Alternative to titanium

Two-piece ceramic implant in the maxillary anterior region

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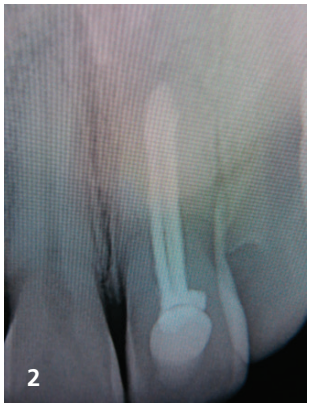
The rehabilitation of patients with the aid of implants is becoming increasingly popular in dental practice. In the situations of gaps in the anterior region, implants are preferable to conventional bridge therapy, especially from an aesthetic point of view. Titanium implants have established as a standard due to good data and many years of successful use. Nevertheless, the use of ceramic implants in dental practice is steadily increasing. The following case report intends to demonstrate the advantages of this material and its manageability in two-part architecture following a clear indication.



The restoration of interdental gaps in the anterior region, whether after trauma or a long-term attempt to preserve one or more teeth with questionable substance condition or infection, repeatedly presents us with challenges in daily practice. Particularly in young patients, the aim is to achieve an aesthetic and, above all, predictably long-term stable rehabilitation. Prosthetic treatment using a conventional bridge construction should be considered of secondary importance compared to implant-prosthetic treatment once the appropriate indications have been established. Providing the patient with comprehensive information after weighing up the advantages and disadvantages plays a central role in the joint decision-making process for treatment.

The decision in favour of an implantological solution also determines the indication for immediate or delayed implantation, the loading time of implants, possible augmentation measures and the material to be used. Finally, the patient's wishes should also be clearly considered. Zirconium dioxide as an alternative material to titanium implants is being mentioned more and more frequently in this context and is therefore subject to the dentist's duty to provide information.

Tooth extraction without immediate or prompt volume-preserving treatment of the socket is always accompanied by resorptive hard- and soft-tissue processes. It is therefore more important to counteract this loss of volume at an early stage, especially in the anterior region.



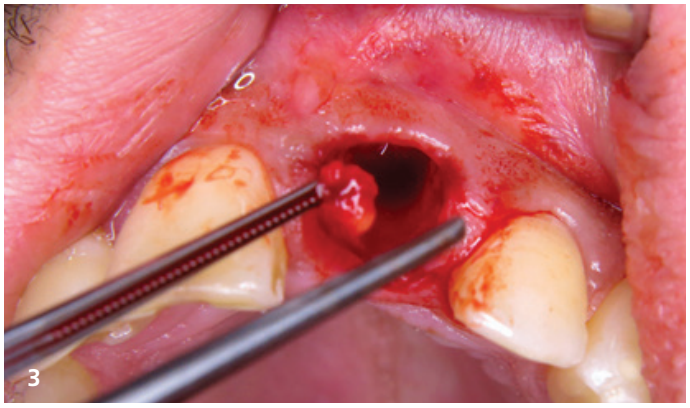
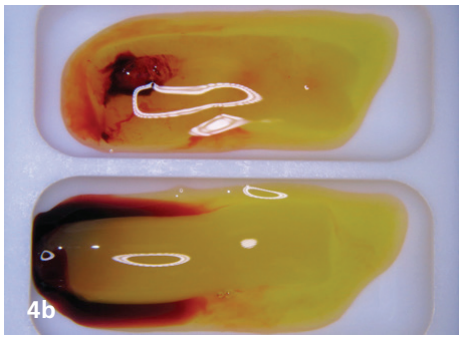


Fig. 1: Initial situation. – **Fig. 2:** X-ray control of the initial situation. – **Fig. 3:** Situation directly after gentle extraction of 21 with part of the apical cyst bellows.





Figs. 4a+b: Blood collection of approx. 20 ml venous autologous blood and prepared product of the A-PRF matrices + PRF liquid after centrifugation at 2,400 rpm in eight minutes.

Immediate implant placement after tooth extraction has been a proven, well-studied, albeit highly indication-driven treatment concept for several years.

In particular, the use of an immediate restoration with or without immediate loading via the corresponding prosthetics should be strictly weighed up depending on the hard-tissue defect, the surrounding soft tissue and the patient's anamnestic information.[1]

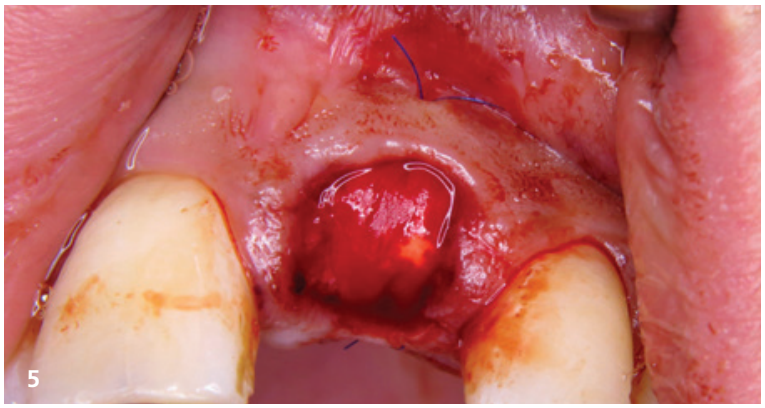
Delayed immediate implant placement or early implant placement after approx. six weeks post-extraction should be considered sensible if the parameters "primary stability with sufficient residual bone" and "stable soft-tissue cover" are given. Only then can additional augmentation measures, whether with hard or soft tissue, be dispensed with. The role of the implant material to be used also plays an important, if not decisive, role here.

Late implant placement at the earliest three months after tooth extraction has long been regarded as the most reliable prognostic method, if not the "gold standard", in implantology. Due to the early onset of resorptive processes in the hard and soft tissues, volume preservation during the healing process must always be the top priority for delayed implant placement, especially in the anterior region. The concept of socket or ridge preservation to maintain the basic alveolar structure through immediate augmentative measures after tooth removal as gently as possible has proven itself over the years. On the one hand, it offers the practitioner a predictably high level of surgical safety regarding the bony quality of the implant site, implant positioning, primary stability, prosthetic planning and, finally, the choice of implant material after the corresponding healing time. On the other hand, the patient also has a prognostically reliable statement about the long-term survival of the implants and their prosthetic restoration.[2,3]

Material properties

Nowadays, only the high-performance material zirconium oxide is used for modern ceramic implants. Due to its very good biocompatibility and excellent material properties such as flexural strength (1,200 to 2,000 MPa), fracture toughness (7–10 MPa $m^{1/2}$) and its white colour, it is very well suited as an aesthetic implant material. Above all, however, the high osseointegrative properties and the very good compatibility in direct contact with soft tissue due to the surface texture give zirconium oxide at least an equal status to titanium, which is considered the "gold standard".[4]

A basic distinction is made between one-piece and two-piece ceramic implants. Although one-piece implants have been on



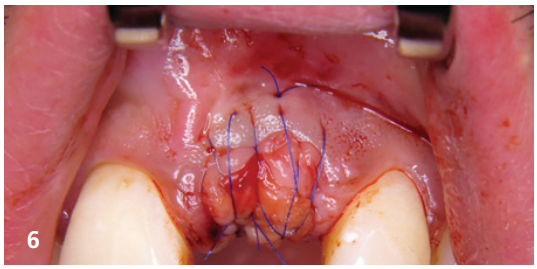
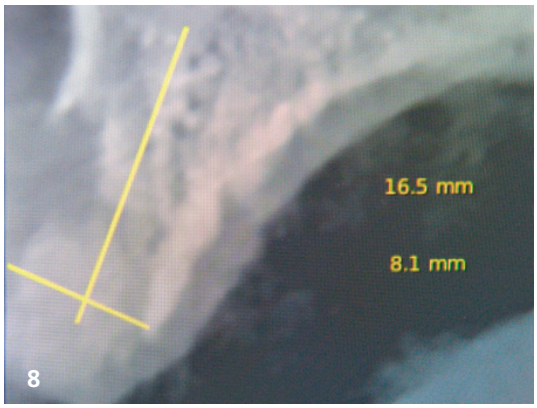




Fig. 5: Situation after ridge preservation of the extraction socket with allogenic prepared bone replacement material and fixation of a porcine collagen membrane in the sense of a GBR. – **Fig. 6:** Situation after insertion and fixation of the A-PRF matrices over the collagen membrane in the sense of "open-wound healing" (Ghanaati, S. et al.). – **Fig. 7:** Condition after six weeks post-op.





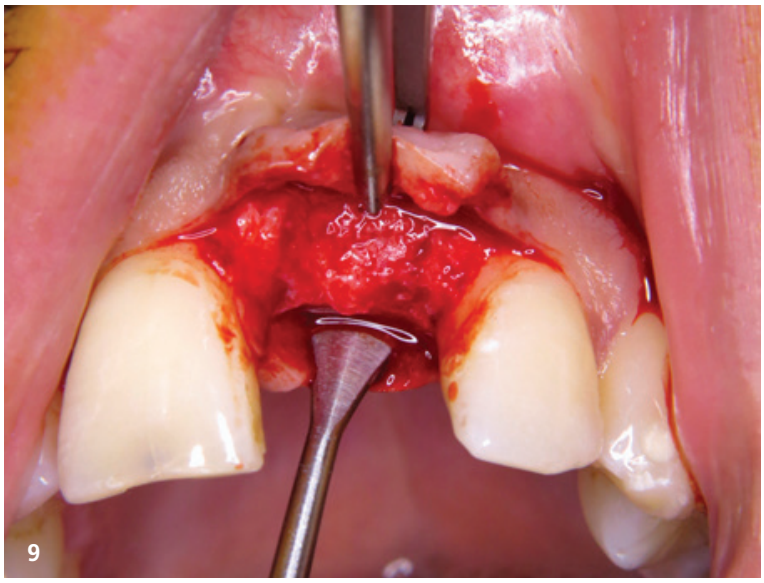


Fig. 8: Diagnostics and planning using CBCT after three months follow-up. – **Fig. 9:** Bony situation at re-entry before the planned implantation. – **Fig. 10:** Drilling sequence for the planned ceramic implant (Neodent Zi).

the market for much longer and have been investigated accordingly, two-piece constructions have become increasingly established in recent years due to the available, albeit still limited, data. Finally, one-piece implant systems are much more limited in their prosthetic restorability, especially in aesthetically demanding areas, and are far less flexible in their use. To address this situation, the industry has developed various two-piece solutions, whereby, like the two-piece titanium implant systems, the screw-retained ceramic implant-abutment architecture has emerged as a design that is safe to use. The internal connection with the corresponding abutment screw appears to play the decisive role here, whereby the long-term results already available, albeit very limited, appear to be promising.[5–7]

It should be emphasised that the consistently positive material properties of zirconium oxide provide us with a genuine alternative to titanium implants and can be safely used in everyday clinical practice by experienced implantologists.

Case description

The male 23-year-old patient first presented to our practice for consultation in October 2022. No anamnestic abnormalities were noted or reported by the patient.

The initial intra-oral examination revealed a primarily healthy, caries-free and functionally unremarkable complete dentition. The patient stated that tooth 21 had suffered anterior trauma in childhood and that he had been undergoing regular dental treatment for at least three years. Nevertheless, according to his own statements, the pain symptoms did not seem to have improved. He was also dissatisfied with the steadily darkening discolouration of the crown of tooth 21 (Fig. 1).

Findings

After a detailed intra- and extra-retinal examination, it was found that the patient had already had multiple apicoectomies performed on tooth 21 in various dental practices following unsuccessful endodontic treatment. Currently, a non-fluctuating, firm, pressure-dolent swelling localised apically in region 21 was found vestibularly. A fistula or secretion discharge via the sulcus could not be detected intra-orally, even on provocation. Palatally, there were no abnormalities on the mucosa. A circular check with a PA probe revealed probing depths of between 2 and 3 mm mesially, distally and palatally without bleeding on probing (BOP). A single vestibular ST of 5 to 6 mm was detected. A longitudinal fracture of tooth 21 was therefore suspected. Furthermore, tooth 21 showed an increased degree of loosening (II–III) and a strong discolouration of the crown in comparison with 12, 11 and 22.

Diagnostics and planning

To supplement the clinical diagnosis and photo documentation, a single-tooth radiograph of 11/21 was taken (Fig. 2) and discussed with the patient. The treatment options were then explained to the patient in detail and all advantages and disadvantages were discussed.

Diagnosis

Unpreservable tooth 21 with suspected longitudinal fracture vestibular central in thick biotype with elongated square crown shape. The vestibular bone lamella is thin but largely preserved. Apically, there is osteolysis with chronic inflammation, possibly

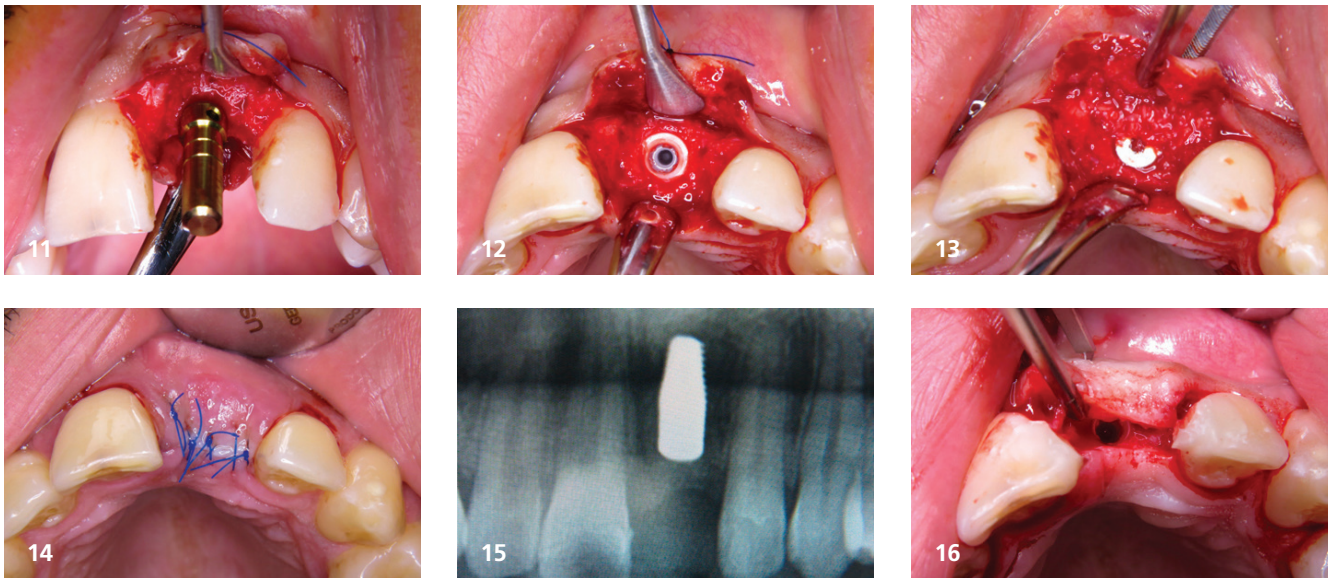


Fig. 11: Position and depth control using a direction indicator after careful preparation of the implant bed according to the drilling protocol. – **Fig. 12:** Situation after mechanical insertion of the implant with appropriate primary stability and a maximum torque of 45 Ncm. – **Fig. 13:** Situation after insertion of the cover screw and augmentation with resorption-stable xenogenic bone replacement material vestibular and crestal. – **Fig. 14:** Tension-free, saliva-proof suture closure for covered healing. – **Fig. 15:** X-ray control after implantation. – **Fig. 16:** Exposure of the implant after a three-month healing phase by means of relief-free skin flap plasty without relief incisions. Situation after removal of the cover screw.

also cyst formation. The neighbouring teeth are clinically and radiographically unremarkable.

Treatment options

The following treatment options for tooth 21 were explained to the patient in detail:

- Removal of tooth 21 and immediate implantation and immediate restoration
- Removal of tooth 21 and immediate implant placement with temporary restoration and delayed prosthetic restoration of the implant
- Removal of tooth 21 with temporary restoration and delayed restoration with an adhesive prosthesis in the form of a Maryland bridge
- Removal of tooth 21 with temporary restoration and subsequent restoration using a conventional bridge construction over the prepared teeth 12, 11 and 22
- Forced extrusion of tooth 21 (e. g. using magnets or orthodontics) and delayed implant placement
- Delayed immediate implant placement or late implant placement after socket/ridge preservation with delayed prosthetic restoration of the implant
- Omission of treatment

After careful consideration, the patient wanted to rehabilitate the situation without grinding the neighbouring teeth and against the option of immediate implant placement. According to the initial diagnosis, the buccal bone lamella appeared to be at least partially intact, so that a safe alveolar defect was to be expected. The treatment decision was therefore in favour of ridge preservation after gentle tooth removal and late implant placement after an expected healing phase of three months.

Discussion

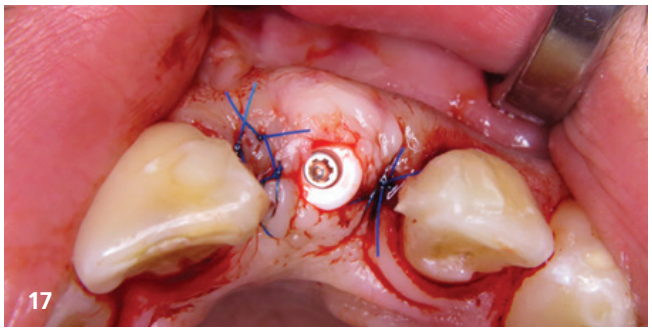
The dental rehabilitation of patients with implants has proven to be successful over the decades of use and the abundance of very good data available. Titanium is still regarded as the "gold standard" material of choice. With the advent and continuous innovative development as well as the increasing number of promising data, implants based on zirconium oxide must currently be clearly mentioned as a therapeutic alternative to titanium.[8]

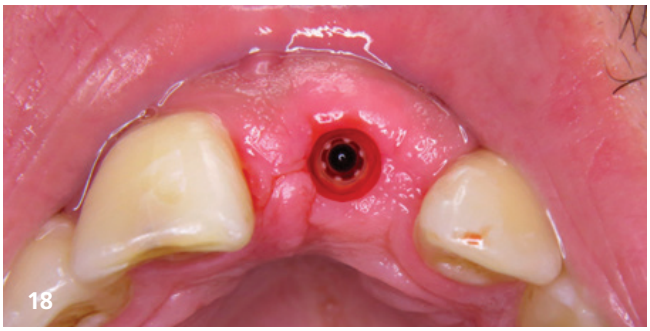
Zirconium oxide is at least on a par with, if not better than, titanium in the following respects:

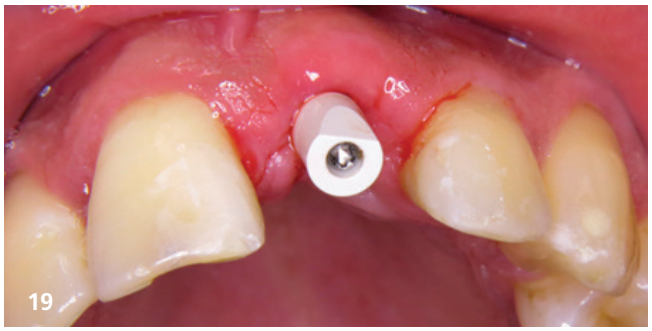
- Very good material properties, such as extremely high flexural strength and fracture toughness.
- Very good osseointegrative properties.
- Low plaque accumulation on contact with peri-implant soft tissue.
- Low risk of peri-implantitis development.

Comparison of material properties

In principle, the material properties of the two materials used, titanium and zirconium dioxide, should first be summarised. On the one hand, the biocompatibility and osseointegration of titanium (pure titanium or cpTi), which has been used for decades,







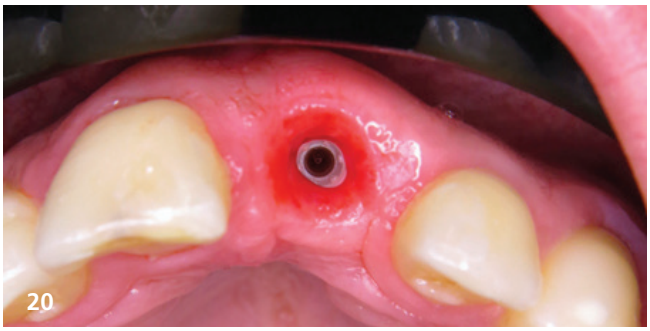


Fig. 17: Situation after insertion of the appropriate gingiva former and tension-free multi-layer suture. – **Fig. 18:** Situation 14 days after implant exposure and suture removal. – **Fig. 19:** Insertion of the system-specific scan body to record the implant position by intra-oral scanning and forwarding to the dental laboratory. – **Fig. 20:** Clinical image of the emergence profile after the six-week provisional phase.

can be explained by the stable passivation layer formed on its surface (titanium dioxide) immediately after exposure to oxygen. Zirconium as a base material, on the other hand, is oxidised through by pressing and heat supply and processed into zirconium dioxide solely due to its manufacturing process. Oxygen as such is therefore already an integral part of the material and its chemical affiliation to the non-metals is clearly established.

Furthermore, zirconium oxide is characterised by a very high flexural strength compared to titanium, which according to the current state of the art and depending on the manufacturer is up to 2,000 MPa with the addition of 20 per cent aluminium oxide ("aluminium-toughened zirconium oxide" ATZ). Titanium, on the other hand, has a flexural strength of around 400 MPa. Long-term material analyses of zirconium implants between 2004 and 2020 showed a significant reduction in fracture susceptibility from 3.4 to 0.2 per cent due to the further development of materials technology.[4,9,10]

In conclusion, it should be noted that zirconium dioxide can be used safely and predictably as a base material for implants due to its very good material properties and can replace titanium as such. However, due to the higher variance in the manufacturing processes of the respective implant suppliers and the lack of sufficient long-term data in material stability beyond five years, there is still no clear consensus.

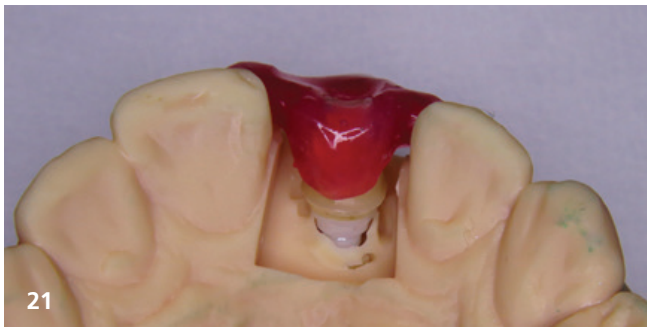
Regarding the implant design in connection with implant survival, there is currently sufficient long-term data for one-piece ceramic systems. Investigation periods of meaningful clinical studies within three to seven years have shown uniformly high implant survival rates of between 97 and 100 per cent, completely independent of the prosthetic restoration using single crowns or bridge constructions.[11–16]

On the other hand, the data situation for two-piece ceramic implant constructions can currently be described as poor due to the limited long-term data available. Nevertheless, the increased flexibility due to the continuous further development, particularly in the area of implant-abutment connection of two-piece zirconium implants, should not be underestimated, especially in the case of challenging bony or soft-tissue defects. Above all, the advantage of the possibility of load-free and covered healing after sometimes complex hard and/or soft-tissue augmentations opens completely new dimensions for the metal-free restoration of patients compared to one-piece ceramic implant restorations. No significant difference in implant survival between one-piece and two-piece implant constructions was shown in reviews.

Nevertheless, the use of two-piece ceramic implant systems is only recommended as an alternative to titanium if the practitioner has provided the patient with detailed information.[8,10,17]

Osseointegration in comparison

Osseointegration, i. e. the functional ingrowth of an implant in bony tissue, is a process consisting of two different phases of structural remodelling of the surrounding hard-tissue anatomy. Phase 1 is referred to as "primary stability" and phase 2 as "secondary stability", which can subsequently also be referred to as "functional ankylosis". Stable healing times with sufficient new bone formation after implant placement, whether with titanium







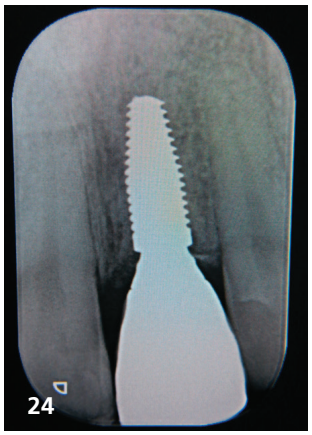


Fig. 21: Definitive customised abutment on the printed master model with insertion aid. – **Fig. 22:** Condition after insertion and torque-controlled screwing of the customised abutment and closure of the screw channel with Teflon tape. – **Fig. 23:** Clinical situation after final insertion of the crown in habitual occlusion and in the open position. – **Fig. 24:** Radiological check after insertion of abutment and crown.

or zirconium dioxide, are stated as two to three months according to the data available. There was no difference in the time required for new bone formation, bone apposition or vascularisation between the materials used. Furthermore, only minor evidence-based differences in osseointegration and soft-tissue deposition were demonstrated in clinical studies after processing and conditioning of the implant surface on both materials.[4,9,18–24]

Comparison of plaque accumulation and peri-implantitis risk

The risk of developing a peri-implant event, depends on various factors. One cause is the inflammatory change in the peri-implant mucosa due to the accumulation of biofilm caused by plaque deposits and its composition. Oral hygiene, changing living and health conditions, the influence of medication, lifestyle habits (such as smoking or alcohol) and suboptimal prosthetic restorations are just a few examples that can favour plaque accumulation on implant surfaces.

Actually, there is currently very little evidence-based data available. The few clinical studies available and referring to small patient populations have shown significantly lower biofilm and plaque accumulation on ceramic implant surfaces compared to titanium. Peri-implant inflammatory reactions in the area[22] of the surrounding soft tissue were among the most pronounced with titanium surfaces. The advantages of ceramic surfaces appear to predominate here. Further and above all long-term clinical follow-up examinations remain to be seen.[21,24–30]

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References



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