In the past ceramic implants were more the domain of holistic dentistry. Today they also provide an additional option in the treatment spectrum of the general implantology practice. Therefore, more and more contributions about ceramic implants are found in specialised publications and scientific conferences. The reason for this has already been mentioned several times in the expert literature. 1

The increase in patient demand plays a role as well as the fact that zirconia as a material brings tangible professional benefits. 2

The Next Generation - two-part screwed ceramic implant

Dr. Jens Tartsch

Improved aesthetics is one of the main arguments of the proponents of ceramic implants. Of course, excellent aesthetic results can be achieved with titanium implants, if enough mucosal thickness of at least 2mm is available. Otherwise the abutment can show a gray shadow through a thin gingival phenotype. 3 The solution in such cases is to use an all-ceramic abutment, however, in combination with titanium implants this can lead to destruction of the implant interface through abrasion. The alternative is a connective tissue graft to increase the thickness of the mucosal tissue, but this means an additional surgical procedure with the corresponding morbidity for the patient. Both can be avoided with ceramic implants.

From clinical experience the essential argument for ceramic implants is the outstanding and almost completely inflammation-free peri-implant tissues. Even if the long-term evidence is still unavailable, after five year 4 there has been no clinically observed cases of peri-implantitis. 5 According to initial findings the reason for this is the excellent biological properties of ceramic implants: a very low bacterial adhesion to ceramic surfaces, significantly better peri-implant soft tissue circulation as well as absence of the biocorrosion and release of TiO2 particles with subsequent tissue reaction observed in recent studies on titanium implants. 6-10

Modern Ceramic Implant Systems

These advantages and the increased demand have led to an especially rapid development in the field of material and guided the surface design of the implants. Modern manufacturing processes (HIP - Hot Isostatic Post compaction) and the Combination of zirconium dioxide with others Ceramics, such as yttrium and alumina, allow today for flexural strengths of 1,200 MPa (Y-TZP-A,0.5% AlO3) and up to 2,000 MPa (ATZ,20% AlO3) .11,12 Modern rough surface design by fine corundum radiation, thermal acid etching, laser modulation or pre-structuring of the mold ensure an almost equivalent Bone Implant Contact (BIC) to titanium implants and thus equal osseointegration.13

The development in ceramic implantology described here

and it's increasing relevance were also recognized by the industry. Almost all renowned implant providers currently include ceramic implants in their product portfolio. The majority are still one-piece ceramic implant systems.The abutment and the implant are made of "One piece" (monobloc) which are considered hermetically sealed (no separate abutment connection, no implant-abutment interface). They have the advantage that their restoration falls within the usual procedure of dentists with impressions and cementation very much like that of a natural tooth. However, restoration of one-piece implants can only be done by cementing the restoration which is therefore neither flexible nor reversible.

The implant shoulder defines the position of the crown margin and corresponds to the cement joint. Thus the crown margin must be positioned as epigingival (gum level) as possible since the removal of the cement sub gingivally past 1.0mm to 1.5mm can no longer be reliably guaranteed.14 However for aesthetic reasons in the anterior region the epigingival placement of the implant shoulder is only possible in rare cases. If the implant shoulder is located too supragingival or the axis of the implant is misaligned for the prosthetic restoration, it can only be corrected by grinding the implant. This brings the risk of damage to the structure of the entire implant body (phase transformation by microcracks). These are among the reasons why even in modern titanium implantology two-piece systems are the gold standard and it is are rare to find specific indications for one-piece titanium implants. The two-piece systems cover almost all indications, allow unloaded healing phase, one-off regenerative procedures and are flexible and reversible.

The "Two-Part" Challenge

Of course, these arguments and principles apply equally to implantology with ceramic implants. However, to make the connection of hard, non-elastic zirconium abutment with a hard, non-elastic zirconia implant is a big challenge for the "two-part" of the system.

A pioneer of two-piece zirconia implants is the company Dentalpoint AG from Switzerland. They focus exclusively on two-piece ceramic implants and, as early as 2006, brought the first two-piece ceramic implant "ZERAMEX® Classic" on the market.

With further research and studies, i.e with the University of Geneva and Bern, came the development of the "ZERAMEX® T", a conical zirconia implant with high primary stability. This successful type of implant is,

Fig. 1: ZERAMEX® P6 implant site 46 in the same patient contralateral to the case presentation site 36. Fig. 2: ZERAMEX® XT with abutment. The four tips at the base of the abutment are not in contact with the implant body and serve exclusively to avoid rotation of the abutment in the implant.
Fig. 3: VICARBO screw P6 (left) and XT (right).

with improved abutment connection, still available today as "ZERAMEX® T Lock". With this implant system the abutment connection is achieved through cementation of the abutment with the implant, so you get the benefit of a two-part system, such as unloaded healing phase, primary wound

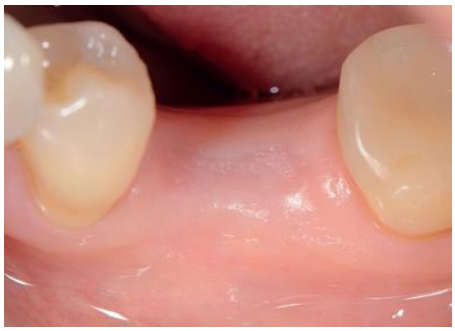


Fig.4: Surgical site

closure for single-stage augmentation and choice of various abutments but it becomes a one-piece implant once the abutment is cemented. Therefore, subjected to the same principles: the abutment is no reversible and should be located at the gingival level and the restoration is also cemented.

Metal-free screw connection

As is well known the screwed connection of abutment and titanium implants allow for a much broader range of indications than the usual ceramic implant systems since it is more resilient to compressive forces which can occur in an internal connection with metal components.15 It is with this in mind that in 2013 Dentalpoint AG introduced to the market the ZERAMEX® P6 (fig. 1). With the new ATZ material (Alumina Toughened Zirconia with 2,000 Mpa Flexural strength) it has since been well proven. The combination of an external hex for the implant-abutment interface and, more importantly, a completely novel metal-free VICARBO screw made of high-strength carbon fibre (60 percent) and rounded threads allows for a precision stress-free fit. According to the manufacturer this screw suit forces up to 85 Ncm2 (recommended 25 Ncm2). It works like a bolt, which anchors the abutment in the implant. The extremely hard ceramic is combined with a very stiff, carbon fibre-reinforced high-performance peek. In a way like reinforced concrete, the ceramic absorbs the compressive forces, while the VICARBO® screw counteracts tensile forces.

The external geometry of the implant corresponds exactly to the outer geometry of the Straumann® SP implant. Therefore, the surgical protocol is also the same as with the Straumann® SP and can be performed with the same surgical instruments. Consequently, it also has the same indications and contraindications as the Straumann® SP implant: The classic tulip-shaped neck area is first and foremost indicated as a "tissue level implant" suitable for the "molar region". Since they have a cement-free screwed connection they can also be placed almost at bone level in the anterior region however, as with the Straumann® SP implant this leads to bone remodeling around the implant neck which is less desirable in the anterior aesthetic region. Because of its wide threads and lower primary stability, it is also best suited for delayed or late implantation rather than immediate placement.

These restrictions led to the logical development of the third member of the ZERAMEX® family: the ZERAMEX® XT implant. With this implant system the advantages of the two other proven implant systems were combined: the conical, high stability implant body of the ZERAMEX® T, the high strength ATZ ceramic (2000 Mpa) and the metal-free reversible VICARBO screw

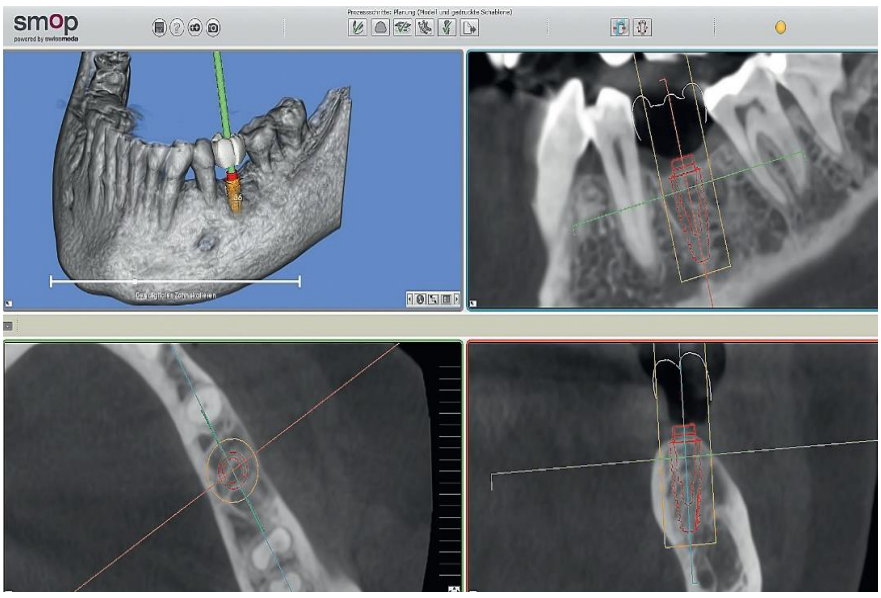


Fig. 5: Implant planning – size and position using SMOP

Fig 6: XT profile drill color coded with carbon coating.

Fig 7: Pilot and profile drill: endosteal length 10mm plus 0.6 mm in the neck area.

with an innovation: the "Bolt-in-tube" – internal connection. The four tips at the base of the abutment are not in contact with the implant body and serve exclusively to avoid rotation of the abutment in the implant (Fig. 2), they do not absorb any forces and can therefore be very delicate. The vertical and horizontal forces are applied as compressive forces on the inner bevelled shoulder of the implant. That way stress peaks in the implant body are avoided. The connection through the VI-CARBO screw is subject to the same principles as the ZERAMEX® P6 implant. Due to the implant geometry, the XT screw is significantly smaller (diameter of the head is 2.3mm) while offering the same strength in a common 4.2mm diameter implant.

Because of the already positive experience related to the osseointegration and implant geometry of the ZERAMEX® T and the stability of the ZERAMEX® P6 VI-CARBO screw design, the pre-clinical addition of the innovative "bolt-in-tube" connection was tested according to ISO 14801. The dynamic fatigue testing provided a positive result of 375 Ncm2 (according to manufacturer's instructions. Since the CE certification was already granted this opened the way for the first pilot case of the ZERAMEX® XT in clinical practice. The world's first insertion of a ZERAMEX® XT implant.

Patient case

Initial situation

In April 2016, a 56-year-old patient in good general health presented in our clinic, wanting to replace her missing tooth 46. Due to recurrent toothache, the tooth had been removed about a year earlier. Because the patient's dermatologist had diagnosed an allergy to aluminum and the patient believed that tita nium implants contain aluminum, she only asked for a ceramic implant. She was correct: Titanium grade 5 contain up to 6 percent per volume of aluminum. Most

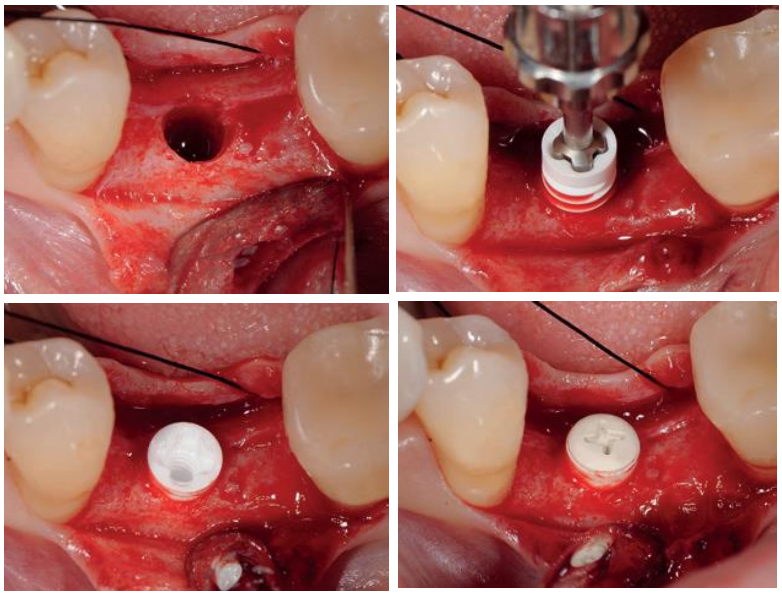


Fig. 8a: Prepared implant bed after osteotomy. - Fig. 8b: Insertion with Bolt-in-Tube Insertion instrument 30 Ncm2. - Fig. 8c: Implant in situ, neck area 0.6 mm supracrestal. - Fig. 8d: The flat healing cap allows for primary wound closure.

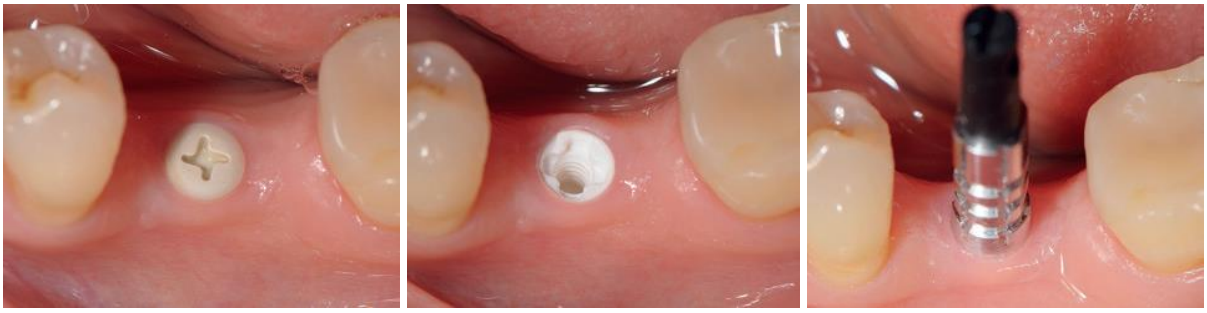


Fig. 9a: Transition phase with gingiva former XT. - Fig. 9b: ZERAMEX® XT implant before impression taking. - Fig. 10: Precise impression taking by open tray impression.

manufacturers use pure titanium grade 4 that does not contain aluminum for the body of the implant however the abutments are made of titanium grade 5 or are manufactured of titanium-aluminum-niobium alloy (TAN) and full ceramic abutment would be contraindicated in the molar area.

As there was enough bone tissue, a ZERAMEX® P6 implant was inserted in June 2016 a screwed single crown was placed in October 2016. As part of the diagnostic preoperative procedure for the implantation of 46, a radiograph (OPG) also showed a periapical lesion on the mesio-buccal root of tooth 36. The patient was informed about this and a detailed discussion about the option of endodontic treatment was provided. She could not decide at that time for treatment of tooth 36.

It is only after the insertion of the crown on implant 46 that she decided against the recommended endodontic procedure and insisted on the removal of the tooth and replacement with another ceramic implant.

It was initially planned to insert another implant about four months after the extraction. At the beginning of November 2016, tooth 36 was therefore removed

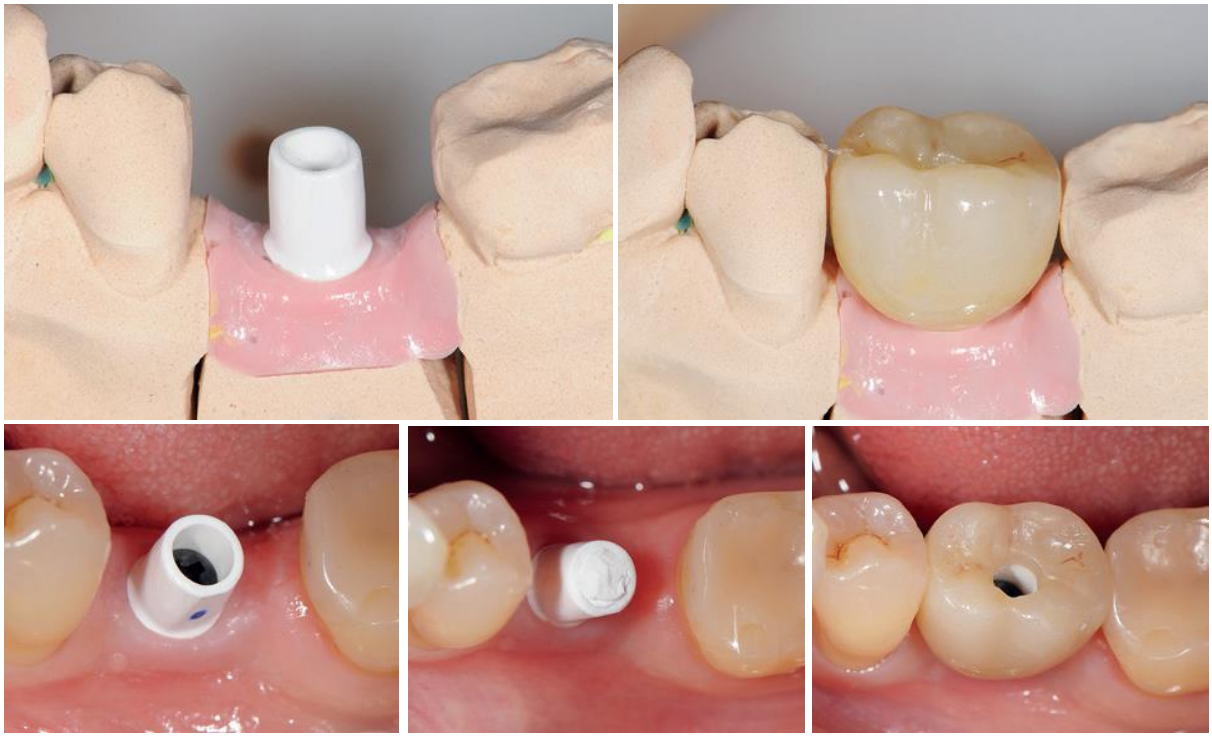
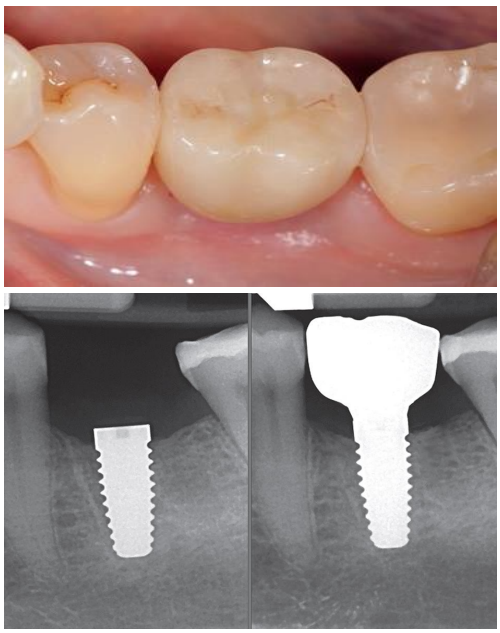


Fig. 11: Individualized abutment on master model. - Fig. 12: Monolithic zirconium crown with occlusal screw connection. - Fig. 13a: Check of the abutment in situ. - Fig. 13b: Closure of the screw channel with Teflon tape in preparation for bonding. - Fig. 13c: restoration cemented in situ, Teflon tape already removed from screw channel.



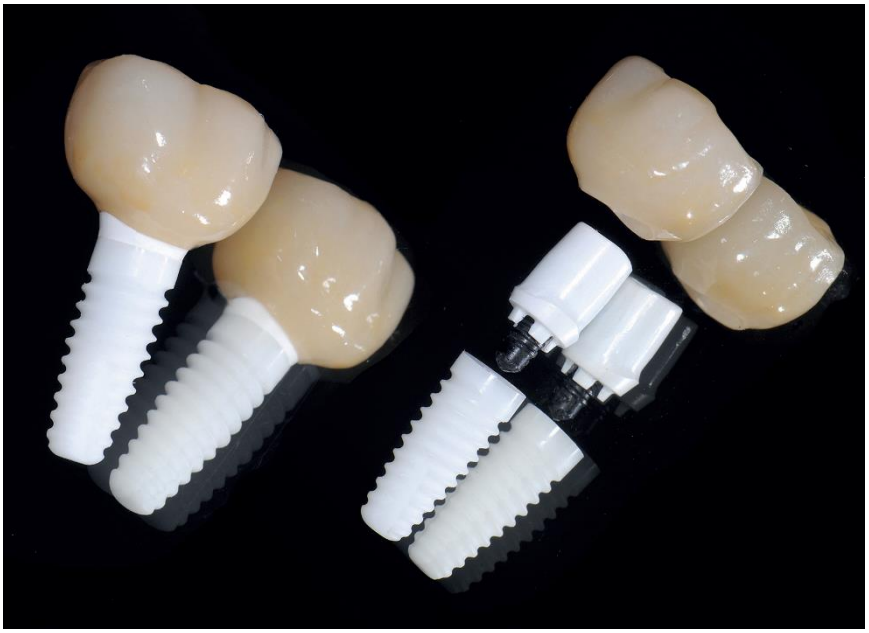


Fig. 14: Crown with composite closure of the screw access channel. - Fig. 15: ZERAMEX® XT - the next generation. - Fig. 16: Postoperative X-ray inspection four Months after supply.

under local anesthesia by hemisection, the gentle removal of the distal root, curettage of the alveola and suture of the of the wound with stabilizing cross sutures. The wound healing proceeded without complications. When the patient came back four months after the extraction for further treatment she presented with ideal soft and hard tissue conditions (Fig. 4), which is a standard situation for a first clinical application of the ceramic implant ZERAMEX® XT. The "pilot patient" situation was explained in detail and the risks and the lack of evidence with this type of implant clarified. Probably due to the positive experience with implant 46 she agreed with the insertion.

Preoperative planning

The selection of the implant took place using a 3-D planning software (SMOP, Swissmeda AG; Fig. 5). Even if, as in this case, no guided surgery procedure was available. This software is a safe preoperative planning. Although the implant geometry of the Straumann Bone Level tapered implant does not accurately correspond to the geometry of the ZERAMEX® XT, the Bone Level Tapered template is similar in length and diameter and can be used to select the position. In this case, an implant with a diameter of 4.2 mm and a length of 10 mm. The specified length corresponds to the endosseous portion of the implant. Note that to the endosseous portion there is an additional etched neck area 1.6mm in height included for biological latitude. Consequently, a 10 mm implant has a de facto total length of 11.6 mm. However, in case of reduced mucosal thickness, the implant can be positioned 1mm lower so that only a neck area of 0.6mm remains above bone level and the endossous portion is then 11mm. The ability to change the position of the implant allows for reliable planning of the abutment height considering the 1mm gingival height of the abutment. For the pilot phase the implant was only available with a 0.6mm neck.

Surgical intervention

Under local anesthesia and after the crestal incision and reflection of the flap, the implant bed was prepared according to surgical protocol. Since the implant geometry is the same as the ZERAMEX® T, the same surgical protocol is used. After preparation with the rose drill, the first osteotomy is performed with the 2.3mm pilot drill to the planned 10mm length considering the correct axis for the

implant. For different lengths corresponding drills with the correct profile are available. So, we begin the preparation with the first "small" 10mm profile drill with a 3.3mm diameter (color code pink), then the "regular" 10mm profile drill with a 4.2mm diameter (color coding green) (Fig. 6). The lower shoulder of the profile drill corresponds with the endosseous length of the implant without the neck (Fig. 7). Because the implant is not self-tapping like a titanium implant, there is no heat generated when screwing the ceramic implant but the last instrument, the tap, must be used for the entire length of the osteotomy. The implant was then placed 0.6mm above bone level and torqued to 30 Ncm2. For the insertion the implant has a new bolt-in-tube internal connection for a positive insertion and optimal transmission of forces (Fig. 8b and c). The healing caps are much flatter than the ZERAMEX® P6 implant and enable a simple primary wound closure (Fig. 8d).

Prosthetic Phase

Clinical experience shows that for ceramic implants as well as for titanium implants a healing time of three months is proven. However due to the “Pilot” nature of the present case, re-entry was performed only after four months with a crestal incision and insertion of the gingiva former.

After the healing of the soft tissues (Fig. 9a and b) the gingiva former was removed two weeks later, and the impression taken (Fig. 10) and the master model was poured. Since this is a high strength ATZ ceramic two-piece implant system, it is possible, if necessary, to individualize the abutment by grinding, either at the dental laboratory or the practice. In this case the abutment shoulder was adjusted to the gingival contour and the abutment height reduced. A monolithic zirconia crown from Zolid FX (Amann Girrbach) with occlusal access to the screw channel was manufactured using CAD / CAM (Fig. 12).

In a similar manner to a Ti-Base, the restoration was cemented with the abutment (RelyX ™ Unicem, 3M ESPE). To avoid any internal stresses in the abutment connection with the ceramic implant, this is done intraorally in the patient’s mouth (Fig. 13a-c). The abutment with the cemented restoration can then be removed and any excess cement safely removed and the restoration polished. For the final insertion a predetermined torque of 25 Ncm2 is mandated. After filling the screw channel with Teflon tape, the access cavity is closed with composite as per usual procedure (Fig. 14).

The result is a metal and cement-free, screwed and reversible single-tooth restoration (Fig. 15). A
Control radiograph was taken postoperatively and four months later with integration of the restoration prepared. They show stable peri-implant bone conditions (Fig. 16). A further comparison is shown at the first annual check.

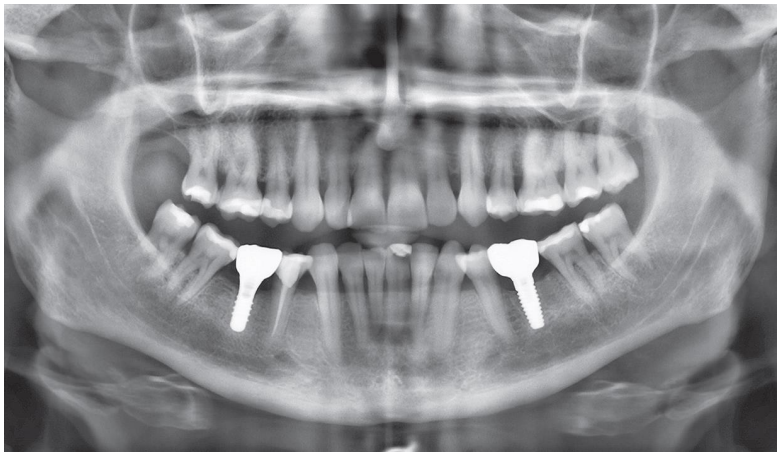


Fig. 17: A special feature - both ZERAMEX® systems in the same jaw: P6 (46) and XT (36).

Summary

Through rapid successful development in material and surface design, ceramic implants such as the ones described in the present case

are clearly matching the usual surgical and prosthetic protocols used for titanium implants. This is certainly an important factor in the future acceptance of ceramic implants in the practice of implantology.

Due to its conical implant body, tight threads for high primary stability, the optional bone level placement and the option of a cement less screw connection the innovative ceramic implant (ZERAMEX® XT) closes the gap:
Beside the already proven metal-free and flexible alternative of ZERAMEX® P6 with now also have the ZERAMEX® XT for the aesthetic anterior region (Fig.17). Further clinical trials must follow.

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