BioImplant: The first anatomically shaped ceramic immediate implant of industry 4.0

Is the screw implant the ideal solution in implantology?

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The world is currently undergoing the 4th industrial revolution, commonly referred to as Industry 4.0 or the Internet of Things. The first industrial revolution was initiated by the use of the steam engine, the second by assembly lines and electricity and the third by computer-controlled machines. In the fourth industrial revolution, production is fully digitized and networked in real time from the patient's individual initial situation, i.e. by digital data acquisition from the patient. The entire value chain, from the development and manufacture of the product, as well as all associated services with all the individual requirements of the patient and dentist, will in future be fully digitally fulfilled via networks in the sense of mass customization (batch size 1). Generally abstract standardized components are a thing of the past; individually specific solutions are the future, in other words: industry 4.0.

And what does Industry 4.0 actually have to do with immediate implantology?

Customized solution

From the outset, dentists and dental technicians have been forced to offer customized solutions for the specific initial situation and, above all, for the patient's personal requirements. Can a standardized screw implant in immediate implantology adequately meet the individual initial situation of the patient?

Modern dental implantology began in the middle of the last century with a simple, machined screw in the healed jawbone by Per-Ingvar Brånemark. However, there have been few or no subsequent innovations over the last 50 years. Instead of groundbreaking innovations, there have mainly been variations of the "basic screw principle", and this has led to an unmanageable variety of implant manufacturers and screw variations. Currently, there are already well over 250 implant manufacturers with well over 3500 screw variations – and the number is growing daily. Compared to the development of computer and mobile phone technology, the development of the screw is mature, so no further innovation can be expected.

Screw implants as the ideal solution?

These titanium screws are available in different lengths and diameters, and are therefore generally abstract and in no way suited to the patient's specific individual situation after a tooth extraction. Due to the lack of fit of a standardized screw to the extraction socket, the patient must regularly be adapted to the implant screw through a variety of often complex surgeries. Despite strict guidelines and highly trained implantologists, implantological procedures are costly, stressful, and the esthetic result cannot be predicted with certainty. It is also evident that every operation carries an inherent risk, since injury to anatomical structures - such as neighboring teeth, nerves, the maxillary sinus, or even the bone structure itself - is inherent in the drilling process.

Four factors for successful implantology

It is undisputed that successful implantology is based on the four factors of biocompatibility, primary stability, atraumatic procedure and reduced stress during the primary osseointegration phase. If these success factors are consistently and logically followed, the ideal implant shape for an immediate implant is one that is anatomically fully adapted to the tooth socket. Based on this requirement, the anatomical immediate implant was consistently developed and used in patients as early as 10 years ago.

Reversal of the principle

The principle is easy to explain. Instead of adapting the patient to a standardized screw by means of surgery, the implant is adapted to the extraction socket using the latest CAD/CAM technology. The anatomically fitting implant can therefore be simply inserted into the socket without any surgery at all, thus eliminating the need for any changes to the bone or soft tissue through drilling and/or bone augmentation or soft tissue plasty.

Difficult start for anatomical implants

All previous attempts to achieve functional and esthetic success with root-shaped implants have ultimately failed miserably, despite initial successes (Kohal et al.). One of the reasons for the failures lies in the conical shape of the tooth root, since a cone only has friction at the last part. A simple copy of the tooth shape therefore leads to weak to no primary stability. If the implant is enlarged by the periodontal gap, it has a significantly better initial primary stability, but the pressure subsequently causes bone resorption over the entire implant-bone surface at the same time. This usually leads to the loss of the implant even before osseointegration can take place. A simple copy of the tooth shape as an implant does have the significant advantage that this shape is not only more natural, but also, and above all, produces the maximum bone-to-implant contact from the outset. However, due to the conical shape, this bond is not sufficiently stable for long enough to lead to reliable osseointegration.

The solution to the problem

It was therefore necessary to solve the problem of the lack of primary stability of a conical root form, and especially the fact that it does not last long enough to keep a root-shaped immediate implant sufficiently primarily stable during the osseointegration phase to achieve secure secondary stability. The solution to this problem lies in the concept of "Differentiated Osseointegration":

Differentiated Osseointegration

It describes the guided balance between bone and implant distance, contact, and compression, taking into account cancellous and cortical bone qualities, with the aim of achieving rapid and secure osseointegration through this differentiation on anatomically shaped implants. The modification of the implant surface/shape is crucial to achieve all three possible bone-implant scenarios in a balanced way: contact in areas of the exact copy of the tooth root, minimal distance in the region of the sensitive thin outer cheek and lip-side bone compacta (bundle bone), and bone compression with macroretentions only in areas adjacent to cancellous bone.

Targeted macroretentions

The shape and surface design of the anatomical immediate implant therefore takes into account the different bone structures of the compacta and cancellous bone. In areas of cortical bone, the implant follows the bone or is slightly recessed from it so that this sensitive bone cannot be fractured. In areas of cancellous bone, the surface is given macroretentions so that the implant can be securely anchored in the bone for 12 weeks. These macroretentions only deform the cancellous bone at certain points, and the microfractures heal quickly due to the good blood supply to the cancellous bone. If macroretentions were to be placed in the area of the compact bone, this would result in a fracture of the thin bone and subsequent resorption.

What does this implant system have to do with the possibilities of Industry 4.0?

Currently, the anatomical immediate implant is produced from an extracted tooth or an impression of the alveolus. In the age of Industry 4.0, however, this implant solution should be manufactured fully digitally from start to finish. This is the only way to produce an anatomically shaped implant before extraction. In principle, this technology already exists only the insertion still has to be done manually. In the fully digital production of anatomical immediate implants, the patient is referred by the dentist for a computed tomography (DVT). The 3D data is uploaded to the cloud, segmented and optimized in shape and surface and sent to a milling center. The dentist receives an all-ceramic, anatomical immediate implant within 4 hours, which can be inserted in less than a minute in a procedure immediately after tooth extraction without surgery.

Investors and industry are needed

The proof of concept has been provided by a 10-year study and now it is up to investors and industry to implement this "Industry 4.0 implant system concept" on an industrial scale and thus make it accessible to all dentists and patients. Thanks to the consistent application of networked computer technology, an implant patient can now be treated individually from start to finish in a fully digital production process, avoiding the use of standard parts and the associated surgery that is inherent in the current system. It is now up to doctors, dental technicians, investors and industry to work together to implement this simple and logical individual ceramic CAD/CAM immediate implant solution in a fully digital workflow for the benefit of all patients who are facing tooth loss.

Indications:

- Single-tooth replacement for teeth that are not worth preserving

Contraindications:

- Periodontally damaged teeth.

Advantages:

- Simple and logical
- No opening of the mucosa, no bone milling, therefore no injury to important anatomical structures possible
- Short treatment time, no multiple or secondary procedures, therefore less patient stress and more economical treatment
- No worse initial situation in the event of implant loss, since the condition is the same as after tooth extraction
- No screw connections, therefore no screw loosening or fractures, no bacterial colonization of gaps
- Immediate support of the bone and soft tissue prevents excessive atrophy
- The crown stump can be ground, and any conventional dental crown can be cemented in place
- Ceramic implants provide an esthetic tooth shade and the best biocompatibility
- No prosthetic/technical parts, no system-specific tools

Disadvantages:

- Currently only available as a one-piece implant
- Further studies are necessary

Two case studies can be found on the following pages >>

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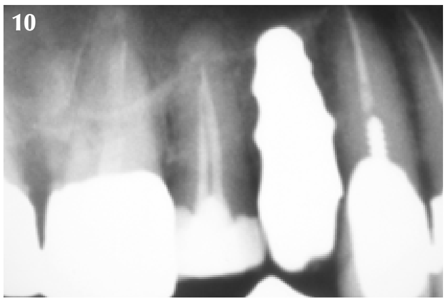
Patient case 1

Patient case with follow-up attention 10 years

63-year-old patient with a non restore able tooth 14, extraction and placement of an anatomical immediate implant after 4 days, healing phase 6 months (without protective splint) and fabrication of a plastic crown. No inflammation in the sense of peri-implantitis was detected during the 10-year follow-up. In contrast to the remaining teeth and the titanium implants 46 and 47, no gingival recession was observed, even with average oral hygiene. The V-shaped collapse of the gingiva fixa postoperatively also restored itself to a physiological width without surgical intervention within the primary osseointegration phase of six months (Fig. 2 and 3).



Caption

Fig. 1: Tooth not worth preserving 14

Fig. 2: Anatomical zirconia implant post operativ

Fig. 3: 12 weeks after surgery, grinding of the stump of crown

Fig. 4: 2 years follow up

Fig. 5: 4 years follow up

Fig. 6: 6 years follow up

Fig. 7: 8 years follow up

Fig. 8: 10 years follow up

Fig. 9: Preoperative X-ray of tooth 14 not worth preserving

Fig. 10: X-ray 1 year after surgery

Fig. 11: X-ray image 10 years after sugery

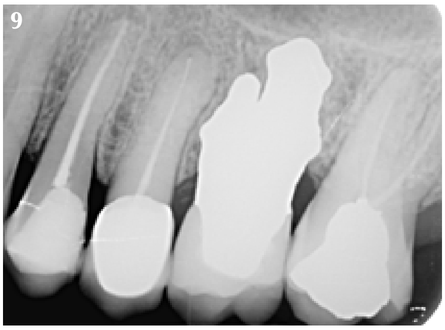
Fig. 12: Anatomical immediate implant with macroretentions, inter-dental view











Patient case 2

Patient case follow-up 3 years

47-year-old female patient with tooth 16 not worth preserving. Extraction and placement of an anatomical immediate implant after 7 days, healing phase 15 weeks (without protective splint) and fabrication of a definitive plastic crown. No inflammation in the sense of peri-implantitis was detected during the 3-year follow-up. Due to the patient's overly intensive oral hygiene, a slight gingival recession occurred at 24, 25 as well as at implant 26.

Captions

Fig. 1: Tooth not worth preserving 26

Fig. 2: Anatomical zirconia implant post surgical crown grinding

Fig. 3: 1 year post-operative

Fig. 4: 1 year post-operative occlusal view

Fig. 5: Perfect definitive reconstruction in function, form, esthetics and translucency without a sinus lift in just 15 weeks

Fig. 6: 3 years post-operative with low Gingival recession at 24, 25 and Implant 26 due to incorrect clieaning technique

Fig. 7: 3-Rooted anatomical immediate implant compared to a conventional screw implant

Fig. 8: Preoperative X-ray

Fig. 9: X-ray image 3 years follow-up