



Customised CAD/CAM abutments and crowns made of zirconium dioxide

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In dental practice all-ceramic restorations have been experiencing enormous growth for years now. In Germany over two million ceramic restorations were inserted in 2006 – after all, metal-free restorations are highly popular with patients. In implant prosthetics as well there is a distinct trend towards the use of all-ceramic systems. In implant dentistry long-term success and a predictable aesthetic outcome depend on the position of the implant and – where indicated – on the use of augmentative procedures. Recently, however, numerous studies have been pointing to the fact that instead of the implants themselves it is more often the prosthetic superstructure which is crucial to long-term success. With regard to biological and mechanical properties considerable importance must be attributed to the abutment as the interface between the crown and the intraosseous implant.

For highly aesthetic restorations the manufacture of ceramic abutments and metal-free superstructures has been recommended for some time now. However, fabricated implant build-ups made of aluminium oxide ceramics, which are still available from some manufacturers, are far too weak and often lead to an unsuccessful outcome. From our experience they are therefore now regarded as obsolete. The superior properties of high-strength zirconium dioxide ceramics, a framework material with universal applications, has brought about a paradigm change in implant prosthetics. We have been providing implant patients with metal-free zirconium dioxide superstructures for six years now without exception.

Zirconium dioxide ceramics: material properties

Owing to its monophase crystalline nanostructure yttrium-stabilised zirconium dioxide has a superior flexural strength of 900 MPa to 1,000 MPa. This offers plenty of reserve for using the material as an absolutely tension-free framework material in implant prosthetics, even over large spans or in boundary situations. On high-polished zirconium dioxide ceramics the plaque deposition is up to 40 % less than on titanium and dentine. In particular, compatibility with patient hygiene is of major importance for the long-term success of implant-borne restorations. According to a histological study^[1] zirconium dioxide abutments have significantly fewer inflammation parameters than titanium abutments. A study to measure the gain of soft tissue^[2] confirms that ceramic abutments are significantly superior to ones made of titanium. On the other hand, Abrahamsson et al. were able to prove that gold abutments and PBM crowns as superstructures often cause soft tissue recessions and a resorption of crestal bone. Zirconium dioxide abutments thus assist active protection of the peri-implant tissue.

Advantages of zirconium dioxide in CAD/CAM manufacture

In the case of metal abutments dark metal parts can become exposed on account of gingival recessions and degradation of crestal bone (Fig. 1). Ceramic abutments allow light transmission into the gingival sulcus, thus preventing the grey of opaque metal parts from showing through the peri-implant tissue. Even if the mucosa is thick at 2.5 mm, the abutment has an influence on the shade perceived of the covering mucous membrane. Customised zirconium dioxide abutments are the best way of ensuring predictable aesthetics.

¹ Degidi, M. 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* 77 (2006), p. 73-80.

² Henriksson, K.; Jemt, T.: Measurements of soft tissue volume in association with single-implant restorations: a 1-year comparative study after abutment connection surgery. *Clin Implant Dent Relat Res* 6 (2004), p. 181-189.

Owing to the need for substantial material grinding the processing of prefabricated build-ups made of zirconium dioxide, aluminium oxide or titanium is problematical. If the ceramics overheat, cracks occur in the microstructure of the material. In addition, reprocessing is always very time-consuming because it has to be performed manually. In the case of cast mesostructures made of precious metal it is often not possible to budget for the cost, and the use of large quantities makes it difficult to create a pore-free cast. With zirconium dioxide the dental technician has, for the first time, a material at his disposal whose absolute homogeneity is not altered by further processing. In the case of customised CAD/CAM abutments and zirconium dioxide crown frameworks the ZENO® Tec system (WIELAND, Pforzheim, Germany), in conjunction with wi.tal system implants (WIELAND, Wiernsheim, Germany) is setting new standards in terms of user friendliness, economy and flexibility.



Fig. 1: Exposed titanium abutments.

Case study: initial situation

For a 41 year-old female patient the plan was to provide her single gap at tooth 46 with a wi.tal implant (diameter 4.3 mm, length 13 mm). Since the bone available was more than sufficient and the proportion accounted for by soft tissue was acceptable, no augmentative procedure was performed in this case. In the aesthetically sensitive anterior area we would nowadays always perform augmentation even though the bone available may seem sufficient.

Implantation

After exposing the bone by means of a partially mobilised mucoperiosteal flap the pilot hole was drilled with a diameter of 2.0 mm (Fig. 2). This was followed by two more shape drillings with a diameter of 3.5 mm and 4.3 mm (Fig. 3). In order to place the implant in very compact bone as epicrestally as possible the cortical bone was reamed with the countersink enclosed with each implant pack (Fig. 4). The implant can be removed from the ergonomic pack with the inserter reliably and without making contact, and can easily be inserted at 35 Ncm with torque assistance even in confined gaps using the slim instrument. Since there is no insertion post, one step in procedure is omitted and the cover screw can be inserted immediately (Fig. 5). The flap was adapted with Gore-Tex sutures.



Fig. 2: Bone situation after exposure with a partially mobilised flap.



Fig. 3: Preparation of the implant bed with a shaping drill.



Fig. 4: Easy removal of the implant from the ergonomic pack with countersink.



Fig. 5: Implant inserted flush with the bone.

In developing the wi.tal system a conscious decision was taken to avoid any extensive implant surgery tray. Consequently, it is possible to conduct implantation efficiently, economically and reliably. Perfect handling and focus on the essentials enable the dentist to concentrate entirely on the patient and the surgical situation. All the drills are single-patient drills with standardised precision and easy-to-see length marks.



Fig. 6: First impression with standard impression post and transfer coping on exposure.

Stripping and impression-taking

A three-month settling-in phase was followed by stripping. A first impression in situ with a standard impression post in the same session (Fig. 6) was used to prepare a customised healing abutment. Initially the patient was provided with a fabricated gingiva former.

Laboratory manufacture of a customised gingiva former

For the emergence profile a customised gingiva former was made of ZENO® PMMA Discs A/B. The letter A stands for dentine in VITAPAN classical shade A3 whilst the letter B stands for dentine in VITAPAN classical shade B1 (Fig. 7). When the implant model had been made with a soft gingival mask, the emergence profile was milled out of the mucosal mask. The scan build-up was screwed in to digitise the implant position. The data obtained was then processed in the system's own software DentalDesigner™. The margin of the gingival former has to be made above the mucosa because there is an increase in volume when tissue is displaced. When the resin had been milled, it was cemented with a titanium insert. A resin cement called Super Bond C&B (J. Morita, Dietzenbach, Germany) has proved reliable. After that the surplus was ground away and the entire build-up was given a high polish.

During insertion of the customised healing abutment the soft tissue has to be displaced conserva-



Fig. 7: Milled healing abutment made of ZENO® PMMA Discs, shade A.

tively (Fig. 8). The abutment was screwed in slowly while applying gentle pressure. Owing to a tube-in-tube connection the vital implant is prevented from rotating over a total length of at least 4 mm. Mere insertion into the sulcus ensures positional stability without a retaining screw. Consequently, with this procedure as well – as with all the other steps – there is no need to provide manual protection against rotation. With many other makes of implant system this simple procedure is not possible because all the parts of the build-up only stop just above the shoulder of the implant, deep in the sulcus.



Fig. 8: Screwing in the customised healing abutment for creating the emergence profile.

Taking the final impression

After 14 days the final impression was taken using an impression post customised in the dental laboratory, under absolute irritation-free conditions. For the closed impression we use Impregum™ (3M Espe, Seefeld, Germany). The standard impression post was customised with GC Pattern Resin LS (GC Europe, Leuven, Belgium) and when the impression is taken it transfers the shape of the emergence profile. If only the standard impression post were used, the soft tissue would return to its original shape in the final impression-taking and thus produce inaccuracies.

Making the superstructures in the laboratory

Now the customised impression post was inserted into the impression. For making the final restoration a mucosal mask is also made (Fig. 9). In order to

transfer the implant position the scan restoration is screwed into place and then scanned (Fig. 10). Positioning the stored scan build-up ensures perfect allocation even in confined gaps. On the order sheet created the design can be freely selected to suit requirements: first the build-up is defined and then the crown is mounted. On request an anatomical crown can also be designed with PMMA, with the aid of which the veneer is made later by the CAO (Computer Aided Overpress) method.

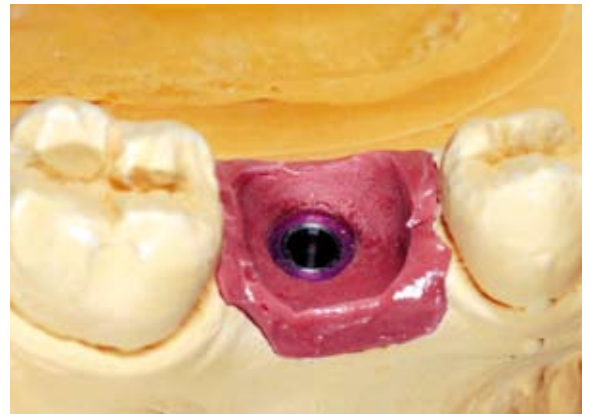


Fig. 9: Model situation after transfer of the emergence profile with a customised impression post.



Fig. 10: Transfer of model situation using a scan build-up.

When designing, first of all the transition is defined between the build-up and the crown (Fig. 11). This area should not be made deeper than 1 mm subgingivally because the cement surplus has to be removed under visual control. Now the emergence profile is finished off (Fig. 12). In doing so it is possible to keep the point of implant emergence much slimmer and only allow greater width at the top. The cross-section provides a good overview here. The 3D view is displayed in the adjacent window. When



Fig. 11: Defining the transition between the build-up and the crown.

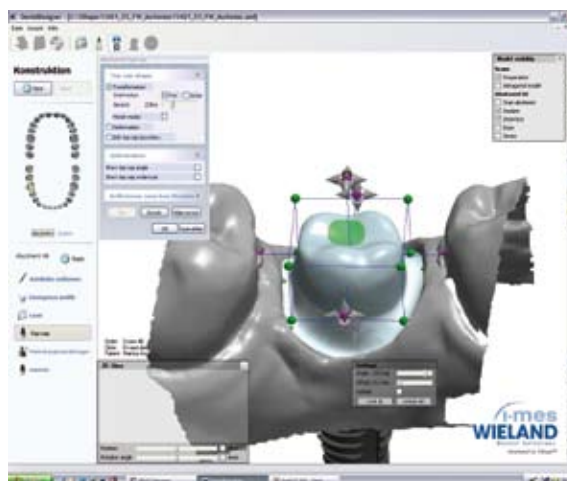


Fig. 13: Aligning and customising the build-up.

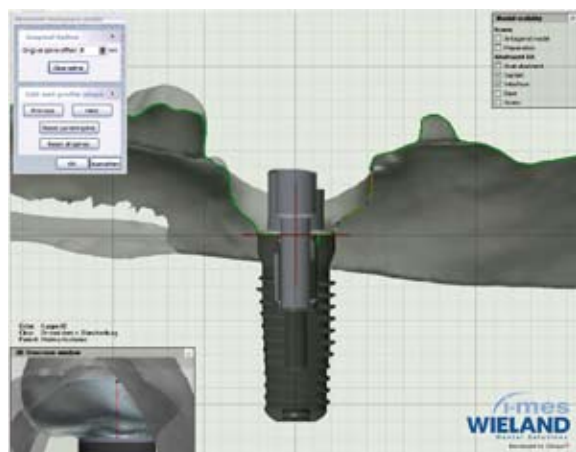


Fig. 12: Shaping of the emergence profile on a cross-section.

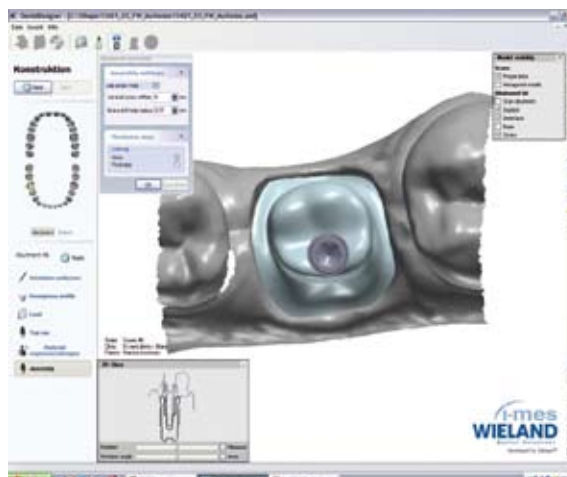


Fig. 14: Customised modification of the screw channel.

the parameters have been defined, build-up can commence. The program indicates the basic shape of a molar. However, it can be replaced by any other shape of tooth if, for example, only a premolar will fit the gap. The build-up can be customised quickly: its size can be increased or reduced by dragging the corners (Fig. 13). It can also be completely moved. By turning at the arrows the build-up can be tilted and adapted to the line of the crown. For the extent of the groove a preset can be selected. Then material can be applied or eroded.

Now the screw diameter is defined. Here it is possible to widen the screw opening to suit requirements so that the screwdriver is not guided too closely (Fig. 14). After completing this operation the computer blocks out the screw opening and proposes the prep line for the crown. The cement gap is also

defined. Manual customisation by the technician is possible here as well (Fig. 15). Owing to the option of scanning the opposite jaw and displaying it on the monitor, when designing a cusp-supported crown the occlusal space can be measured out accurately for the veneer porcelain. If an anatomical crown is to be made of resin by the CAO method, it is now first brought into position. Owing to deformation points the shape can be properly adapted to the antagonist. Making the tooth seemingly abraded is therefore feasible. Only when the anatomic design has been finalised is the crown computed in such a way that it represents an anatomically reduced shape (Fig. 16).

Finally the data is saved and three data records are generated (Fig. 17). This way each element can be milled from a different material. For the build-up we have selected the pre-shaded ZENO® Zr Discs B2

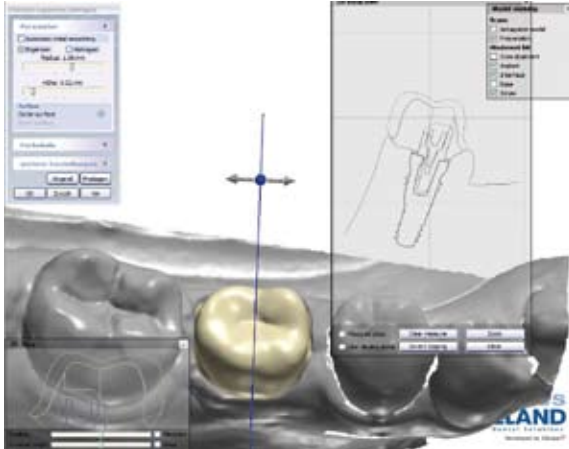


Fig. 15: Ready-designed coping, checking the entire construction, defining the cross-section.

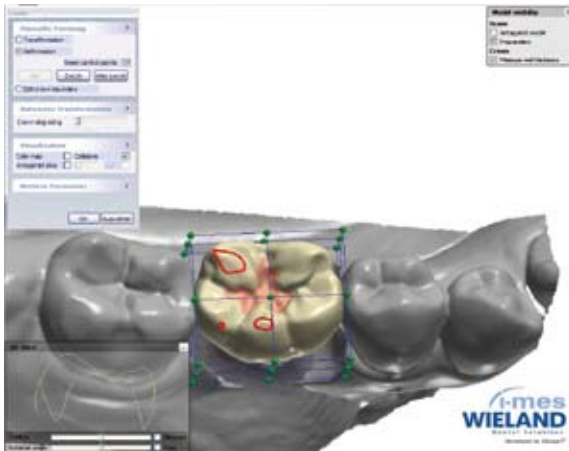


Fig. 16: CAO design for an overpress crown.

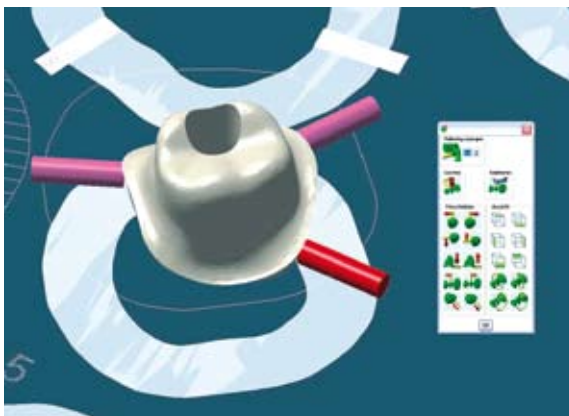


Fig. 17: Placement of the build-up in the CAM module.



Fig. 18: Milled customized abutment made of ZENO® Zr B2.



Fig. 19: Milled ZENO® crown.

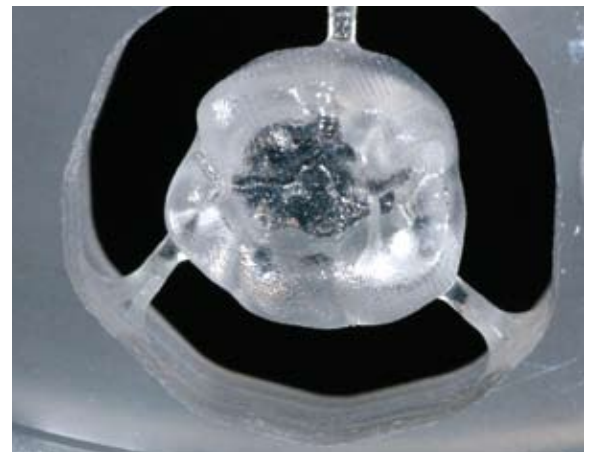


Fig. 20: Milled PMMA crown for the overpress technique.

(Fig. 18). The latter were also re-shaded with Zircolor in order to obtain a dental neck in the shade A 3.5. The crown itself was milled from an unshaded Disc (Fig. 19) and then brought up to shade A2 with the dye Zircolor. The overpress crown was milled from ZENO® PMMA Discs (Fig. 20). After fusion there are

three parts available with excellent fit (Fig. 21). Cementing is again performed with Super Bond C&B. The titanium connector was blasted with the aid of the Rocotec™ system (3M Espe) and conditioned with silane solution ESPE™ SiL. The emergence profile was high-polished. For this purpose we use diamond



Fig. 21: Fitted components just after fusion.

burs of various grain sizes. An optimum transition is achieved by affixing the crown margin to the build-up direct. Valuable production time is saved by simultaneous fusion of crown and build-up.

In the present case study two crowns were made on the build-up: one for conventional veneering by means of ZIROX® veneer porcelain (WIELAND) and another for overpressing with the ceramic PressX™ Zr (WIELAND). The crown made of PressX™ Zr is chiefly made on a machine. We prefer it as a low-cost alternative to the all-ceramic crown. Since the finishing of the PMMA crown is performed with a relatively large tool (diameter 1 mm), the fissures are finished with a smaller contour. Shading the structures reduces the light transmission capacity of the crowns to a certain extent. Light refraction takes place in the extrinsic dye, which is why this technique is reserved for the posterior region (Fig. 22). The layered crown does not leave much to be desired. Owing to the many modifiers and well-matched dentines a highly aesthetic crown can be achieved with minimal input.



Fig. 22: CA0 crown

Insertion

The CAD/CAM custom-shaded ZENO® Tec abutment was screwed into place under torque control (Fig. 23). The groove comes to rest exactly paramarginally in the hygienically uncritical area. We cement final crowns to implant abutments on a semi-permanent basis using the cement ImProv™ (Dentegris, Düsseldorf, Germany) (Fig. 24).



Fig. 23: Customised ZENO® abutment with accurate epigingival shoulder.



Fig. 24: Custom-layered ZENO® crown after cementing.

Sources of error

Since patients with implant-borne restorations can bite firmly again and attachment of the implant abutments is not tegumental (slightly resilient) as with teeth, masticatory forces are enormous. It is therefore important for the dental technician to model the zirconium dioxide coping with cusp support in order to ensure that the layer thickness of the veneer porcelain is consistent. Here the ZENO® Tec system provides reliable, flexible design and monitoring options. For example, ceramic fractures, so-called chipping, can be avoided. In order to allow perfect light

transmission through the crown into the ceramic abutment down to the subgingival area we do not use opaque glass ionomer cements or zinc phosphate cements in the aesthetically relevant region. They would cause the cement margin to be revealed. Apart from causing technical difficulties, the use of prefabricated abutments constitutes the risk of positioning the shoulder too far subgingivally. As a result, this area cannot be monitored when the crown is being cemented in place. If remnants of cement remain, this causes periimplantitis (Fig. 25).

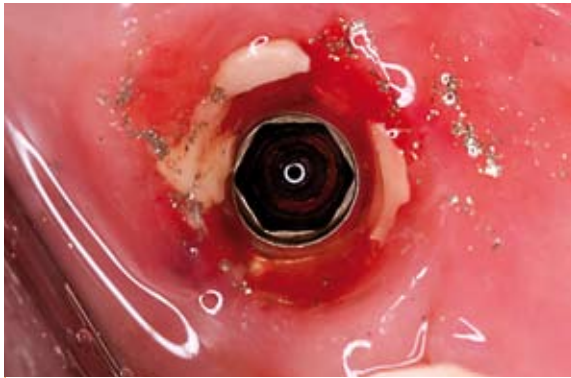


Fig. 25: Periimplantitis caused by remnants of cement and far subgingival transition from the standard abutment to the crown

Conclusion

Whilst there were no clinical studies available during the initial phase of making restorations with zirconium dioxide, there are now results from several multi-centre long-term studies. CAD/CAM restorations made of zirconium dioxide prove to be just as reliable as the golden standard. However, especially in implant dentistry they allow a quantum leap in terms of biocompatibility and aesthetics. By optimising the software, improving milling strategies, increasing the level of automation and extending the range of materials available some systems, including the ZENO® Tec system, have succeeded in raising the level of economy and precision substantially. In this instance the flexible design software does not limit dental technicians or dentists in their many different decisions to be taken with regard to treatment and design. In addition, particularly in the combination of implant dentistry and metal-free prosthetics made of zirconium dioxide frameworks, the fact that the ZENO® Tec system is fully compatible with the

implants in the vital system is of inestimable importance to patients, dentists and dental technicians. ■

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■ 1991 registration as a dentist ■ 1994 doctorate awarded ■ since 1995 joint practice with Dr. Herbert Pacha ■ 1998 four years of further training: dentistry diploma awarded by the Academy of Naturopathy ■ first user of the CERCON system in prosthetics and implant dentistry in Germany ■ 2007 development of a dental preparation set for CAD/CAM restorations with zirconium dioxide frameworks ■ numerous technical publications and lectures

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