subsequent preparation and an impression once again. Every dental technician is well advised not to take this decision without consulting the dental surgeon, as the likelihood of doing exactly the same as the dentist would have decided to do is fairly low. Ultimately, the dentist bears all the responsibility after the work is accepted and therefore all dental work must also be carried out in accordance with what the dentist prescribes.

The dentist should know that it is advantageous to round off all the edges of the stumps as much as possible, in order to avoid milling radius corrections on the zirconium framework, as this will lead to additional cavitation and therefore a need for space.

In the case of implant work, the abutment or framework design is in the hands of the dental technician and the need for space is therefore not a problem.

Sintered composite crowns require at least 1.5 mm of occlusal distance to the antagonist (fig. 1), which is roughly composed of the following values:

Cement joint	0.1 mm
Milling radius correction	0.1 mm
Zirconium framework	0.6 mm
Sintered joint	0.1 mm
Veneer	0.6 mm

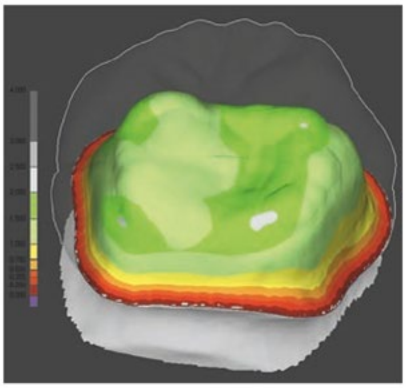


Fig. 1 A clinical crown preparation with at least 1.5 mm of occlusal space (milling radius correction already included).

Fig. 2 Telescopic framework shape of the coloured zirconium oxide framework of an occlusally screwed implant crown.

Fig. 3 Widened lingual, lightcoloured zirconium edge with somewhat darker veneer. Such a difference in the upper as well as the lower jaw is orally not an aesthetic problem.

Fig. 4 The mandibular molar crown from figure 3 in the mouth.

This distance is not greater, as it is also ideal for other all-ceramic solutions or PFM crowns and can be implemented clinically in most cases without a problem. For lithium disilicate, the manufacturer specifies a minimum material thickness of 1.0 mm, although it has proven to be the case that when using it as a sintered veneer element 0.6 mm are sufficient due to the stable anchoring on the framework.

2. Correct framework design

In order to apply the veneer component to the framework without any trouble, it must be designed to be free of undercuts, or telescopic so to speak in the area of the joint surface (fig. 2). In addition, it has proven to be sufficient, in addition to the occlusal and vestibular surface, to only provide the incisal portion of the lingual surfaces with veneers and to make the zirconium framework correspondingly wide lingually. This makes it easier to model the veneer and the joining. When using coloured zirconium oxide, the colour differences can be kept very slight, although the patient will not perceive the different colours of the framework and veneer as lingually annoying (fig. 3 and 4).

To achieve a reproducible aesthetic result, the layer thickness of the veneer should be as consistent as possible, both occlusally as well as vestibularly. Therefore, the shape of the framework results from an even reduction of the previously prepared anatomical wax-up by 0.6–0.8 mm depending on the space available.

Fig. 5 Monitoring the even anatomic form reduction with a silicone key.

Fig. 6 Correct course of the sintered joint below the approximal contact.

This can be checked using a silicone key (fig. 5). In particular, by using a HT-3 (high translucency) lithium disilicate, a veneer that is too massive may inadvertently slide too much in a greyish translucent direction. On the other hand, it makes sense to plan for a little more veneer thickness below the occlusal contact point areas, in case something has to be ground in there occlusally.

Finally, when designing the framework, special attention should be paid not to let the joint gap run exactly through the approximal contact area, so that if a correction is required in this area, the dentist will not grind the sintered joint and therefore open up possible pores (fig. 6, see also point 7).

3. Precisely fitting components

An accurate fit is one of the main requirements for good dental technology. With sintered composite, a join gap that is as even and small as possible is also important for a good result. For this reason, the completed components must be carefully fitted on to the frameworks. In the case of DCMhotbond Fusio, the lithium disilicate is combined in a crystallised state with the zirconium oxide in the furna-ce, so that no account has to be taken of shrinkage of the veneer.

4. join with coloured glass solder

The DCMhotbond Fusio system consists of finely ground ceramic (6 µ or 12 µ grain size) and an appropriate liquid (fig. 7). It is mixed in exactly the same way as glaze, so that a viscid consistency is created.

It is advisable to colour the DCMhotbond Fusio glass solder (e.g. with Fancolor watersoluble colour pencils by Caran d´Ache), to achieve better visual control. On the one hand, to see whether glass solder has not inadvertently got inside the crown, secondly the little bubbles and possible flaws are easier to identify through the veneer.

The glass solder is applied with surplus to both the framework as well as the inside of the veneer (fig. 8). The joint should be provided with a definite amount of surplus in a circular fashion, as the material shrinks when sintering. In order to minimise the amount of liquid contained in the glass solder, it is important to allow the joined crowns to dry at 380°C for at least 20 minutes before sintering.

Fig. 7 DCMhotbond Fusio at 12 µ grain size.

Fig. 8 Application of yellow coloured glass solder on the framework and in the veneer.

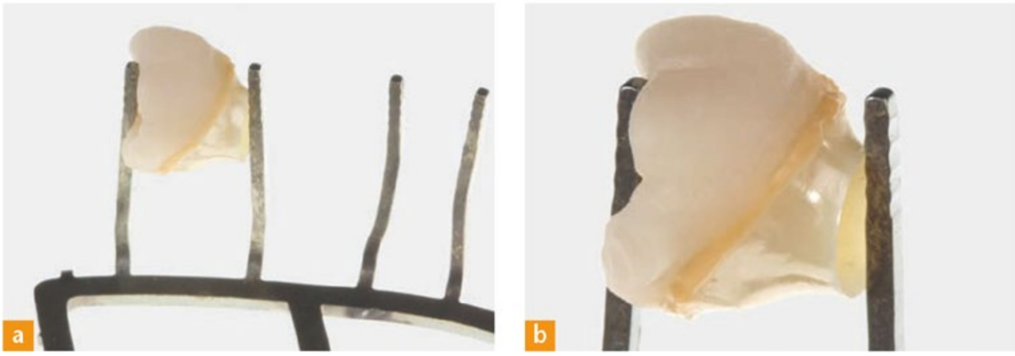


Fig. 9a and b Clamping bracket of the two sintered composite components during the furnace sintering.

5. Mechanical anchorage using holding clips

Wedging with clamps is important as the liquid contained in the glass solder evaporates and has to escape during sintering. This results in internal pressure against the two parts, which in some cases may move apart. The use of Clever Spider has proven effective (Smile Line, St-Imier, Switzerland, fig. 9).

6. Correct firing

As already mentioned above, one of the main tasks with a sintered composite is to sinter the ceramic solder in the joint gap in such a way that the residual moisture that evaporates does not cause excessive flaws as it escapes. It is therefore particularly important to adhere to the firing curve in figure 10.

Based on the authors' experience, a 100% homogeneous pore-free join is not possible in every case, although this has no clinically relevant adverse effects on overall stability due to the sintered composite's high level of bonding strength. However, the result may be that in individual cases small air-filled cavities will remain both on the periphery of as well as inside the sintered joint. If this is not familiar and not dealt with appropriately, this is the reason for clinical complications in the form of dark discolouration of the cavities.

7. Complete sealing of the joint with glaze/veneer ceramic and monitoring

For the reason described above, when using DCMhotbond Fusio, it is essential subsequently to overlay and completely seal the sintered joint with a glaze and/or veneer ceramic (fig. 11). If veneer ceramic is used, it has proven effective to provide the veneer on the periphery with a minimal negative step in order to create space for the material (fig. 12).

Fig. 10 Furnace programme for sintering.

Fig. 11 Application of veneer material to the already ceramic joined crown.

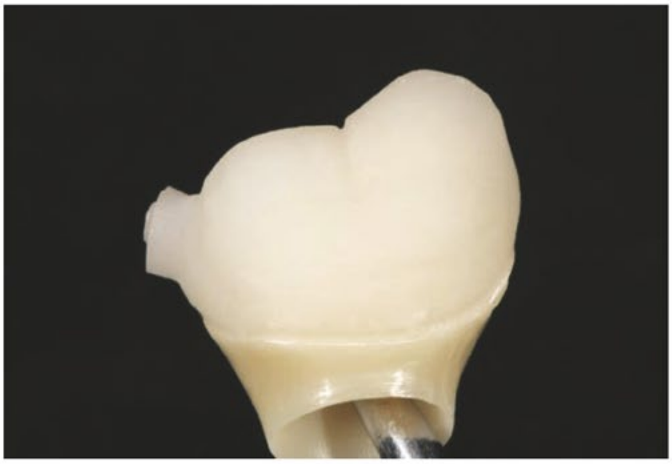


Fig. 12 Gap-free fitting and loosely placed veneer, minimal negative step on the edge due to slightly shortened but dense peripheral area.

Fig. 13 Characterisation of an occlusally screwed implant crown with paints.

The correct course of the joint gap in the approximal area has already been mentioned but the dentist should also know that the sintered joint should not be ground at any point in general. In addition, sintered composite crowns should be ground occlusally before the final cementing, in order to avoid grinding through to the joint ceramic of work already cemented in the mouth. The clinical consequence of an opened sintered joint with cavities is dark discolouration that spreads beneath the veneer.

As DCMhotbond Fusio sinters at a temperature of 780°C, it is possible without difficulty to carry out further corrections and characterisations after the sinter firing with low-combustible ceramic compounds, paints and glazes at 750°C (fig. 13).

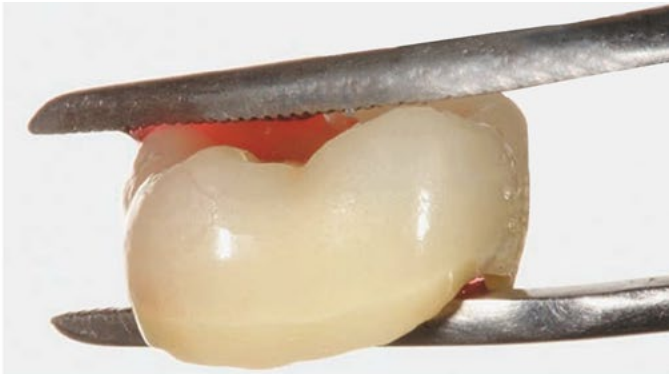


Fig. 14 and 15 Inspection of the complete sealing of the sintered joint using a colour penetration test.

Fig. 16 Three separate veneers with green coloured glass solder on the bridge framework before sinter firing

Fig. 17 Sintered composite bridge with pontic overlay in zirconium oxide.

8. Special features of bridges

In order to be certain that the joint is completely sealed on the surface, it is advisable to dip the completed restoration in a colour solution and check it visually for penetrating colour. The authors use red food colouring for this (fig. 14 and 15).

In the case of bridge restorations, it is possible with DCMhotbond Fusio to apply the veneers individually (fig. 16). The advantage here is that the height in the connecting area does not have to be reduced in order to make room to block the veneers. For the long-term stability of all-ceramic bridges, the height of the connector is usually more important than its width, which is why efforts should be made to extend it for the stable structural ceramic (zirconium oxide) as far as the anatomic situation allows. In addition, this procedure allows for a definite anatomical separation of the individual pontics (fig. 17 and 18). The pontic overlays are usually left in zirconium oxide polished to a high gloss, as this has the best biological compatibility of all materials in contact with soft tissue (fig. 19).2,4 With bridges, particular care should also be taken to ensure all the transitions from the framework and veneer are sealed. Zirconium oxide as Withsufficientconnectingcross-sections of 9–16 mm2 , theframeworkmaterialalso enables the production of wide-spanning sintered composite bridges with three pontics.

Fig. 18 Sintered composite bridge with natural separation of units.

Fig. 19 Sintered composite bridge 35–37 in the mouth.

Conclusion

Considering the criteria presented here is crucial for reliable production of firmly fitted, all-ceramic sintered composite restorations. The fact that the application of sintered composite technology as a relatively recent method requires something of a learning curve for the first-time user is understandable. After five years of daily experience in several dental labs and the corresponding clinical observation period, the authors are unaware of any uncertainties that have not been mentioned in this article. In order to learn about the actual handling and how to deal correctly with the materials, it is definitely advisable to enrol in practical courses.

From the authors' perspective, especially on implants, zirconium lithium disilicate crowns are currently the most reliable, aesthetic and functional type of all-ceramic fixed restoration, whether in the form of individual crowns or bridges.

The option of cementing conventionally does not require the dentist to change the procedure that is usual with metal ceramics. All-ceramic crowns and bridges look more natural and vital than metal ceramics and the dental stumps are not overshadowed by a metal frame. Dark edges on crowns are one of the main concerns of patients with crown restorations. Due to the dual-layer structure of the sintered composite work, if the correct colour is chosen for materials (coloured zirconium oxide, HT, MT or LT lithium disilicate), the natural structure of teeth can be mimicked to a certain extent, so that they look very natural. Not least, the pressing of veneers enables the exact and rational implementation of functional occlusal surface morphology after diagnostic wax-ups. Thus, a previously planned and intended contact point distribution is very precisely possible. From the authors' perspective, the technique presented is therefore the currently most valuable form of dental restoration in terms of a fixed result, whereby safety first is the most important watchword, in the sense that the risk of fractures should be as low as possible. In this respect, the previous observations indicate that if processed and applied properly, sintered composite technology is superior to the decades-old standard of metal ceramics.

Literature

1. Beuer F, Schweiger J, Eichberger M, Kappert HF, Gernet W and Edelhoff D. High-strength CAD/CAM-fabricated veneering material sintered to zirconia copings – a new fabrication mode for all-ceramic restorations. Dent Mater J 2009;25:121–128.

2. Degidi et. al: Inflammatory Infiltrate, Microvessel Density, Nitric Oxide Synthase Expression, Vascular Endothelial Growth Factor Expression and Proliferative Activity in Peri-Implant Soft Tissues Around Titanium and Zirconium Oxide Healing Caps. J Periodontol 2006;77:73–80.

3. Hajtó J, Frei S, Gehringer U: Vollkeramische Seitenzahnrestaurationen – Das Nonplusultra. das dental labor 2011;59:676–683.

4. Scarano A, Piattelli M, Caputi S, Favero GA, Piattelli A.: Bacterial adhesion on commercially pure titanium and zirconium oxide disks: an in vivo human study. J Periodontol 2004;75(2):292–296.

5. Schwarz S, Schröder C, Corcodel N, Hassel AJ, Rammelsberg P.: Retrospective comparison of semipermanent and permanent cementation of implant-supported single crowns and FDPs with regard to the incidence of survival and complications. Clin Implant Dent Relat Res 2012;14 Suppl 1: e151–158.

6. Schweiger, J, Beuer, F, Eichberger, M: Sinterverbundkronen und -brücken: Neue Wege zur Herstellung von computergefertigtem Zahnersatz. Digital Dental News 2007;1:14–21.

7. Tinschert J, Natt, G, Braumüller D, Cfer R, Wolfart S: Festigkeitsverhalten von Sinterverbundsystemen. d dental praxis 2011;28:4–11.

8. Tinschert J, Natt, G: Festigkeitsverhalten von Infix-Brücken mit CAD/CAM-gefertigten Keramikverblendungen. DIGITAL_DENTAL.NEWS 2012;6:28–38.

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DCM hotbond

ZTM Hans- Joachim Lotz *(Master dental technician)*
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„For me, hotbond is the most innovative development currently on the dental market and is indispensable in my daily work."

ZTM Uwe Gehringer *(Master dental technician)*
Made by Uwe Gehringer Dentallabor, Frauenstr. 11, 804691 München, Germany

„At last we can connect high-strength lithium disilicate to zirconium dioxide with a material locking bond."

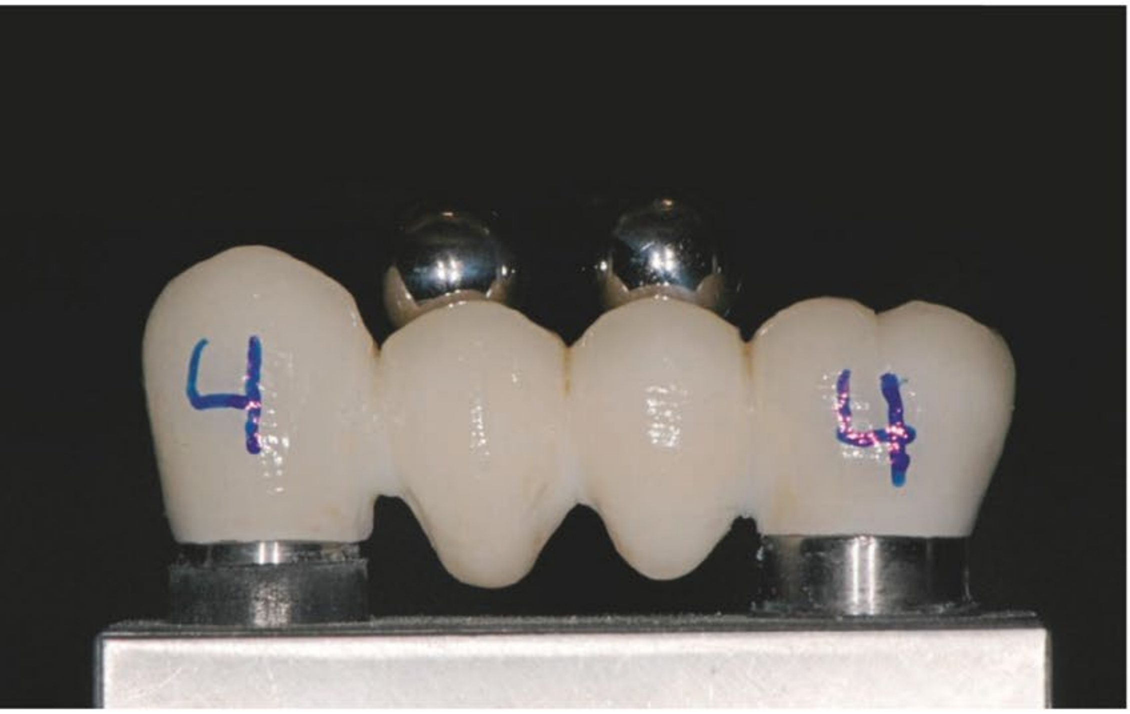
ZTM Andreas Kunz *(Master dental technician)*
Andreas Kunz Zahntechnik, Schumannstr. 1, 10117 Berlin, Germany

„We have since gathered a great deal of experience in joining pressed lithium disilicate with zirconium dioxide frameworks. The uncomplicated handling and high success rates for using hotbond really convinced us."

ZTM Maxi Findeiß *(Master dental technician)*
Dentallabor Grüttner GmbH, Ernst-Thälmann-Str. 3, 07381 Pößneck, Germany

„We have been using hotbond for around 6 months, mainly for zirconium jobs, in preference to EMax for stability reasons! Inlay bridges and crowns with small bonding surfaces or extremely low layer thickness often requires the restoration to be inserted by bonding!
After a brief test phase we adopted it in our portfolio and our clients even accept an additional charge for the additional work!
We have yet to exhaust all the possibilities and certainly continue to look forward to seeing what else this material is capable of!"

You will find further statements following the next article



Summary

Production-related stresses and distortions in the white state of ground zirconium oxide frameworks may jeopardise the exact fit of the restoration and prevent it from being incorporated. Separating and then joining the frameworks affected analogous to soldering or lasering in metalwork would be a new approach to solving this problem. This study examined the resilience of 4unit zirconium oxide bridges separated and then joined in the connector or in the intermediate pontic with ceramic solder.

Indices

Zirconium oxide, bridges, all-ceramic, joints, ceramic solder, ceramic joining

Influence of joining on the stabilityof four-unit zirconium oxide bridges

Timea Wimmer, Jürg Hostettler, Florian Beuer, Bogna Stawarczyk

Introduction

Bridge frameworks made of high-tensile, yttrium partly-stabilised zirconium oxide have Introduction become established alongside metal ceramics in the posterior teeth area. In addition to good aesthetic results, zirconium oxide has a high level of stability and biocompatibility as well as mechanical properties similar to metal ceramics.[8,18] The clinical suitability of zirconium oxide as a framework material for dentures in the posterior teeth sector has since been confirmed in numerous studies.[11]

The design and production of zirconium oxide frameworks is carried out with computer support using CAD/CAM technology. The frameworks are ground out of industrially prefabricated blanks. Two processing options are available: Zirconium oxide is used either as a densely sintered material or pre-sintered and referred to as a white body. If grinding the shape occurs in the densely sintered state, no further sintering is required. As a result, these restorations fit very well.[29,30] However, due to the pronounced hardness of the material, there are disadvantages in terms of a greatly increased wear-out rate of the required diamond-coated grinding tools combined with the increased time needed for the grinding process.[29,30] Furthermore, there is an increased risk of surface damage to the ceramic during this hard machining process.[6] In contrast, grinding the shape of zirconium oxide in the pre-sintered state/white body is much easier and more efficient.[4]

However, a sinter firing is then required to achieve the ideal material properties. This process involves shrinkage of 25 to 30%, which is automatically compensated for by the CAD software through a correspondingly larger dimensioning of the framework when it is milled.[19,25] Due to the inaccuracies that may result from the sintering shrinkage, the scanning process, the compensating software design and the grinding process, the fit of these restorations made from pre-sintered blocks is jeopardised.

In-vitro examinations of the accuracy of fit were incapable of showing evidence of the superiority of CAD/CAM produced zirconium oxide restorations compared with metal ceramic restorations.[19,31] According to Kuni et al, the shrinkage that occurs due to the sintering process in the area of the pontic as well as the warping of the framework during the sinter firing have an impact on the fit of three and four-unit dentures.[15] Furthermore, clinical studies have shown an insufficient margin fit of zirconium oxide frameworks with the risks involved of secondary caries formation, periodontal problems and the risk of mechanical failure such as broken screws in implant restorations.[7,23,29] The problem of stresses occurring in large frameworks is evident particularly in implant prosthetics.[21] The stresses cannot be compensated for due to the lack of a periodontal gap.

To solve this problem, the inaccurate fit can be compensated for on the one hand via the adhesive gap by gluing in secondary structures such as galvanic caps. Another option is to segment and join framework parts.[16] Adhesions are ruled out here, as they do not withstand the heavy loads and the ongoing biodegradation.[16] Lasering has been described for aluminium oxide,[20] but it does not work with zirconium oxide due to the transformative changes and formation of cracks. On the other hand, joining using specifically developed composite elements constitutes an alternative. This procedure has been described for horizontal and vertical extensions of zirconium oxide restorations.[16,21,34] In electronics, the soldering of glass and ceramics has been a well known method for some time.[34] Similar to metals technology, it is based on diffusion bonding with or without spontaneous/controlled crystallisation of the solder.[34]

Zirconium oxide restorations ground to shape in their white state have shown a twist that is in the order of magnitude of cast CoCr bridge frameworks.[1] To restore the fit analogous to soldering or lasering in metalworking, the separation of the zirconium oxide frameworks and subsequent joining would be appropriate.

For dental applications, DCMhotbond zircon (DCM GmbH, Rostock) was developed as a silicate material for positive substance bonding of zirconium oxide frameworks. However, according to the manufacturer, a parallel flat join of separated or broken bridges is contraindicated.

The problem

The twisting of bridge frameworks ground to shape from pre-sintered zirconium oxide results in inaccurate fits. The separation and subsequent joining of the affected frameworks analogous to soldering with alloys would be desirable. The aim of this study was to examine the stability of the joined zirconium oxide frameworks.

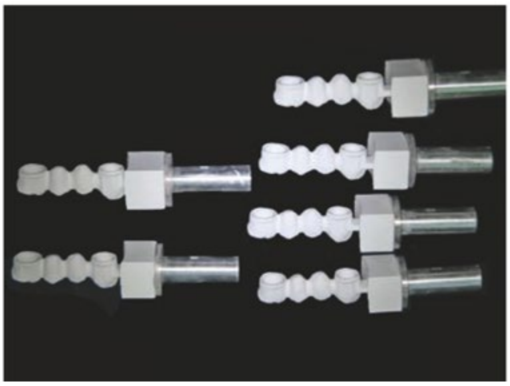


Fig. 1 Ground to shape bridge frameworks in their white state.

Fig. 2 In the mesial intermediate link and separated frameworks in the central.

Material and methods

A CoCrMo master model with prepared stumps of a canine tooth and a first molar was used to manufacture standardised bridge frameworks. The rotationally symmetrical model stumps were designed as cylinders. They had a diameter of 7 mm (canine) and 8 mm (first molar) at shoulder level; their height was 5 mm. The tooth stumps were prepared with a 1 mm wide circular shoulder and 6° conicity. They were mounted in an aluminium block in such a way that the rotational axes were 23.5 mm apart. To simulate the intrinsic mobility of natural teeth in the periodontium, the stumps were enveloped in a 0.75 mm thick rubber sleeve.[22]

After scanning the test model (inEos Blue, Sirona, Bensheim), the test specimens were constructed on the digitalised model in accordance with a four-unit, anatomically shaped bridge framework from the canine to the first molar (Cerec 3D, software version 3.10, Sirona). The connectors had an oval cross-section of 13.7 mm2. The frameworks were ground to shape in the Cerec MC XL milling unit (Cerec MC XL, Sirona) 48 times in their white state (DD Bio ZS, Dental Direkt, Bielefeld). The same dataset for all the frameworks guaranteed consistency of shape (fig. 1).

The frameworks were then randomly divided into four groups of 12 test specimens each. Group 1 remained untouched. Group 2 was subject to thermal treatment (tab. 1), whereas the bridge frameworks of groups 3 and 4 were each cut at one point using a diamond-coated disc (Dynex cutting discs Brillant, Renfert, Hilzingen). With group 3 the separation point was in the mesial pontic; with group 4 the separation was carried out at the central connector between the premolars (fig. 2). In order to achieve clean separating surfaces, these were reworked with a turbine (KaVo Experttorque E680 L, KaVo, Biberach) and subject to water cooling. The expansion of the gap created was 0.7 to 1.0 mm.

Material	Name	Manufacturer
Zirconium oxide framework	DD Bio ZS	Dental Direkt, Bielefeld
Veneer ceramic	Vita VM 9	Vita Zahnfabrik, Bad Säckingen
Ceramic solder	DCMhotbond zircon	DCM GmbH, Rostock

Tab. 1 The materials used.

Fig. 3 Corundum rays of the surface to be joined.

Fig. 4 Glass body to be joined.

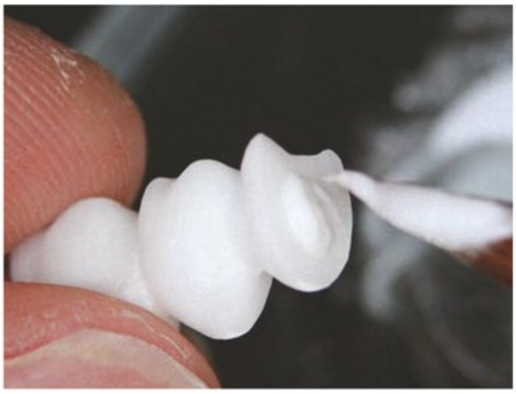


Fig. 5 Wetting the surface to be soldered with the jointing compound.

Fig. 6 Assembly on the plaster model using the silicone key

The bridge frameworks were then sintered in the sinter furnace in accordance with the manufacturer specifications (Vita Zyrcomat, Vita Zahnfabrik, Bad Sckingen).

To prepare for the subsequent joining of frameworks, the surfaces to be joined were corundum-blasted with 50 µm of aluminium oxide (Renfert) (Cemat NT4, Wassermann, Hamburg) (fig. 3). Furthermore, a silicone key (Dentona 1:1 gum, Dentona AG, Dortmund) was produced using an intact bridge framework, in order to be able to fix the separate segments on the model in a standardised way. The DCMhotbond zircon ceramic solder was used for joining (fig. 4). This is a single-glass solder, which according to the processing instructions is used for the positive substance bonding of zirconium oxide frameworks. It consists of a silicate special glass powder, which is mixed with a special fluid.

The powder dosage was measured using a dispenser. Next to this, a few drops of the associated fluid was dripped on until the powder was saturated. Using a spatula, the compound was mixed to a viscous, creamy consistency, and care was taken not to stir in any air bubbles. After applying the material to the surfaces to be joined using a brush, the two segments were placed together on the plaster model and the fit was examined using the silicone key (fig. 5 and 6). The follow-up operation was then carried out in terms of rendering superfluous material with a brush. Once the joint compound has been solidified using a hot air drier, the bridge could be carefully lifted from the model for any necessary corrections to be made. With a liquid firing pad (DCMhotbond zircon, DCM GmbH)

Fig. 7 Production of an individual firing tray with firing pad.

Fig. 8 Positioning of the bridge to be joined on the conventional firing tray.

An individual firing tray was produced (fig. 7), in order to prevent the bridge framework from possibly slipping on the conventional tray during the firing process. Once the firing pad had dried out, the framework was affixed to the conventional firing tray (Vita Zahnfabrik) (fig. 8) and the ceramic solder sintered in accordance with the manufacturer's specifications in the ceramic furnace (Vita Vacumat 40T, Vita Zahnfabrik). The bridge's slow cooling process was followed by cleaning the crown inside surfaces (removal of support pins, blasting). Diamond abrasive wheels were used to finish work to the joint area subject to water cooling. Table 1 is a summary of the materials used to make the bridge.

The next step was to veneer all the frameworks in a consistent shape. The milled surface of the zirconium oxide frameworks was not corundum-blasted or reworked using a milling machine, in order not to provoke any unnecessary uncontrolled phase change. The frameworks were ultrasonically cleansed with distilled water and dried carefully. To achieve consistently shaped veneers, a silicone stencil (Dentona 1:1 gum, Dentona AG) was also used. With their assistance, the dentine material (Vita VM 9, Vita Zahnfabrik) was applied to the frameworks (fig. 9). The firing process then took place in the ceramic furnace (Vita Vacumat 40T) (tab. 2). Care was taken to ensure that the firing temperature for the veneer ceramic was at least 20°C below the joining temperature. The shape was corrected due to shrinkage of the veneer ceramic.

Tab. 2 The thermal treatment and the firing data of the veneer ceramic and the ceramic solder.

Thermal treatment	Vacuum at (°C)	Vacuum from (°C)	Acceleration rate	Firing temperature (°C)	Hold time (min.)
	50	1000	30	1000	34
Vita VM 9	Pre-drying		Acceleration rate (°C/min.)	Firing temperature (°C)	Hold time (min.)
	Temperature (°C)	Time (min.)			
Dentine 1	500	6	55	910	1
Dentine 2	500	6	55	910	1
Final firing	500	-	80	900	1
DCMhothond zircon	Vacuum at (°C)	Vacuum from (°C)	Acceleration rate	Acceleration rate (°C)	Hold time (min.)
	450	1000	30	1000	3

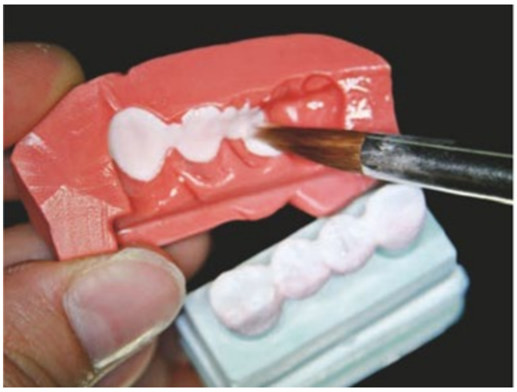


Fig. 9 Veneering of the framework using the silicone stencil.

Fig. 10 The veneered bridge.

by a second dentine firing in each case, followed by a final firing. Cutting and glazing materials were not used. Figure 10 shows one of the veneered bridges.

After veneering, the connector cross-section was 41.7 mm2. Both pontics had a depth that was occlusally consistent with the test stamps.

For the breaking load test, the bridges were positioned without cement on the stumps of the test model and placed under stress in a four-point bending test with two steel balls on the pontics (D = 5 mm) in a universal testing machine (Zwick/Roell Z010, Zwick, Ulm) at a feed rate of 1 mm per minute until fracturing. There were two types of fracture: the framework fracture and chipping of the veneer ceramic (tab. 3). A double folded Teflon film (0.2 mm) (Angst und Pfister, Zürich, Switzerland) was placed between the balls and the bridge, in order to ensure a homogeneous distribution of load on the pontics. The test set-up is shown in figure 11.

The statistical evaluation of the results was carried out using the one-way analysis method of One Way Anova (SSPS version 20, SPSS Inc, Chicago, IL, USA). In the event of a significant difference, a subsequent post-hoc Scheffé test was used to check which groups differed. It was assumed that $p < 0.05$ indicates a significant difference, which corresponds to an error probability of no more than 5%.

Results

The breaking loads measured for the four test groups are shown in the attached bar chart (fig. 12). The breaking loads achieved until chipping of the veneer ceramic were in the range of readings of 655 N (bridges joined at the pontic) and 789 N (thermally treated group). The mean value of the control group was 751 N. No significant differences were found between the four test groups.

Group	Breaking loads (N) chipping	Breaking loads (N) framework fracture
Intact bridges	751 ± 160$_a$	814 ± 133$_a$
Thermal treatment	789 ± 324$_a$	1261 ± 294$_b$
Bridges joined at the pontic	655 ± 230$_a$	1132 ± 490$_{ab}$
Bridges joined at the connector	757 ± 249$_a$	768 ± 239$_a$
*Different letters indicate significant differences (p = 0.05).		

Tab. 3 Descriptive statistics with significant differences in the measured breaking load values of the bridges (N)*.

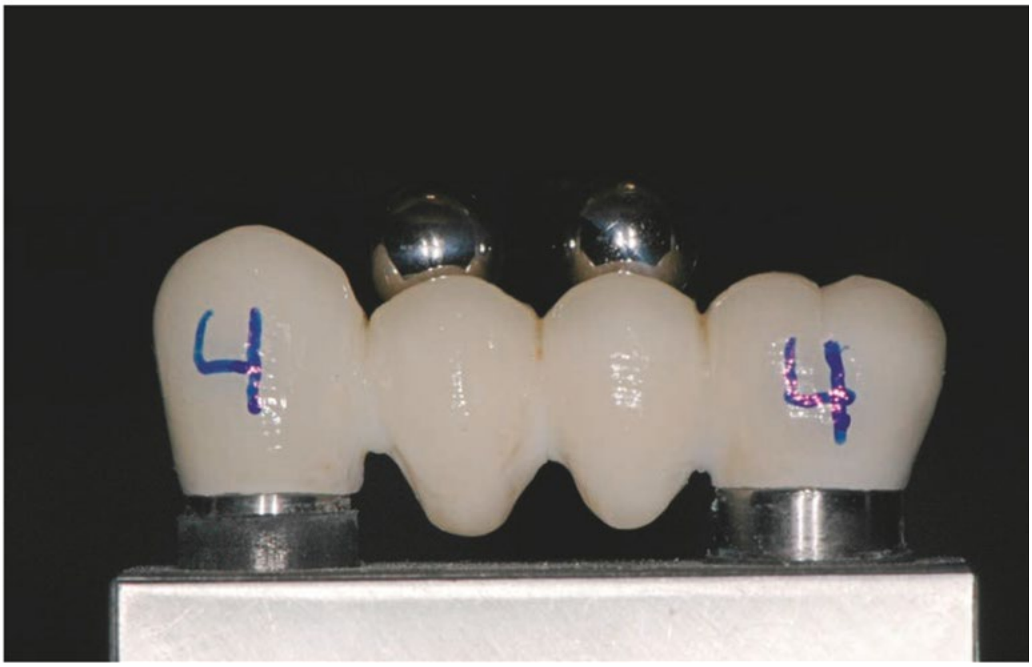


Fig. 11 The test set-up to measure the breaking load in the four-point

The mean measured breaking load of the framework fractures ranged from 768 N (groups joined in the connector) to 1,261 N (thermally treated samples). The control group with a mean breaking load of 814 N as well as the bridges joined at the connector showed significantly lower readings compared with the bridges joined at the pontic (p = 0.001). The thermally treated test group showed significantly higher breaking loads than the untreated bridges and those joined at the connector.

The data presented here were already published in the Journal of the Mechanical Behaviour of Biomedical Materials in April 2013.[32]

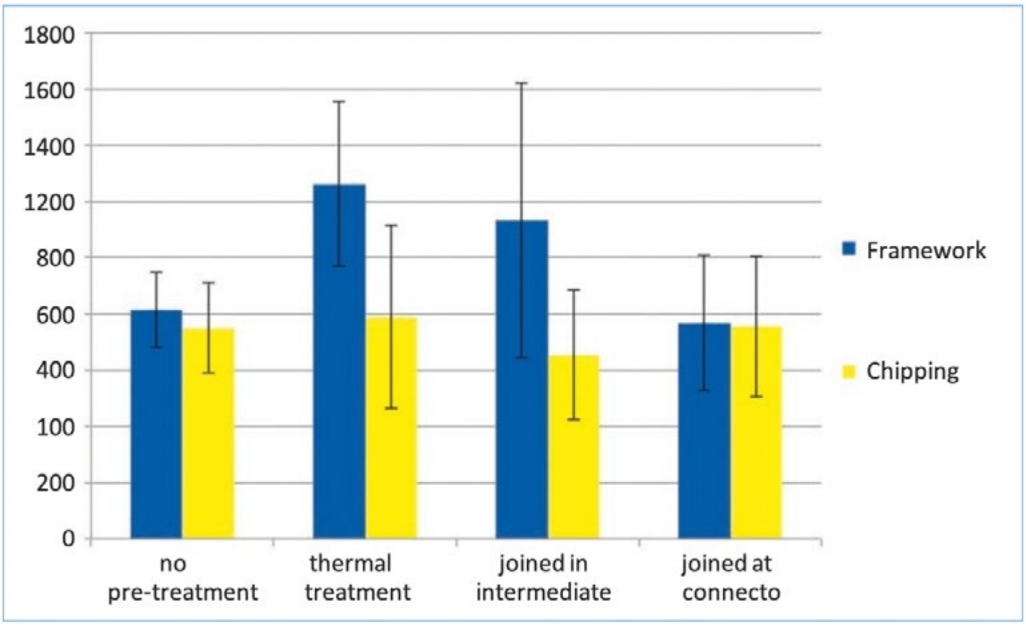


Fig. 12 The bar chart of the measured breaking loads (N) for chipping and framework fracture.

Discussion

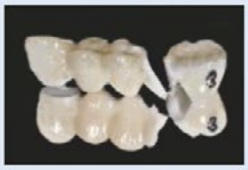
Until chipping of the veneer ceramic occurred, there were no significant differences in breaking load between any of the four test groups. With regard to the framework fracture, the untreated bridges and those joined at the connector also showed similar breaking load values. Significant differences occurred between the joined groups, whereby the bridges joined at the pontic even had significantly higher breaking loads than the frameworks that had been joined at the connector. Similarly, significantly higher breaking load values were measured for the bridges joined at the pontic than for the untreated samples. The thermal treatment resulted in breaking loads that exceeded the breaking load of bridges joined at the connector and the untreated bridges. One explanation for this result could be the tetragonal-monoclinic phase transition of the zirconium oxide. Both the grinding and machining of the ceramic as well as cracks and sintering may result in a conversion from a tetragonal to monoclinic crystal form.[14,18] This leads to pressure stresses on the ceramic surface.[27] In order to achieve a tetragonal surface again, what is referred to as a regeneration firing is recommended.[27] Therefore, the thermal treatment carried out in this test could have resulted in these higher breaking load readings.

The bridges joined at the pontics showed strength levels that were in the order of magnitude of ntreated and thermally treated samples. Compared with the bridge frameworks joined at the central connector, they showed almost 50% higher breaking loads. The larger cross-sectional area of the joint compared with the connector strength could be a reason for this. The impact of the trial set-up on this result should also be discussed. The load was introduced in areas of the central fossae of the pontics. This could have induced a higher stress concentration at the central connector. In a test setup similar to this study, Dittmer et al. investigated the stress distribution of a four-unit bridge using the finite element method (FEM). The resulting stress was concentrated in the gingival side of the central connector.[5] In addition, a breakage in the central connector was described in numerous invitro studies.[13,17,24]

In this study too, fractures occurred when considering the untreated and joined groups between the two pontics with the single exception for the untreated group and two exceptions for the bridges joined at the pontic (tab. 4). With the group joined at the connector, the fracture ran through the joint gap without exception. The thermally treated samples broke mainly in the area of the distal connector (tab. 4).

There are a whole variety of uses for ceramic solders: They are used in horizontal and vertical extensions of framework structures, repairs, abutment optimisations and to compensate for stresses of production-related inaccurate fits of large-span restorations.[16,21,34,35] According to the manufacturer of the ceramic solder used in this study, however, this is not approved for joining parallel surfaces of broken or separated bridges. The ceramic solder is made of a silicate material. The bonding strength between zirconium oxide and silicate ceramic has been the subject of numerous publications, in order to investigate the failure of veneered zirconium oxide restorations.[2,3,10,26,33] The background to this was the high chipping rate of veneered ceramic.[23]

Tab. 4 Relative frequency with 95% confidence interval of fracture images: Break at the medial pontic, at the central connector area, at the mesial and distal connector area.

				
Intact bridges	–	91.7% (61.5; 99.8)	–	8.33% (0.2; 38.5)
Thermal treatment	8.33% (0.2; 38.5)	83.3 % (51.6; 97.9)	–	8.33% (0.2; 38.5)
Bridges joined at the pontic	–	100 % (73.5; 100)	–	–
Bridges joined at the connector	–	–	25.0 (5.5; 57.2)	75.0 (42.8; 94.5)

However, in a composite test, separation of the veneer from the framework does not occur. The break runs completely through the veneer ceramic. As such, not only is a mechanical interlocking of the veneer ceramic with the zirconium oxide framework expected; a chemical bond via oxygen bridge bonds is discussed.[21,28] In addition to factors such as the cooling rate as well as the thermal expansion coefficient, the thickness of the veneer layer plays an important role in fractures of the veneer ceramic: Thicker veneer thicknesses led to higher chipping rates.[10] In this study, the gap created between the bridge parts to be joined was kept narrow at a size of 0.7 to 1.0 mm. The effective surface of the joints was also much less than the area to be veneered in zirconium oxide restorations. Both factors could have contributed to the stability of the joined sections.

Riemer-Krammer et al. describe an inherent connection of glass solders with surfacetreated zirconium oxide due to the formation of a reactive layer with possible infiltration and diffusion.[21] After the glass solder was fired on the zirconium oxide, fractures were detected solely in the veneer material or the break ran across all the layers of the restoration.[21,34] Zothner et al. could not find any break in the joint area of the bridges joined using the segment system technique either.[34] Provoked destruction of the soldered joint area showed fractures obliquely through the glass solder as well as the zirconium oxide framework.[34]

To summarise, it should be emphasised that chewing forces of approx. 400 N occur in the posterior tooth region.[12] The fracture loads of all four groups in this study were far above this reading. However, it should be noted that the samples in this study were not subjected to any artificial ageing. Moisture in the oral cavity combined with mechanical stress may lead to a decrease in the stability of the restoration.[9,13] This is why further in-vitro examinations are required while taking account of the clinical situation. Ultimately, the values of this study should also be confirmed in an in-vivo study.

Conclusion

The joining of separated bridge frameworks initially shows no negative impact on the breaking load of four-unit veneered zirconium oxide bridges. Thermal treatment improved the overall stability of the restorations.

Acknowledgements

The authors thank DCM GmbH, Rostock for providing the solder and Dental Direkt, Bielefeld for the zirconium oxide blanks. Vita Zahnfabrik kindly provided the Vita VM 9 veneering ceramic for this investigation.

Literature

1. Abduo J, Bennani V, Lyons K, Waddell N, Swain M. A novel in vitro approach to assess the fit of implant frameworks. Clin Oral Implants Res 2011;22:658-663.
2. Aboushelib MN, Kleverlaan CJ, Feilzer AJ. Microtensile bond strength of different components of ,core veneered all-ceramic restorations. Part II: Zirconia veneering ceramics. Dent Mater 2006;22:857-863.
3. Belli R, Frankenberger R, Appelt A et al. Thermal-induced residual stresses affect the lifetime of zirconia-veneer crowns. Dent Mater 2013;29:181-190.
4. Beuer F, Naumann M, Gernet W, Sorensen JA. Precision of fit: zirconia three-unit fixed dental prostheses. Clin Oral Investig 2009;13:343-349.
5. Dittmer MP, Kohorst P, Borchers L, Stiesch M. Influence of the supporting structure on stress distribution in all-ceramic FPDs. Int J Prosthodont 2010;23:63-68.
6. Edelhoff D, Weber V, Johnen C, Beuer F. Klinische Erfahrungen mit CAD/CAM-gefertigten Zirkonoxid-Brückengerüsten des Digident-Systems. Quintessenz 2007;58:371-383.
7. Felton DA, Kanoy BE, Bayne SC, Wirthman GP. Effect of in vivo crown margin discrepancies on periodontal health. J Prosthet Dent 1991;65:357-364.
8. Filser F, Kocher P, Weibel F, Luthy H, Scharer P, Gauckler LJ. Reliability and strength of allceramic dental restorations fabricated by direct ceramic machining (DCM). Int J Comput Dent 2001;4:89-106.
9. Fischer J, Stawarczyk B, Hammerle CH. Flexural strength of veneering ceramics for zirconia. J Dent 2008;36:316-321.
10. Guazzato M, Walton TR, Franklin W, Davis G, Bohl C, Klineberg I. Influence of thickness and cooling rate on development of spontaneous cracks in porcelain/zirconia structures. Aust Dent J 2010;55:306-310.
11. Heintze SD, Rousson V. Survival of zirconia-and metal-supported fixed dental prostheses: a sys-tematic review. Int J Prosthodont 2010;23:493-502.
12. Helkimo E, Carlsson GE, Helkimo M. Bite force and state of dentition. Acta Odontol Scand 1977;35:297-303.
13. Kohorst P, Dittmer MP, Borchers L, Stiesch-Scholz M. Influence of cyclic fatigue in water on the load-bearing capacity of dental bridges made of zirconia. Acta Biomater 2008;4:14401447.
14. Kosmac T, Oblak C, Jevnikar P, Funduk N, Marion L. The effect of surface grinding and sandblas-ting on flexural strength and reliability of Y-TZP zirconia ceramic. Dent Mater 1999;15:426-433.
15. Kunii J, Hotta Y, Tamaki Y, et al. Effect of sintering on the marginal and internal fit of CAD/CAM-fa-bricated zirconia frameworks. Dent Mater J 2007;26:820-826.
16. Langschwager A, Friedrich R, Mitrovic A, Hopp M, Biffar R. Okklusal modifizierte Zirkonoxid-brücke. Implantatprothetische Restauration eines komplexen Behandlungsfalls. Quintessenz Zahntech 2013;39:352-368.
17. Larsson C, Holm L, Lovgren N, Kokubo Y, Vult von Steyern P. Fracture strength of four-unit YTZP FPD cores designed with varying connector diameter. An in-vitro study. J Oral Rehabil 2007;34:702-709.
18. Piconi C, Maccauro G. Zirconia as a ceramic biomaterial. Biomaterials 1999;20:1-25.
19. Reich S, Wichmann M, Nkenke E, Proeschel P. Clinical fit of all-ceramic three-unit fixed partial dentures, generated with three different CAD/CAM systems. Eur J Oral Sci 2005;113:174-179.
20. Reinecke AM, Exner H. A new promising joining technology. J Cer Proc Res 2001;2:45-50.
21. Riemer-Krammer B, Eilert C, Friedrich R, Mitrovic A, Hopp M, Biffar R. Innovationen und, Teamarbeit in der Implantatprothetik. Quintessenz Zahntech 2011;37:656-670.
22. Rosentritt M, Behr M, Scharnagl P, Handel G, Kolbeck C. Influence of resilient support of abutment teeth on fracture resistance of all-ceramic fixed partial dentures: an in vitro study. Int J Prosthodont 2011;24:465-468.

23. Sailer I, Feher A, Filser F, et al. Prospective clinical study of zirconia posterior fixed partial dentures: 3-year follow-up. Quintessence Int 2006;37:685-693.
24. Sarafidou K, Stiesch M, Dittmer MP, Jorn D, Borchers L, Kohorst P. Load-bearing capacity of artificially aged zirconia fixed dental prostheses with heterogeneous abutment supports. Clin Oral Investig 2012;16:961-968.
25. Sax C, Hammerle CH, Sailer I. 10-year clinical outcomes of fixed dental prostheses with zirconia frameworks. Int J Comput Dent 2011;14:183-202.
26. Swain MV. Unstable cracking (chipping) of veneering porcelain on all-ceramic dental crowns and fixed partial dentures. Acta Biomater 2009;5:1668-1677.
27. Tholey M, Rutten L, Rutten P. Sicher zur Ästhetik mit Gerüsten aus Zirkoniumdioxid. Quintessenz Zahntech 2011;37:460-469.
28. Tholey MJ, Marc S. Haftverbundmechanismen in dentalen Schichtsystemen. Quintessenz Zahntech 2007;33:160-168.
29. Tinschert J, Natt G, Mautsch W, Spiekermann H, Anusavice KJ. Marginal fit of alumina-and zirconia-based fixed partial dentures produced by a CAD/CAM system. Oper Dent 2001;26:367-374.
30. Vult von Steyern P, Carlson P, Nilner K. All-ceramic fixed partial dentures designed according to the DC-Zirkon technique. A 2-year clinical study. J Oral Rehabil 2005;32:180-187.
31. Wettstein F, Sailer I, Roos M, Hammerle CH. Clinical study of the internal gaps of zirconia and metal frameworks for fixed partial dentures. Eur J Oral Sci 2008;116:272-279.
32. Wimmer T, Hostettler J, Beuer F, Stawarczyk B. Load-bearing capacity of soldered and subsequently veneered 4-unit zirconia FDPs. Journal of the mechanical behavior of biomedical materials 2013;23:1-7.
33. Zhang Z, Zhou S, Li Q, Li W, Swain MV. Sensitivity analysis of bi-layered ceramic dental restorations. Dent Mater 2012;28:e6-14.
34. Zothner A, Mitrovic M, Eilert C, et al. Die Segment-System-Technik mittels HotGlue-Fügung. Fertigung einer zirkulären Oberkieferversorgung aus Zirkoniumdioxid auf Implantaten. Quintessenz Zahntech 2008;34:566-581.
35. Zothner A, Moss C, Hopp M, et al. Oberflächenkonditionierung von Zirkoniumdioxid zur Verbesserung des Klebeverbundes. Quintessenz Zahntech 2009;39:874-886.

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Summary
Manufacturing-related stresses and distortions of zirconia frameworks milled in the white stage can compromise the accuracy of fit and preclude the applicability of the restoration. A separation and subsequent joining of affected frameworks similar to soldering or lasering in metallurgy might be a novel approach to solve this problem. Therefore, in the present study, the load-bearing capacity of joint four-unit zirconia fixed dental prostheses (FDPs) was investigated. For this purpose, four groups of frameworks, which were congruent concerning their shape, were fabricated. The first group was not treated; group two was treated thermally. In group three the frameworks were separated at the mesial pontic, in group four at the central connector. The respective parts of the frameworks were joined using a ceramic solder and veneered congruently. Subsequently, the fracture load was determined and data were statistically analyzed.

DCM hotbond

Dr. med. dent. Jan Hajtó
Spezialist für Ästhetische Zahnheilkunde (DGÄZ), *Specialist for aesthetic dentistry,* **Brienner Str. 7, 80333 München** Germany

„DCMhotbond fusio is the perfect solution for continuously loaded and highly aesthetic full ceramic restorations made of zirconium oxide and lithium disilicate. I have personally employed high-strength aesthetic zirconium oxide / lithium disilicate composite crowns and bridges on teeth and implants bonded with DCMhotbond with clinical success for five years now. Chipping is certainly a thing of the past.“

Dr. med. dent. Peter Randelzhofer, Weinstr. 4, 80333 München, Germany

„hotbond is one of the most important factors for my implant-prosthetic treatment concept. It enables different materials to be connected such that they can bring their best characteristic to bear in the right place. Stability - function and aesthetics united“.

Dr. Michael Hopp, Zahnarzt, Implantologe, Werkstoffkundler, *Dentist, Implantologist, Materials Scientist*
Kranoldplatz 5, 12209 Berlin, Germany

„... DCMhotbond glass solder is a material for firm bonding, not a typical veneer ceramic material used in dentistry. This makes glass solders a separate class of materials. There is nothing comparable on the dental market.“ (Expert report on material - locked bonding with DCMhotbond, 2010)

Dipl.-Ing. Ruedger Rubbert
Natural Dental Implants AG (CEO), Dieffenbachstr. 33, 10967 Berlin, Germany

„We subjected the DCMhotbond bond between our REPLICATE™ implant body (titanium) and abutment (zirconium ceramic) to a dynamic stress test in accordance with ISO 14801. On a „worst case“ assumption, we selected the model design of the narrowest human tooth, a central mandibular incisor, as test specimen. The standard requires that a minimum number of test specimens each withstand 5 million cycles under increased oscillating load at an angle of 30° to the perpendicular. The maximum load where the required number of test specimens had not fractured was 450 Newton. This corresponds to a load of approx. 45 kg on each mandibular incisor in a normal environment. 5 million cycles at the load quoted mean that a patient would have to bite on a cherry pit with an implant in the mandibular position for at least 100 years and 137 times per day, at least with damaging the glass solder connection. However, this experiment is not recommended for patients for various reasons.“

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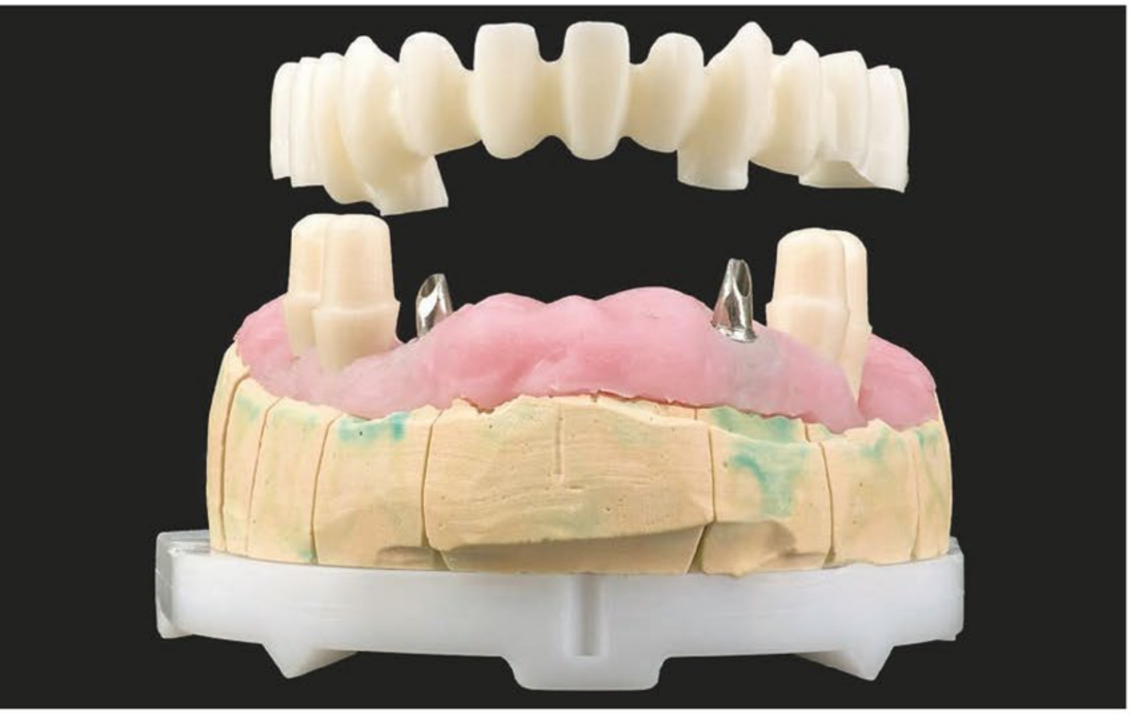


Summary

Circular bridges, also based on zirconium oxide, have inaccurate fits due to their production-related distortions. An implant-supported restoration will therefore always provoke stresses at the interface. The current work shows a possibility of compensating for stress with a soldered intermediate passivefit connector.

The hard bite in the predamaged dentition with restoration of the antagonistic mandible may lead to the use of composite occlusal surfaces on a ceramic bridge in a mandible to minimise functional discomfort, but implementing this remains a technical challenge.

Occlusally modified zirconium oxide bridge

Implant prosthetic restoration of acomplex treatment case

Indices

Zirconium oxide, all-ceramic, ceramic joining, ceramic solder, Hotbond, gnathology, implant restoration, implant prosthetics, passive-fit connector, composite veneer, plastic composite

Arvid Langschwager, René Friedrich, Aurica Mitrovic, Michael Hopp, Reiner Biffar

Introduction

Functionality and aesthetics play a fundamental role in modern dentistry,[14] so the success of the ZrO_2 application with its white or tooth-coloured framework structures is not surprising.

Despite the framework's light colour, the price cannot compete with non-precious metal casting frameworks and it is unlikely that blank distributors will get approval for indications with delicate support structures. Nonetheless, the development is interesting and is being pursued consistently. Baltzer and Kaufmann-Jinoian1 require a minimum cross-section of the frameworks for fixed restorations. The mechanical values achieved are also important, which differ from HIP-ZrO_2 in how they are manufactured.[4]

In implantology, circular bridges made of zirconium oxide have been used successfully in practical applications for some time.[9] However, due to limitations in the production technology of various CAD/CAM systems, these bridges had to be put together using different segments and positively connected using glass solders. The initially used attachment-type connecting elements8 were optimised in terms of stability and process for ceramic technology to form rounded joining elements without shifting and sliding characteristics.[19]

With segment technology, as also carried out in industrial applications, such as with ceramic green solders or laser welding, a minimisation of stress and improved fit of dentures has been postulated,[3] but not yet demonstrated.

Despite all the advantages and expectations of the white material, the issue of stress in large frameworks remains, especially when some major differences in dimensions and volume occur. The causes are on the one hand the manufacturing process with follow-up sintering operations and the production of blanks. Depending on the manufacturing process, packing density and size of the blanks, a distortion is generated when sintering, which may lead to fit inaccuracies. Various methods of technical implementation of the restorations remedy this. Gluing secondary structures, such as galvanic caps using the passive-fit technique, compensates for the inaccurate fit over the adhesive gap. Another method is the segmentation and joining of framework parts. The lasering of high-performance, oxide-based ceramics, as Reinecke and Exner have described for aluminium oxide,[11] does not work with ZrO_2 due to the transformative changes and formation of cracks. This leaves only gluing and soldering. Composite-based adhesives are often discussed but are not stable and durable enough in the framework area due to the high levels of stress and ongoing biodegradation without pre-treating the zirconium oxide. Soldering using specifically developed composite elements is a viable alternative, as they have been described for horizontal and vertical extensions of zirconium oxide structures.[19]

A second important aspect is the occlusal arrangement. Even though the placement of fixed restorations is today almost completely achieved using ceramic veneers, the question of a “hard” bite still arises. The development of hydrothermal ceramics has not produced any significant improvement in this regard. One longterm desire to be able to combine the good plaque resistance of ceramics, especially in the transgingival and the abutment area as well as all the bridge elements that are in contact with the mucous membrane, with the limited abrasion capability of the composite materials, has not been implemented so far due to the low-level adhesion of composites on ZrO_2 structures. By coating the ZrO_2 surface with special glass solders and forming a reaction layer, it is possible to create a permanent bond based on the patented process of Hopp and Zothner[6]. In terms of the gnathological approach, the procedure was first applied by Riemer-Krammer et al.[12] in a removable implant-anchored restoration.

The patient case

Patient history

The 58-year-old patient first attended the surgery in May 2012 with a request for a prosthetic restoration of the upper and lower jaw. His general medical history showed no indication of acute or chronic diseases. The patient’s facial skin showed no pathological changes. His facial features and lips appeared sunken. His pronunciation was very blurred and unclear due to his missing teeth. Palpation of the temperomandibular joints and chewing muscles was normal. There were no indications of TMJ disease, although definite signs of abrasion were evident on the incisal surfaces of his lower front teeth. The submandibular lymph nodes were not palpable or painful to pressure.

Fig. 1 a The en-face view of the patient with reduced height of the lower face and b profile view.

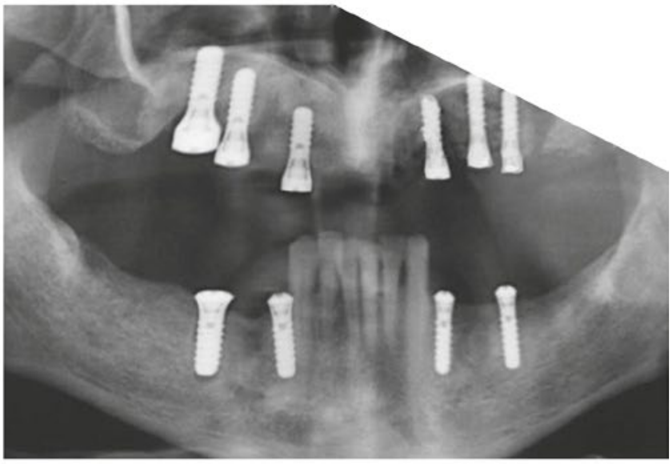


Fig. 2 Orthopantogram of the implant situation with inserted implants in all four quadrants.

Fig. 3 a The intra-oral situation. Top view of b the upper jaw and c lower jaw.

In addition to the general record of findings, en-face and profile shots (fig. 1) of the patient were taken. The patient stated that he had not worn any dentures or interim dentures for approx. three years. An orthopantomogram showed a damaged but worth preserving set of mandibular front teeth and inserted implants in all four quadrants (fig. 2). There were no further pathological changes in the jaw. The dental examination also revealed a large vertical dimension due to long-term absence of teeth (fig. 3a), exposed transgingival parts with screw plug in regio 16, 15, 13, 23–25 in the upper jaw and 34, 36, 44, 46, in the lower jaw (fig. 3b and 3c). The anterior residual dentition 33-43 was caries-free, vital, there was no degree of loosening (grade 0) or incisal abrasions.

The periodontal status showed a PSI code 2 at the front of the lower jaw, with slightly generalised bone loss and gingival recessions at 33, 41, 43. Apart from the horizontal bone reduction, the X-ray status of teeth 33–43 was unremarkable.

Due to the patient's oral hygiene status, implementation of a prophylactic programme was mandatory. The patient was encouraged and instructed to practise oral hygiene including mucous membrane care by a dental assistant. At a follow-up session, an excellent state of oral hygiene was diagnosed with an API (approximal plaque index) of < 21%, which may be considered the basis for long-term implant prosthetic success.

The patient had extensive documentation of the previously treated oral and maxillofacial surgeon with him. The required implants were carried out in advance at a local oral and maxillofacial practice. A sinus lift was carried out with nanobone granules and a biogide membrane on both sides of the upper jaw (regio 14–16 and 24–26). Due to the transgingival Straumann system used (Straumann, Freiburg), the implants did not have to be exposed.

Therapy planning and prosthetic care

Since the patient attended the surgery for prosthetic care following an already completed surgical pre-treatment, there was no need for extensive planning in relation to prosthetic construction. The patient expressly requested a fixed denture, which it was possible to implement with the appropriate abutment distribution. Table 1 shows the current findings and the planned denture.

		K	K	B	K	B	B	B	B	K	K	K	B		
f	f	i	i	f	i	f	f	f	f	i	i	i	f	f	f
18	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
48	**47**	**46**	**45**	**44**	**43**	**42**	**41**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**
f	f	i	f	i							i	f	i	f	f
		K	B	K							K	B	K		

Tab. 1 Intra-oral findings with prosthetic planning (m = missing, i = implant, c = crown, b = pontic).

The lowering of the vertical dimension was compensated for by the definitive denture. An interim provisional restoration for the adjustment and reorientation of muscles, tendons and joints was not prepared, as the patient rejected the proposed interim solution. He also rejected a non-tooth coloured metallic denture. Based on situation models, face bow and support pin registration as well as photos the patient brought of himself with all his teeth, aesthetic and functional tryins were initially carried out using wax/plastic prosthetics as a tooth set-up. The requirement for the dentistry work was therefore a tooth-coloured restoration, which should nonetheless have a “softer” bite.

Dental implemen tation

After taking an impression with an individual tray and Impregum (3M ESPE, Seefeld) cut models of the upper and lower jaw were produced with a gingival mask (fig. 4). Appropriate abutments were selected and milled in the milling device in parallel and conically to 6°. The models were scanned in the 3Shape scanner (3Shape, Copenhagen, Denmark), the bridge frameworks were designed with the appropriate software using CAD. Figures 5a and b show screen-shots of the designed lower joint frameworks in the combined technique for the ceramic and occlusal composite veneer. The vestibular and occlusal detailed representations of the third and fourth quadrants with the patelliform indentations for the veneer material can be seen in figure 5b.

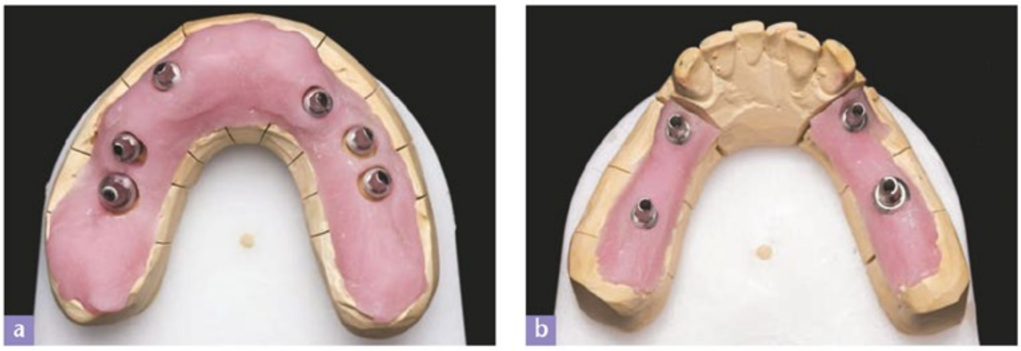


Fig. 4 The implant model of a upper and b lower jaw.

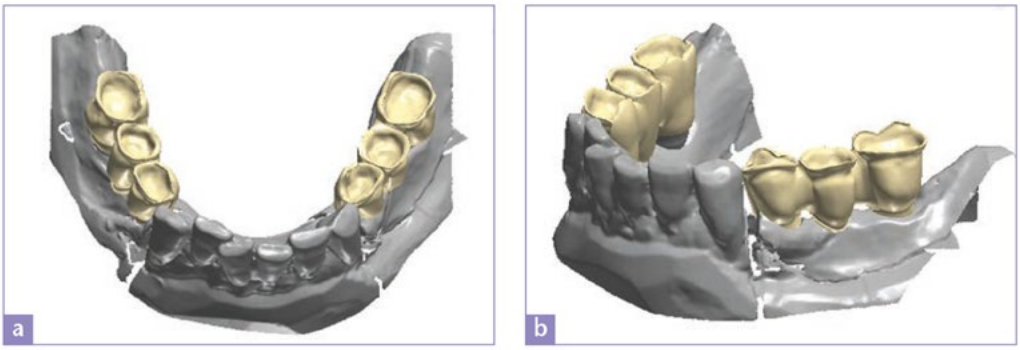


Fig. 5 Screen-shots a of the CAD planning of the lower jaw bridge frameworks and b detailed representation of the third quadrant.

Fig. 6 A milled bridge framework.

Fig. 7 The lower jaw bridge framework is placed against the wax set-up of the upper jaw in the articulator.

The CAM programming of the bridge frameworks in zirconium oxide was carried out by the Cercon Brain Expert (DeguDent, Hanau). Figure 6 shows a milled, finished and sintered bridge framework with a typical brim to support the subsequent composite veneer. The fit and occlusal connections of the bridge frameworks will be checked against the upper jaw tooth set-up in the articulator (fig. 7). After inserting the abutments in the lower jaw (fig. 8), the situation is transferred to the mouth via a bite registration and also checked for fit and control of the three-dimensional relation as well as sufficient space for the composite veneer. Figures 9a and b show the bridge frameworks from the top and in relation to the wax set-up in the upper jaw.

The finished frameworks are sandblasted at 2 bar, evenly coated in an airbrush process with DCMhotbond zirconnect (Dental Balance, Ratzeburg) (fig. 10) and fired in accordance with the firing instructions at 1,000°C. The shiny surface after the firing has a perfect Zirconnect coating and a good firing result

Fig. 8 The lower jaw with inserted abutments.

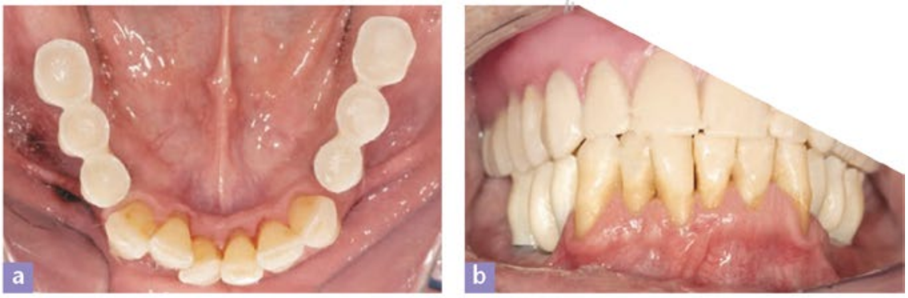


Fig. 9 The bridge frameworks viewed a from above and b in relation to the wax set-up in the upper jaw.

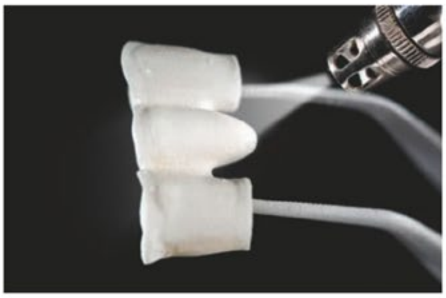


Fig. 10 Coating the framework with

Fig. 11 The shiny surface shows a perfect Zirconnect coating.

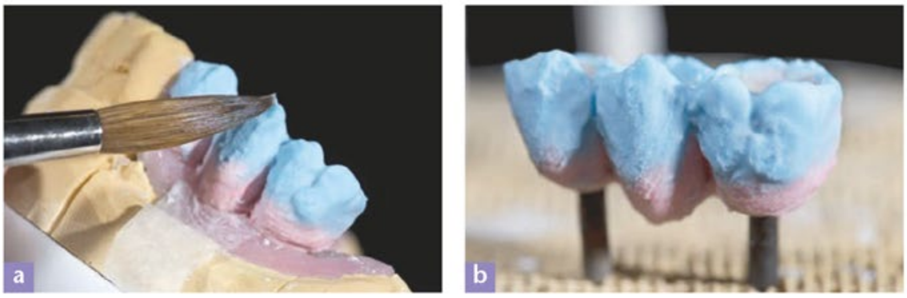


Fig. 12 a Applying the individual veneer with ceramic and b the completely layered framework on the firing tray.

Fig. 13 Etching the Zirconnect layer with C-Link etch.

(Fig. 11): After sandblasting again, the ceramic veneering of the bridge frameworks is carried out (fig. 12a) with Cercon Ceram Kiss (DeguDent), fired in the first dentine firing at 830°C, with the exception of the occlusal surface. Figure 12b shows the fully layered framework on the firing tray. The firing process is carried out in a conventional ceramic furnace (Zubler Varo 200, Zubler, Ulm). After the ceramic veneer work has been completed, the occlusal composite layer of the bridge is sandblasted briefly once again and the Zirconnect layer is etched up to the edge of the veneer with C-Link etch (C-Link, Steco, Hamburg) (fig. 13). The etching time is 60 seconds. Only by etching the Zirconnect composite layer is it possible to demonstrate a morphological surface structure and a definite increase in roughness depth (fig. 14). The etched occlusal surfaces are now silanised with C-Link silane using the process patented by Hopp and Zothner6 (fig. 15a), dried and the C-Link connector is applied to create the bond (fig. 15b).

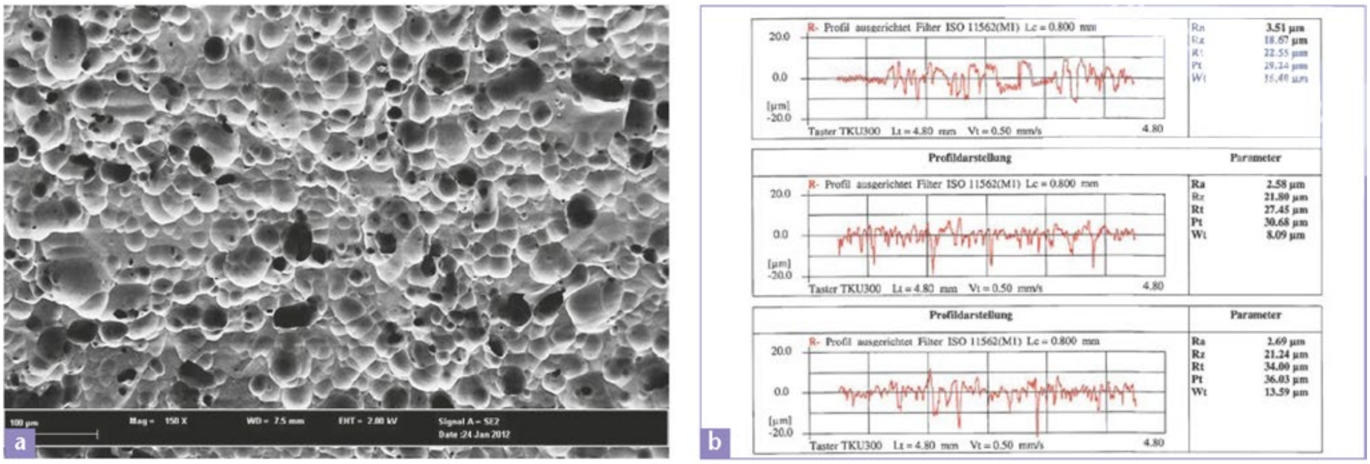


Fig. 14 a The surface structure after etching alone, SEM image and b the roughness measurement of the etched surfaces.

Fig. 15 a The occlusal surfaces are silanised; b attachment of the C-Link connector; c the layered application of the occlusal surfaces in composite; d the occlusal layering of the chewing surfaces is complete; e polymerising of the veneer composite; f the occlusal area of the second bridge is ready for coating.

The chewing surfaces are applied layer by layer with Venus Pearl (Heraeus Kulzer, Hanau) in filling composite (fig. 15c) thanks to good experiences with it, also when used in dentistry. The occlusal layering is carried out in accordance with gnathological guidelines (fig. 15d) and polymerised (fig. 15e). The occlusal area of the second bridge is prepared for coating and is completed using the same procedure (fig. 15f). The smooth, patelliform composite surfaces are clearly visible; due to the technique presented, there is no need for undercuts and retention structures. Once completed, an occlusion check is carried out on the work in the mouth against the tooth set-up in the upper jaw (fig. 16).

Fig. 16 The occlusion check of the completed lower jaw bridges a on the right and b left placed against the upper jaw wax set-up.

Fig. 17 The situation in the articulator shows the great difference in the vertical dimension.

Fig. 18 The finished abutment extension (passive fit) on the left.

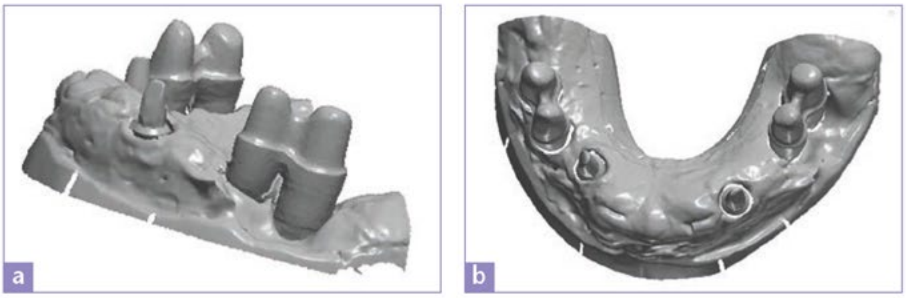
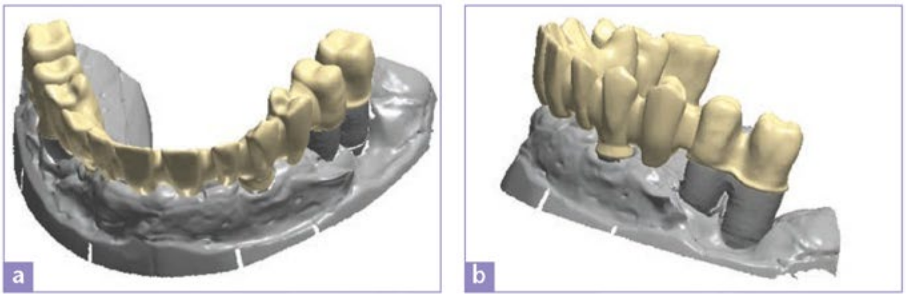


Fig. 19 Screen shots: a The abutment extension on the model in a detailed lateral view; b both abutment extensions on the model from the occlusal.

Fig. 20 Screen shots: a The bridge modellation on the model from oblique occlusal; b the bridge in the transitional area to the abutment extensions, first quadrant.



In the articulator the large vertical difference is evident after completing the mandibular restorations due to bone resorption in the maxillary posterior tooth area (fig. 17). There is a clear vertical step between the canine premolar area and the molar area, which has to be compensated for by the height of the denture. Because the blank thickness was exceeded, a vertical division was provided for in the distal area of the bridge. This is how very large differences can be overcome. In the event of stresses that also arise in zirconium oxide with very large spans and volumes, stresses due to production-related inaccuracies can be compensated for by soldering a connector to achieve a passive fit.

The extensions for the respective distal implants were achieved via scanned in wax-ups in the form of blocked cone parts made of milled ZrO_2 ceramic. Figure 18 shows the finished connectors in the first and second quadrants on the model.

Fig. 21 The milled, sintered and completed bridge framework in ZrO_2 ceramic.

Fig. 22 The separate components of the framework on the model.

Fig. 23 a Try-in of the passive-fit extensions; b The bridge framework is fixed on the abutment extensions; c And d Control of the bridge fit in the first and second quadrants.

The model with the produced passive-fit connectors was scanned as the basis for the upper part of the circular bridge (fig. 19) and the circular part digitally designed. Figure 20a shows a screen-shot of the bridge modellation of the model from oblique occlusal; figure 20b shows a screen-shot of the bridge in the distal transitional area to the connectors in the first quadrant. Figure 21 shows the occlusal framework part of the milled, sintered and completed bridge in ZrO_2 ceramic and figure 22 all the framework parts in the exploded view of the model.

For stress-free bonding of parts using the glass solder technique, these are inserted in the mouth as try-ins (fig. 23a), their fit is checked, they are connected using provisional cement (Tempbond, Kerr, Rastatt) (fig. 23b) and the vertical checked. Figures 23c and 23d show the bridge fit in the first and second quadrants after fixing. A pick-up impression is then taken with Impregum (3M ESPE) (fig. 24). The created model with individual stumps from Pattern Resin (GC

Fig. 24 Situation after pick-up impression in the mouth.

Fig. 25 The fixed bridge on a new model.

Germany, Bad Homburg) on dowel pins served as a master model for all work until completion (fig. 25). Figures 26a and 26b show how the connectors are fixed on both sides in the circular bridge section.

The fixing material is burnt out in the ceramic furnace at 300°C and the contaminated contact surfaces soiled with carbon residue are sandblasted before soldering (fig. 26c). In figure 26d the connectors are placed on the model and prepared for soldering. The DCMhotbond zirkon ceramic solder (Dental Balance) is mixed according to the manufacturer's instructions, applied to the connectors and into the bridge framework (fig. 26e and 26f). Both parts are placed in their final position on the model by applying slight pressure (fig. 26g). A previously created control key made of light-curing tray material makes checking easier. The surplus solder is placed in a circular shape at the solder points due to the need for a reservoir to pull when melting and is carefully dried with an industrial hair drier until a chalky stability is achieved. The construction can now be lifted from the model distortion-free, checked and mounted on the firing tray to be soldered (fig. 26h). The use of a honeycomb firing tray made of ZrO_2 is preferable, as distortions can be minimised in the soldering process using the same CTE. Finally, DCMhotbond zirconnect is sprayed on to the surface coating of the bridge (fig. 26i). Firing takes place at the same time, as the working temperatures for both DCMhotbond zirkon as well as DCMhotbond zirconnect are 1,000°C.

A non-destructive quality check of the solder seams was carried out on the finished soldered and coated framework using a micro-CT from industrial applications; it shows a flawless solder joint in the horizontal and vertical sectional planes (fig. 27), which only has subtle indentations on the periphery. However, these do not have to be resoldered, as they are automatically sealed with the veneering ceramic.

Before the ceramic veneering, the framework is checked for its fit, sandblasted and veneered using Cercon Ceram Kiss veneering ceramic (DeguDent) including the gingival body. The furnace used was a Zubler Varo 200. Figure 28 shows the sides of the bridge in the first quadrant after the first dentine firing, layering of the gingival body was also already started.

Fig. 26 Fixing the abutment extension a right and b left; c burning out the fixation in the ceramic furnace; d the abutment extensions are prepared for soldering; e applying the ceramic solder to the abutment extension and f into the bridge framework; g both parts are placed in their end position on the model; h the bridge framework mounted on the firing tray before soldering; i spraying DCMhotbond zirconnect on the surface coating.

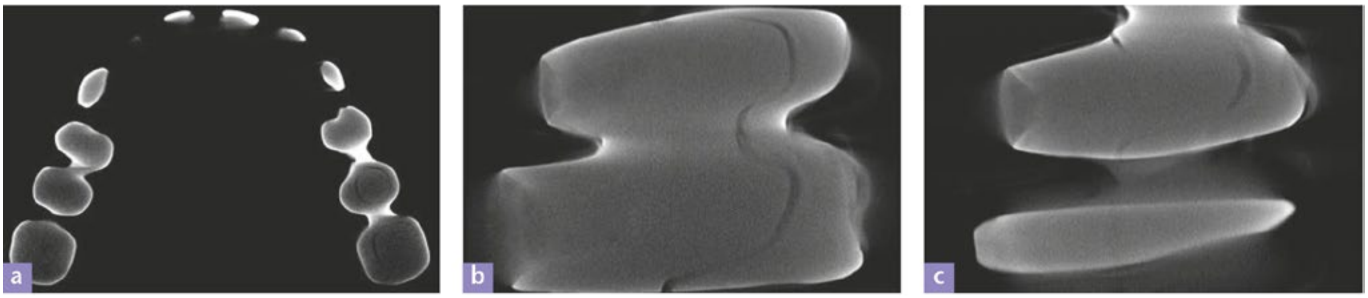


Fig. 27 a A horizontal micro-CT image through the bridge; b and c two vertical micro-CT images through different abutmentframework areas of the passive-fit connection.

Further layering as well as the frontal and palatal views with finished gingival material already applied are seen in figures 29a to 29c. The layered bridge is mounted on the firing tray in figure 29d and shown on the model in occlusal view after firing (fig. 30).

Fig. 28 The bridge in the articulator after the first firing, second quadrant, gingival layering has started.

Fig. 29 Further layering in the second quadrant a from frontal b and palatal view c With already applied gingival material; d the layered bridge on the firing tray.

Fig. 30 The maxillary bridge after completion from an occlusal view.

Fig. 31 The completed work in the articulator, frontal view.

Great importance was attached to the position of the approximal contacts and a smooth result for the front teeth. With another try-in, the required minimal occlusal corrections were also carried out by grinding.

Figure 31 shows the complete restoration in both jaws from the front as well as figure 32 showing the raised maxillary bridge from the basal after completion. The separate coating of the insides of the crown with DCMhotbond zirconnect provides an option of efficient sandblasting and etching of the insides. Figure 33 shows the additional etching in the maxillary restoration to achieve better cement bonding. All three restorations were semipermanently achieved with Tempbond (Kerr).

Fig. 32 The completed maxillary bridge.

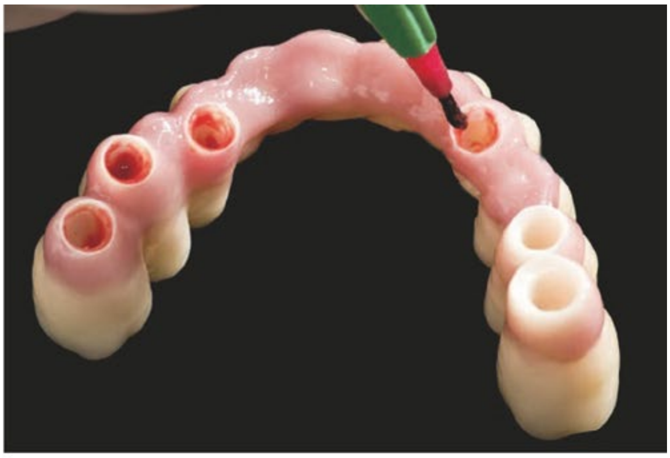


Fig. 33 Preparation of the crown insides with additional etching in the maxillary restoration.

Fig. 34 a The frontal view of the integrated restorations; b course of the bridge and lip line match perfectly when laughing; c profile view of the patient.

By coating the insides of the crowns with Zirconnect, the durability of the cement used is definitely improved and after the construction has been removed, the material remains on the ceramic side, which has either not been or only infrequently observed with purely ZrO_2 constructions.

The frontal view of the integrated restorations shows a good aesthetic image (fig. 34a), bridge course and lip line match perfectly when laughing (fig. 34b). The patient's profile view (fig. 34c) has also improved, the pseudoprogeny due to absence of teeth has been compensated for. The patient appeared to be exceptionally satisfied from an aesthetic point of view and in terms of occlusal functioning.

Aftercare

A follow-up programme was set up for the patient and initiated with the implementation of the restoration. The prophylactic sessions are arranged in the first year initially at three-monthly intervals. Examination appointments were arranged after three months and then twice a year with at least one X-ray.

Discussion

If a patient has not had a denture for several years, the consequences can be atrophy of the chewing and facial muscles, which may include digestive disorders and abnormal stress on the temporomandibulaur joint. Malfunctions of the jaw area are also very closely interconnected with those of the locomotor system, as they depend on each other. Bite and abnormal occlusion naturally have an impact on the locomotor system via endless chains of muscles. Teeth, jaws, jaw joints, masticatory and facial muscles are an inseparable part of our complex locomotor system. Facial structures are also an important basis of our physiognomy and contribute to our social integration and acceptance.

The integration of a completely all-ceramic definitive denture seemed to be risky in view of the patient's abnormal stress on his orofacial structures, especially as implants do not have any physiological compliance due to the absence of a periodontum and chewing forces arising from implant-anchored restorations show definitely more strength potential.

The restoration with one-piece circular bridges is an option on implants with ideal abutment distribution compared with short separate segments. On the one hand, the number of implants can be reduced and, as in this particular case, these may be combined into clusters on both sides.

The minimisation of stresses and compensation as a passive fit via glued-in galvanic secondary parts is state of the art these days. The long technological process chain of white milled ZrO_2restorations inevitably leads to stresses, which cannot be compensated for at the implant interface. This also shows the development in dentistry, which works in the sensitive system of implant support, e.g. with the CerFric procedure, in order to compensate for fit inaccuracies and stresses, without integrating an additional material thickness of cap and adhesive.[10] In addition, if the intention is to work with fixed, metal-free restorations, the procedure described above of soldering in or on of passive-fit connectors can be used, even against the background that all thermal joint methods are not entirely free of distortion.

The coating and positive connection of zirconium oxide frameworks and parts is still a technological challenge. With the rapid and widespread introduction of ZrO^2 restorations, the issue of safe and long-term stable veneering methods and materials is one of the most important. Stawarczyk and Fischer consider the veneer stability and practicability of veneer ceramics for ZrO^2 in dentistry as a matter of course,[13] safe and statistically comparable with other veneering systems.

Tholey and Stephan have suspected for some time that ceramic veneering based on wash firings at elevated temperatures involves not only a mechanical interlocking of veneering ceramics with the ZrO^2 framework, as there is also a flawless bond with the ceramic even with smooth, non-sandblasted frameworks.[15] Hopp et al.[5] have demonstrated this bond. The much-discussed chipping[16,17] on veneering ceramics can be minimised by a fully anatomically reduced framework design in addition to a bonding layer that acts as a buffer. Despite all the material's advantages, Zarone et al.[18] regard the brief observation time as a disadvantage and therefore only a limited way of comparing the effectiveness of metal-ceramic restorations.

The lack of functionality of silanisations on pure ZrO^2 is sufficiently well known, which is why ZrO_2 bonders have been developed based on phosphate. The problem of an inadequate connection of ZrO^2 to composite materials and dental plastics can be eliminated with a secure connection using an infiltrating special glass, as Zothner et al.20 have also described it for the adhesive connections. It is then possible to resort to tried and trusted silanisations again.

Fazit

Even the cementing of ZrO_2 restorations improves, if a solder inserted into the insides of the crowns entails optimised structuring and thus improves the wedging effect in conventional cements. Semipermanent cements such as TempBond also show better adhesion.

As Kern has said, conventional cementing is of great importance and has low susceptibility to errors: "Compared with the adhesive fixation described below, conventional cementing is easier and cheaper and can still be carried out clinically, if an adhesive fixation is eliminated due to an organic surface contamination that cannot be ruled out with certainty (e.g. saliva, sulcus fluid or blood)."[7] Blöcker and Moss also prefer conventional cementing and come to the conclusion that "So far, this is why we have cemented all our crown and bridge work with COP or GIC and have had good experiences with it for the last eight years."[2]

The authors have great hopes that hybrid technique presented here in framework veneering could be an option for improved gnathological comfort for patients and protection for regulatory and implementary structures of mastication.

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Literature

acknowledgements

1. Baltzer A, Kaufmann-Jinoian V. Dimensionierung der Brückengerüste. Quintessenz Zahntech 2004;30:1108-1117.
2. Blöcker TO, Moss CH. Das Zementieren zirkonoxidkeramischer Versorgungen – Teil 1. J Cont Dent Educ 2011;1:96-107.
3. Brevier Technische Keramik, Verband der keramischen Industrie e.V. Lauf: Fahner Verlag, 2003.
4. Erdelt K, Beuer F, Schweiger J, et al. Die Biegefestigkeit von weißkörpergefrästem Zirkoniumdioxid. Quintessenz Zahntech 2004;30:942–954.
5. Hopp M, Mitrovic A, Moss CH. Drum prüfe, was sich ewig bindet. Zahntech Mag 2010;14:698–705.
6. Hopp M, Zothner A. Verfahren der Konditionierung der Oberflächen von Dentalkomponenten und Verwendung des Verfahrens. Patentschrift DE 10 2009 051 655 B3 2010.12.30 C04B 41/85 (2006.01), Erteilung 30.12.2010.
7. Kern M. Befestigung von Oxidkeramiken. In: Tinschert J, Natt G (Hrsg.). Oxidkeramiken und CAD/CAM-Technologien. Köln: Deutscher Ärzte Verlag, 2007.
8. Langschwager A: Die zirkuläre durch Geschiebe verbundene cercon®-Unterkieferbrücke. Quintessenz Zahntech 2003;29:262-271.
9. Langschwager A. Zirkuläre vollkeramische Implantatversorgung auf Zirkonoxidbasis. Implantol J 2004;5:26–32.
10. Lipp C. CAD/CAM vs. Kopierfräse: CerFric-Sekundärteile aus Zirkondioxid. Dent Labor 2007;55:1-12.
11. Reinecke AM, Exner H. A new promising joining technology. J Cer Proc Res 2001;2:45–50.
12. Riemer-Krammer B, Eilert C, Friedrich R, et al. Verurteilt zum Erfolg – Mit Innovationen und Team- work in der Implantatprothetik zum Ziel. In Vorbereitung.
13. Stawarczyk B, Fischer J. Vollkeramik, Titan oder konventionelle Metallkeramik: Welche Bruchlasten halten die Rekonstruktionen in vitro aus? Quintessenz Zahntech 2008;34:556–564.

14. Tholey M, Rutten L, Rutten P. Sicher zur Ästhetik mit Gerüsten aus Zirkoniumdioxid. Quintessenz Zahntech 2011;37:460–469.
15. Tholey MJ, Stephan M. Haftverbundmechanismen in dentalen Schichtsystemen. Quintessenz Zahntech 2007;33:160-168.
16. Tinschert J, Natt G, Latzke P, et al. Vollkeramische Brücken aus DC-Zirkon – ein klinisches Konzept mit Erfolg. Dtsch Zahnärztl Z 2005;60:435–445.
17. Vult von Steyern P, Carlsson P, Nilner K. All-ceramic fixed partial dentures designed according to the DC-Zirkon technique. A 2-year clinical study. J Oral Rehabil 2005;32:180–187.
18. Zarone F, Russo S, Sorrentino R. From porcelain-to-metal to zirconia: Clinical and experimental considerations. Dent Mat 2011;27:83–96.
19. Zothner A, Mitrovic M, Eilert C, et al. Die Segment-System-Technik mittels HotGlue-Fügung: Fertigung einer zirkulärer Oberkieferversorgung aus Zirkoniumdioxid auf Implantaten. Quintessenz Zahntech 2008;34:566–581.
20. Zothner A, Moss CH, Hopp M, et al. Oberflächenkonditionierung von Zirkoniumdioxid zur Verbesserung des Klebeverbundes. Quintessenz Zahntech 2009;35:874–886.

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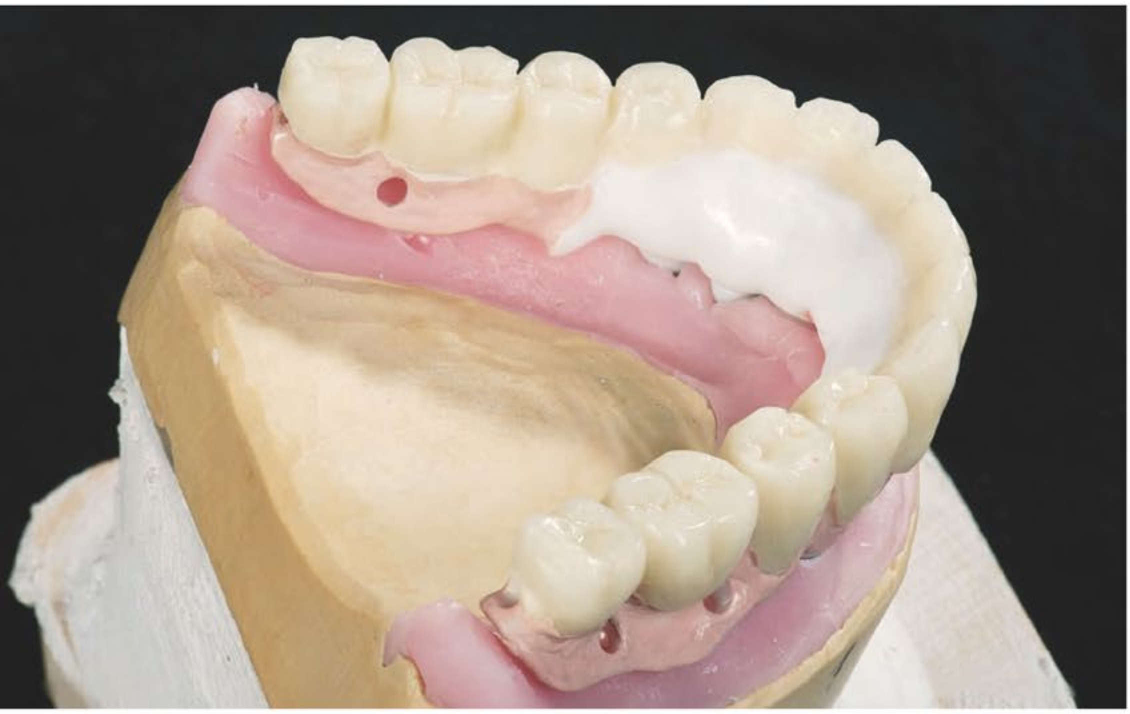
ZIRCONIUM DIOXIDE



Summary

Two options are presented for a telescopic mandible restoration on six implants, based on a ZrO_2 framework. In addition to the ceramically veneered version, a composite and plastic veneered version is produced, whose bond between the structural ceramics and plastic is secured by the patented DCMhotbond silane bond.

Indices

Zirconium dioxide, all-ceramic, ceramic joining, ceramic solder, DCMhotbond, segment system technique, wetting, composite veneering, plastic composite, airbrush technique, flexural strength, implant restoration, implant prosthetics

Innovations and teamwork in implantation prosthetics

Bärbel Riemer-Krammer, Catrin Eilert, René Friedrich, Aurica Mitrovic, Michael Hopp, Reiner Biffar

Functionality and aesthetics play a fundamental role in modern dentistry,[12] so the rapid acceptance of the zirconium dioxide application with its white or toothcoloured framework structures is not surprising.

Using zirconium dioxide (ZrO_2) as framework material for removable dentures, is gaining ground slowly but steadily. In addition to conventional bridge frameworks, structures are also being produced more frequently with free ending, gingival-based restorations. As Kühn[7] comments: "Milled zirconium dioxide structures do away with one of the last domains of cast metal frameworks." The connection between the framework and secondary caps are for him no longer a problem due to the development of modern bonding and adhesive systems.

The framework colour is certainly light, the price may not compete with nonprecious metal cast frameworks and blank distributors are unlikely to receive approval for these indications, especially for the production of delicate tertiary structures. Nonetheless, the development is interesting and is being pursued consistently. Baltzer1 demands minimum cross-section of frameworks for fixed restorations; investigations of this kind are still unavailable for the removable sector.

The mechanical values achieved are also important, which differ from HIP-ZrO_2 in how they are manufactured.[2]

Despite all the advantages and expectations of the white material, the issue of stress in large frameworks remains. The causes are on the one hand the manufacturing process with follow-up sintering operations and secondly the production of blanks. Depending on the manufacturing process, packing density and size of the blanks, a distortion is generated when sintering, which may lead to fit inaccuracies. Various methods of technical implementation of the restorations remedy this. Gluingin secondary structures, such as galvanic caps, compensates for the inaccurate fit over the adhesive gap. Another method is the segmentation and joining of framework parts. The lasering of high-performance ceramics on the basis of oxide, such as Reinecke and Exner9 have described for aluminium oxide, does not work with ZrO_2 due to the transformative changes and formation of cracks. This leaves only gluing and soldering.

Composite-based adhesives are often discussed but are not stable and durable enough in the framework area due to the high levels of stress and ongoing biodegradation. Soldering using specifically developed composite elements is a viable alternative, as they have been described for horizontal and vertical extensions of zirconium oxide structures.[17]

Case presentation Dental and dental technician procedure with a restoration

When her treatment began in November 2008, the patient complained of a poorly fitting total prosthetic denture in her lower jaw, whose fit deteriorated constantly and could not be improved even after several relinings. She has not had teeth since 2003. Her lip profile is slightly sunken (fig. 1a and 1b). The patient is generally in good condition; she makes a vital and active impression with successfully treated thyroid disease. Intraorally, the full dentures she had worn for five years were showing abrasions of the occlusal complexes and discolouration. Their hold was poor. The lower jaw showed narrow alveolar ridges, a flat anterior vestibulum and greatly atrophied distal comb areas (fig. 2). The lower jaw's degree of atrophy corresponded to Atwood grade 3. The X-ray findings

Fig. 1 a The patient's enface image; b the patient's profile, the drooping lip area is clearly visible.

Fig. 2 The intra-oral situation of the lower jaw without teeth.

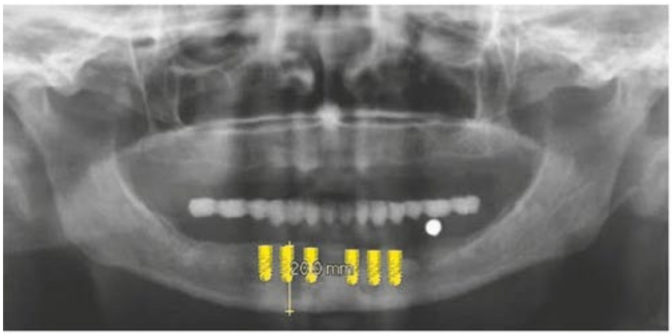


Fig. 3 The planning OPG with measuring ball, X-ray opaque teeth and integrated implant images.

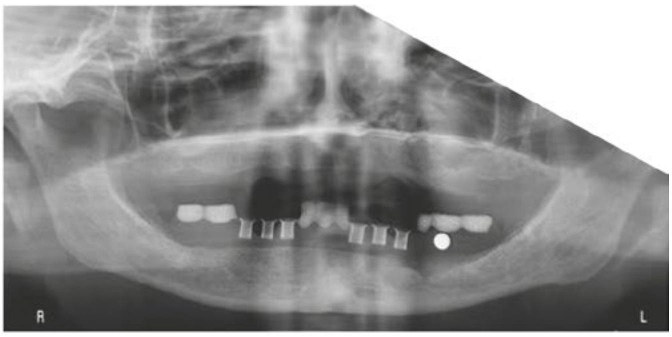


Fig. 4 The OPG with drilling template.

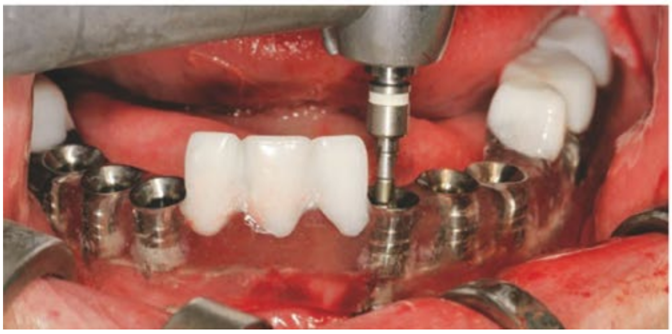


Fig. 5 Insertion of the drilling studs into the bone using the drilling template.

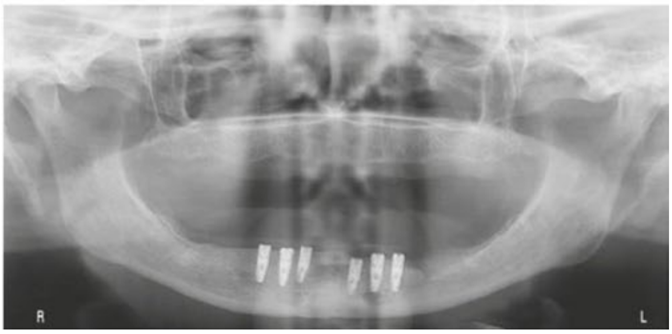


Fig. 6 The OPG for checking after implantation.

matched the clinical conditions, but allow for the insertion of implants in the interforaminal region despite various bone defects.

In a joint discussion with the prosthetist and surgeon, the patient preferred an implant-supported prosthesis on four implants, although the number of implants was subsequently determined as six. Following upper and lower jaw impressions with alginate, planning models were created and articulated. A diagnostic wax-up with an X-ray opaque occlusal complex was used to measure the lower jaw and to plan for the implants (fig. 3). Based on the wax-up, a scanned prosthesis was prepared and another OPG created (fig. 4). Using the scanned prosthesis with the drilling sleeves of titanium, the implant cavities in regio 44, 43, 42, 32, 33 and 34 were inserted into the bone (fig. 5) and six Xive implants (Dentsply Friadent, Mannheim) were inserted in November 2009. At the same time, a dental fragment in regio 35 was carefully removed. Following complete wound closure with individual button sutures (Supramid 4.0) a postoperative X-ray check (OPG) was prepared (fig. 6). The interim restoration was carried out using the available lower jaw prosthesis underlaid with Ufi Gel permanent (Voco GmbH, Cuxhaven). In January 2010, the implant was uncovered with an OPG check after complication-free healing, whereby no bone resorption was discernible. The periotest values of the healed implant show good osseo-integration, in detail at 34: -6 units, at 33: -5, at 32: -5, at 42: -4, at 43: - 6, at 44: -5 units.

Fig. 7 The gingival formers in situ with good mucosal conditions.

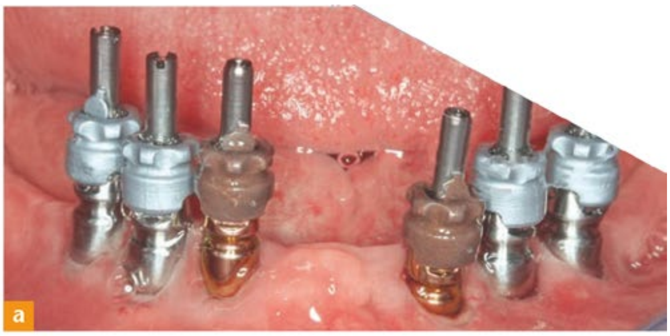


Fig. 8 a Impression post for open tray technique; b creation of an arbitrary face bow registration.

Fig. 9 Titanium bases prepared on the model for further processing.

Fig. 10 Application of DCMhotbond Tizio Connect using an airbrush pistol.

The mucus membrane around the inserted sulcus formers healed without reaction (fig. 7). After making a customised tray for the open impression, the impression was taken with Impregum Penta Soft (3M Espe, Seefeld) (fig. 8a). Bite registration was carried out using a hand bite, based on the bite height of the scan rail. In addition, an arbitrary face bow registration was created (fig. 8b).

The models were prepared in the lab and fixed in the articulator. In accordance with the placement of teeth in the scan prosthesis, the abutments were selected, individualised and sandblasted, secured with a shrink tube (fig. 9).[4]

The abutments are sprayed with DCMhotbond Tizio Connect (DCM, Rostock), coated, fired, the all-ceramic coverings made of zirconium dioxide created and connected with DCMhotbond Tizio in the already familiar glass soldering procedure for hybrid abutments[18] using a thermal soldering process (fig. 10 to 14).

The solder joint is smoothed using a diamond grinder, rubber polisher and special polisher and polished to a high gloss, which gently polishes the connecting geometry discoloured by the firing process with a brush and fine titanium polishing paste.

Fig. 11 The abutments after successful Tizio precoating.

Fig. 12 The ceramic covers are created and prepared for soldering.

Fig. 13 Abutments mounted on the firing tray before soldering.

Fig. 14 Successful production of hybrid abutments.

The transitional area of the joint is then smooth and shiny and shows only slight roughness even in the scanning electron microscopic image (fig. 15). The ceramic part of the abutments is reworked and polished using special cutters with water cooling. Figure 16 shows the completed abutments on the model and figure 17 in the mouth. A collective impression of the abutments was taken with a customised tray using Impregum Penta Soft (3M Espe). The galvanic caps on the abutments were then produced in the lab (Solaris, DeguDent, Hanau) (fig. 18a).

Separate ways of manufacturing

In this particular case, the patient was to decide whether she should have a telescopic all-ceramic bridge, constructed up to the 6s, or would be better off with a prosthetic-like, plastic reinforced restoration, telescopically anchored and lined up to the 7s. The common feature of both works was to be the framework of zirconium dioxide.

Both designs were created in segmented form, scanned and implemented in ZrO_2 with the Cercon system (DeguDent). The master model was identical, so that the designs created were interchangeable and could be worn accurately fitting in the mouth.

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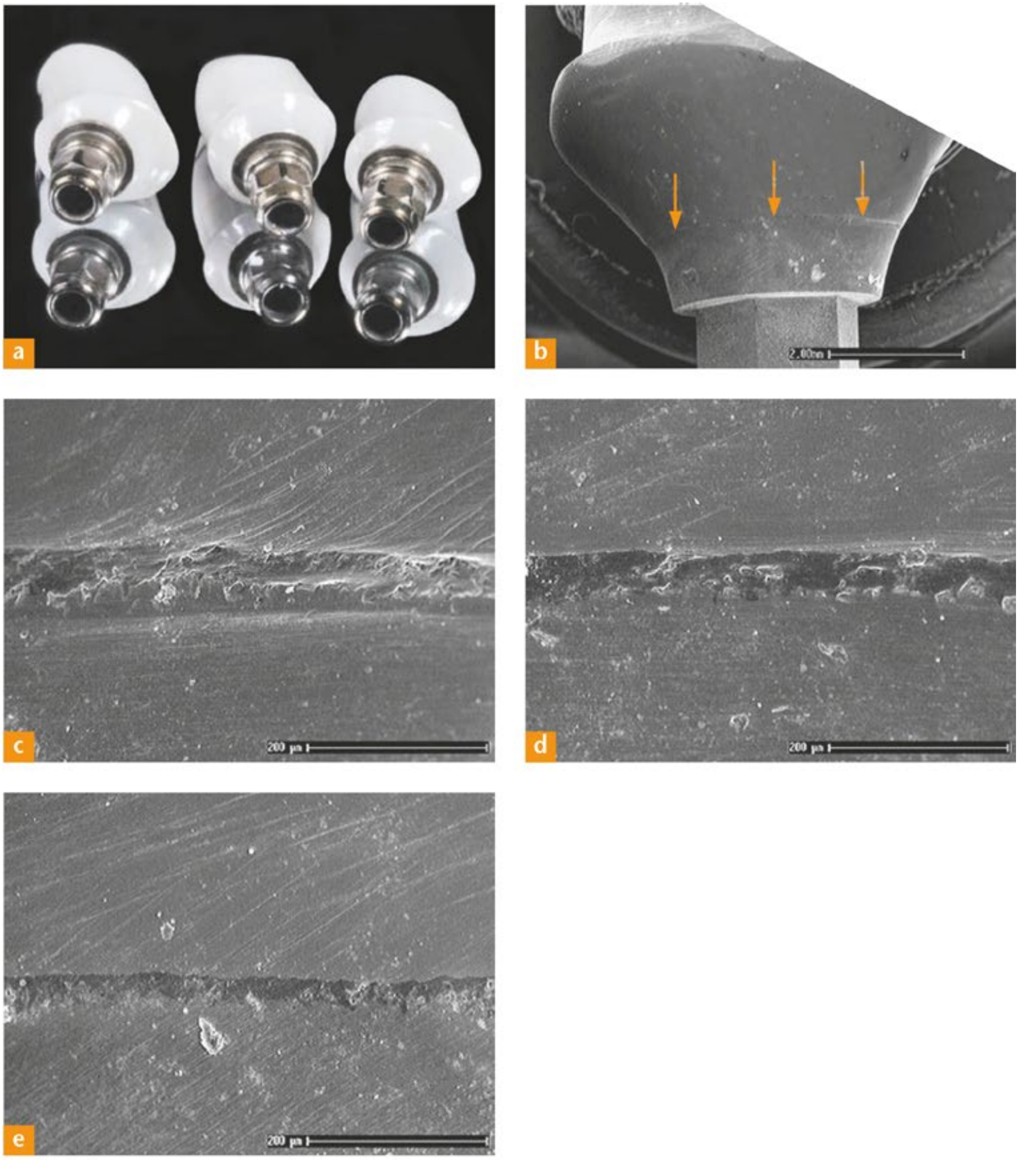

Fig. 15 Representation of the soldering area in SEM; a soldered abutments; b view of the solder joint (magnification x 9); c up to e detailed images (magnification x 120).

Fig. 16 The completed abutments in the articulator.

Fig. 17 The abutment try-in in the mouth.

Fig. 18 a The galvanic caps on the abutments. **b** Placement of the finished bridge segments on the master model with the applied solder. **c** Inserting the liquid firing pad into the framework. **d** Mounting the bridge on the firing tray. **e** Checking the framework after soldering on the model, the solder gap is seen as transparent. **f** Layering of the veneers with ceramic material. **g** Working on the gingival material on the basal surfaces.

The all-ceramic veneered telescopic bridge

The telescopic bridge restoration was created in two separate segments, soldered in the anterior dental area. Figure 18b shows the placement of the completed bridge segments on the master model with the solder applied to the connecting element. After positioning at the end position and drying the solder using a drier, the framework could be lifted, reworked and checked for fit.

After inserting the liquid firing pad (DCMhotbond Fix, DCM) into the framework (fig. 18c) the bridge was then mounted on the firing tray (fig. 18d). After soldering and simultaneous coating of the surface with DCMhotbond zirconnect, the framework is checked for its fit on the model (fig. 18e). The solder gap was transparent. The veneering of the framework was carried out using

Fig. 19 The completed restoration on the model.

Fig. 20 The completed bridge in situ.

ZrO_2-compatible ceramics (Kiss, DeguDent) (fig. 18f). Gingival material was worked in on the basal surfaces of the construction and all the adjacent parts of the mucous membrane (fig. 18g). Figure 19 shows the completed restoration on the model and figure 20 in situ in the mouth.

The composite veneered and plasticrein-forced telescopic prosthesis

For the second version, the plastic-reinforced telescopic prosthesis with teeth arranged in composite, four framework segments were milled from ZrO_2 after modellation (fig. 21a). The segments are connected to each other with connecting elements for the soldering technique[17] in a loose fit, which provides enough room for the glass solder (fig. 21b). The framework segments are fixed to the model with the refractory DCMhotbond zircon solder material, the material is dried using a drier and the surplus is reworked (fig. 21c). After drying, the solder material has stability similar to blackboard chalk, so the technician can easily remove the construction from the model, check its fit and rework it. Assembly on the firing tray is carried out with DCMhotbond Fix, a pasty liquid firing pad. Due to the size of the construction and the free ending segments, these are supported separately on the firing tray. Using a honeycomb carrier made of ZrO_2 is recommended, in order to minimise distortions when firing with the same CTE in the system. At the same time, the framework surface is coated with DCMhotbond zirconnect as a bonder for further veneering steps in the spraying process.[19] As the firing temperatures of both materials are identical, both these steps can be combined (fig. 21d). Figure 21e shows the construction still in the furnace with red heat after successful soldering. In a second firing step, the insides and undersides of the framework are coated with DCMhotbond zirconnect. The framework has a basal design similar to that of a conventional framework, so that the retention areas of the saddles function normally in conjunction with the plastic (fig. 21f). The surface precoated with the Zirconnect material is blasted with corundum (125 µm, 2 bar) (fig. 21g). The following step is to etch the glass with the etching agent (red gel) C-Link (Steco, Hamburg) (fig. 21h). After thorough rinsing and drying, the surface is then silanised with C-Link silane (fig. 21i). In the final sealing step, the C-Link connector is applied and photo-polymerised (fig. 21j).

Fig. 21 a The milled framework segments made of ZrO_2. **b** All the parts fit loosely together. **c** The framework segments fixed on the model with solder material. **d** Assembly on the firing tray, the framework surface is coated with Zirconnect. **e** After successful soldering. **f** The framework from a basal perspective, the conventional framework design is recognisable. **g** Sandblasting of the conditioned surface. **h** Etching of the surface with C-Link etching agent. **i** Silanisation of the surface with C-Link silane. **j** Photo-polymerisation of the C-Link connector. **k** Checking the framework in the articulator.

Following the surface conditioning, the framework is checked once again for fit in the articulator (fig. 21k). The even space for the counterbite, which is required for the veneering material, is clearly visible. The overlaying of the framework begins with the application of opaque in the area of the teeth (fig. 21l) and a gum-coloured opaque in the area of the gingival covers and saddles

Fig. 21 l Applying the opaque. **m** Gum-coloured opaque is applied. **n** The framework prepared for veneering. **o** Layering of the veneer composite. **p** Modellation of the teeth from composite is completed. **q** Modellation of the subsequent plastic reinforcement in wax. **r** Creation of the outer rim. **s** The plastic reinforcement in the casting process. **t** The basal view before gluing the galvanic caps.

(Fig. 21m). Figure 21n shows the framework prepared for veneering with composite material (Signum, Heraeus Kulzer, Hanau). Layering of the veneering composite is carried out in layers, in accordance with the desired colour and is intermediately hardened in the polymerisation unit (fig. 21o).

Fig. 22 The lower jaw prosthesis in the articulator.

Fig. 24 A view of the lower jaw restoration from above.

Fig. 25 a The en-face image following the restoration. b The profile view of the face shows an attractive lip profile.

Figure 21p shows the completed modellation of the teeth made of composite. Prosthetic teeth were already dispensed with in the concept, which is why these areas are already designed in the framework in ZrO_2. The free spaces and functional peripheral areas are implemented in prosthetic plastic in the next step. It is based on a conventional wax-up (fig. 21q). For the implementation in plastic, an outer rim is made (fig. 21r), which serves as the shape for the plastic reinforcement in the casting process (fig. 21s). Figure 21t shows the basal view of the lower jaw prosthesis before gluing in the galvanic caps and figure 22 additionally being checked again in the articulator. The galvanic caps are glued directly in the mouth to the abutments inserted with an insertion key using Nimetic Cem (3M Espe), the prosthesis reworked from a basal angle and the adhesive edges are polished. After checking the occlusion and articulation against the upper jaw prosthesis optimised in the meantime, the grinding points were reworked and polished. Figure 23 shows the completed restoration in situ from an anterior view and figure 24 from above. The en-face and profile images following the restoration show not only a happy patient but also an attractive lip profile (fig. 25a and 25b). A follow-up appointment confirmed the good fit and function, rewarded for the months of hard work and limitation. A check-up OPG from April

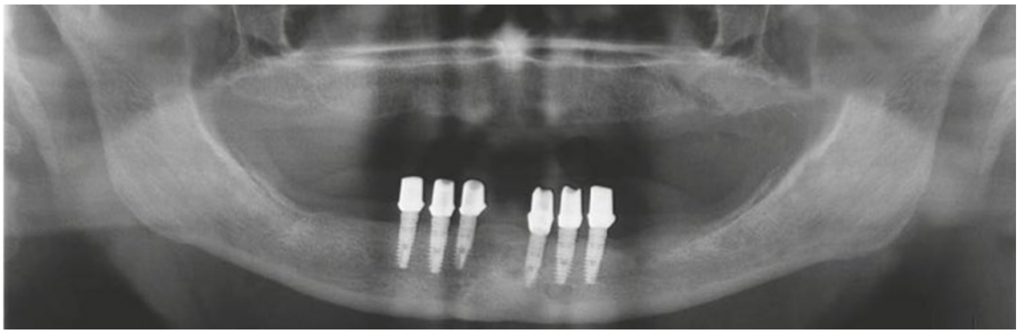

Fig. 26 The OPG as a checkup 2011.

2011 also confirms the good bone situation and suggests a stress-free fit and optimum functioning (fig. 26).

Patient evaluation

The patient wore both restorations and rated them in regard to comfort and functionality as shown in table 1. The patient made the following assessment: "The ceramic veneered prosthetic is shorter, so I don't chew so well. It also narrows the space for the tongue a bit when speaking, so I have the feeling that I'm hissing a bit when I speak. The shorter version (all-ceramic design, authors' note) makes the cheeks look more sunken."

Evaluated criteria	Implant-bearing, removable restoration 37 – 47, composite veneered and plastic reinforced	Implant-bearing, removable restoration 36 – 46, ceramic veneered
Wear comfort	Same	
Hardness in the bite	Better	Worse
Mucosal stress (feeling of pressure)	Same	
Occlusal force	Better	Worse
Cleaning options	Same	
Practicability	Same	
Colour	Same	
Shape	Better	Worse
Aesthetics	Same	

Table 1 The patient's subjective evaluation of the two superstructures.

Coating of zirconium dioxide frameworks

With the rapid and widespread takeover of ZrO_2 restorations, the issue of safe and long-term stable veneering methods and materials is one of the most important. Stawarczyk and Fischer consider the veneer stability and practicability of veneer ceramics for ZrO_2 in dentistry as a matter of course,[10] safe and statistically comparable with other veneering systems. Tholey and Stephan[13] have suspected for some time that ceramic veneering based on wash firings at elevated temperatures involves not only a mechanical interlocking of veneering ceramics with the ZrO_2 framework, as there is also a flawless bond with the ceramic even with smooth, non-sandblasted frameworks. Hopp et al.[3] were also able to demonstrate this bond. The much discussed chipping[14,15] on veneering ceramics can be minimised by a fully anatomically reduced framework design in addition to a bonding layer that acts as a buffer.

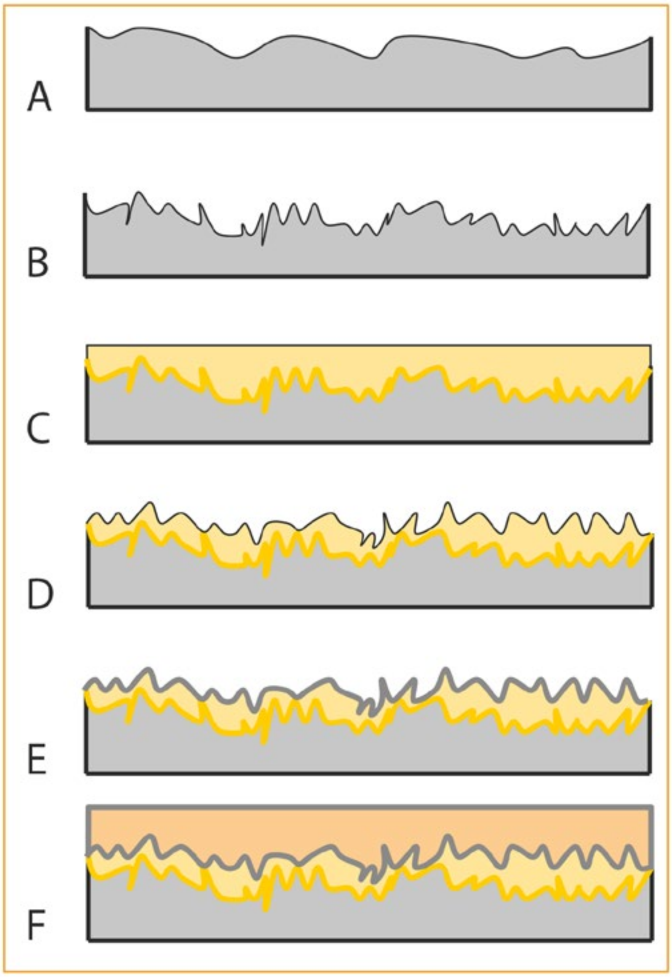

Fig. 27 The diagram showing the bond between zirconium dioxide and plastic:

A Surface-treated ZrO_2, e.g. by means of CAD/CAM processing

B Section through the surface after sandblasting

C Section after firing a ceramic solder E D Section after sandblasting and etching of the ceramic solder

E after the subsequent silanisation

F after the application of a composite adhesive and connection with a second structure.

Despite all the material's advantages, Zarone et al.[16] regard the brief observation time as a disadvantage and therefore only a limited way of comparing the effectiveness of metal-ceramic restorations.

The lack of functionality of silanisations is sufficiently well known, which is why ZrO_2 bonders have been developed based on phosphate. The problem of an inadequate connection of ZrO_2 to composite materials and dental plastics can be eliminated with a secure connection using an infiltrating glass[5]. Figure 27 shows a diagram of the gradual connection of machined or manually processed ZrO_2 with plastic-based materials. The basis is a thoroughly wet glass, which is capable of forming an active reaction layer with a possible infiltration and diffusion. The previous weakness of several liners of not forming an stable bonding layer on ZrO_2, is shown in the destruction of constructions that is associated with a direct blasting off of the veneer material. Secure bonders or even glass solders such as DCMhotbond zirconnect show fracture layers only in the veneer material or across all layers of the system.[17]

Both works were completed with glued galvanic secondary parts. The question is: Is it also possible to use the direct method, i.e. ZrO_2 on ZrO_2? Stephan11 has shown that it works. However, at present, this is likely to be restricted to constructions made of hiped ZrO_2 and in combination with natural supports (teeth) that are capable of compensating for even the most minimal fit inaccuracies via movements in the periodontal gap. This also shows the development in dentistry, which works with the CerFric process in the sensitive system of implant support, to compensate for inaccuracies in fit and stresses, without integrating additional material strength from the cap and adhesive.[6,8]

The result of the patient survey raises two questions that have been discussed repeatedly. Firstly: Is the bite on the all-ceramic occlusal surfaces too "hard" and does it exceed the capacity to compensate for natural and artificial supports as well as the tegument? The patient finds it more comfortable to bite against a composite surface. Secondly: How many teeth do people need? Even though five units per quadrant are certainly sufficient for mastication and support of the jaw joint, it has been shown in this particular case that the distal extension up to tooth 7 was preferred from an aesthetic and physiognomic point of view. The patient then chose this second "longer" version to use in the long term and it showed no defects over a period of nine months in which it was worn. Neither a prosthesis of this type nor the short wearing time are sufficient to make a final assessment. However, it is an interesting approach to integrate the structural ceramic of zirconium dioxide as a tertiary structure in the removable prosthesis using modern materials and innovative bonding techniques.

1. Baltzer A, Kaufmann-Jinoian V. Dimensionierung der Brückengerüste. Quintessenz Zahntech 2004;30:1108–1117.
2. Erdelt K, Beuer F, Schweiger J, Eichberger M, Gernet W. Die Biegefestigkeit von weißkörpergefrästem Zirkoniumdioxid. Quintessenz Zahntech 2004;30:942–954.
3. Hopp M, Mitrovic A, Moss CH. Drum prüfe, was sich ewig bindet. Zahntech Mag 2010;14:698–705.
4. Hopp M, Kurtz Th, Steffen A, Biffar R. Konditionierung von Abutments – sicher und einfach; Quintessenz Zahntech 2010;36:808–812.
5. Hopp M, Zothner A. Verfahren der Konditionierung der Oberflächen von Dentalkomponenten und Verwendung des Verfahrens; Patentschrift DE 10 2009 051 655 B3 2010.12.30 C04B 41/85 (2006.01), Erteilung 30.12.2010.
6. Karl M, Bauernschmidt B. Erste Erfahrungen mit teleskopierendem Zahnersatz aus 100% Zirkoni- umdioxid. Quintessenz Zahntech 2010;36:86–94.
7. Kühn T. Zirkoniumdioxid als großer Verbinder in der Doppelkronentechnik. Quintessenz Zahntech 2011;37:488–498.
8. Lipp C. CAD/CAM vs. Kopierfräse: CerFric-Sekundärteile aus Zirkondioxid. Dent Labor 2007;55:1–12.
9. Reinecke AM, Exner H. A new promising joining technology. J Cer Proc Res 2001;2:45–50.
10. Stawarczyk B, Fischer J. Vollkeramik, Titan oder konventionelle Metallkeramik: Welche Bruchlasten halten die Rekonstruktionen in vitro aus? Quintessenz Zahntech 2008;34:556–564.
11. Stephan K. Ist die teleskopierende Zirkonoxidbrücke ohne Galvano möglich? Quintessenz Zahntech 2004;30:772–778.
12. Tholey M, Rutten L, Rutten P. Sicher zur Ästhetik mit Gerüsten aus Zirkoniumdioxid. Quintessenz Zahntech 2011;37:460–469.
13. Tholey MJ, Stephan M. Haftverbundmechanismen in dentalen Schichtsystemen. Quintessenz Zahntech 2007;33:160-168.
14. Tinschert J, Natt G, Latzke P, Schulze K, Heussen N, Spikermann H. Vollkeramische Brücken aus DC-Zirkon – ein klinisches Konzept mit Erfolg. Dtsch Zahnärztl Z 2005;60:435–445.

15. Vult von Steyern P, Carlsson P, Nilner K. All-ceramic fixed partial dentures designed according to the DC-Zirkon technique. A 2-year clinical study. J Oral Rehabil 2005;32:180–187.
16. Zarone F, Russo S, Sorrentino R. From porcelain-to-metal to zirconia: Clinical and experimental considerations. Dent Mater 2011;27:83–96.
17. Zothner A, Mitrovic M, Eilert et al. Die Segment-System-Technik mittels HotGlue-Fügung: Fertigung einer zirkulären Oberkieferversorgung aus Zirkoniumdioxid auf Implantaten. Quintessenz Zahntech 2008;34:566–581.
18. Zothner A, Hopp M, Friedrich R et al. Die Evolution des Abutments – Stoffschlüssiger keramischer Verbund bei Abutments aus Titan und Zirkoniumdioxid. Quintessenz Zahntech 2009;35:620– 634.
19. Zothner A, Moss C, Hopp M et al. Oberflächenkonditionierung von Zirkoniumdioxid zur Verbesserung des Klebeverbunds. Quintessenz Zahntech 2009;35:874–886.

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DCM hotbond at a glance.

DCMhotbond zirconnect

Firing process protocol

Start temperature	450°C
Dry	2 min.
Burn	1.000°C
Acceleration rate	60°C/min
Hold	1 min
Vacuum at	450°C
Vacuum till	1.000°C

DCMhotbond fusio

Firing process protocol

Start temperature	450°C
Dry	6 min.
Burn	800°C
Acceleration rate	55°C/min
Hold	1 min
Vacuum at	450°C
Vacuum till	800°C

DCMhotbond zircon

Firing process protocol

Start temperature	450°C
Dry	mind. 30 min.
Burn	1.000°C
Acceleration rate	30°C/min
Hold	3 min
Vacuum at	450°C
Vacuum till	1.000°C

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fusio	fusio 12	12134	3 g	33	99,00 €	3,00 €
fusio	fusio 12	10134	10 g	120	198,00 €	1,65 €
fusio	fusio liquid	10234	20 ml	100	19,00 €	0,19 €
fusio	fusio connect spray	10035	50 ml	90	175,00 €	1,95 €

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