The treatment of toothless jaws

A case for CAD/CAM

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_Prosthetic devices can be fitted in various ways. Digital technologies have made their mark in implantology for quite a while, and they provide options for quality solutions. Classical indications for implant-prosthetic treatments include dentures for the toothless jaw. For this type of dentures, clinical studies document a high survival rate of about 85 to 90 % (Attard et al. 2004a, Attard et al. 2004b) with observation periods of up to 20 years.

According to the number of the inserted implants, various prosthetic concepts have established themselves for the fitting of supraconstructions (Zitzmann and Marinello 2002). Generally, there is either a fixed denture mounted on six to eight implants and borne by these only, or a removable denture with a reduced number of implants.

The decision process for the selection of a suitable denture depends, on the one hand, on subjective criteria (patient's expectations, financial conditions) and, on the other hand, on clinical aspects (anatomic criteria, technical and clinical reliability of implants and supraconstruction). Accordingly, the success of the prosthetics depends on these factors (Fig. 1):

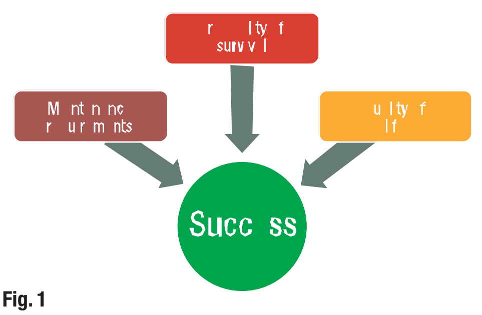


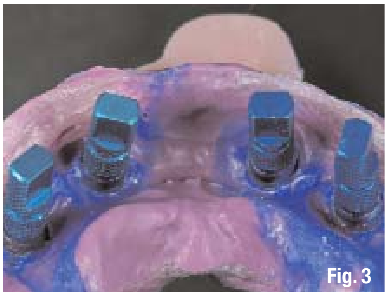
Fig. 1

Fig. 1_Subjective and objective prosthetic success criterions.

_Subjective criteria (patient satisfaction and quality of life);
_Objective criteria (probability of survival); and
_Necessary maintenance effort during the lifetime of the denture.

_Criterions for the selection of the type of denture

Fixed as well as removable implant-prosthetic dentures in the toothless jaw, as opposed to the conventional full denture, have proven to significantly increase the patients' satisfaction and to improve the ability to chew (Raghoebar et al. 2003, van der Bilt 2006). This means that already the insertion of two to four implants can lead to a clear improvement of the quality of life. Therefore, the removable implant-supported and implant-retained coverdenture prosthesis is nowadays considered an effective therapy. However, there was also evidence that, in particular, the choice of fitting elements (magnets, ball-heads, bridges, telescopes) in a removable denture has an influence on patient satisfaction. A comparative cross-over study has shown that, with respect to stability and retention power as well as the achievable patient satisfaction, magnets are inferior to the fitting with ball-heads (Burns et al. 1995a, Burns et al. 1995b). A comparison of ball-head elements and over-denture attachments used for the fitting of an implant-retained Coverdenture prosthesis did not show any differences in terms of patient satisfaction (MacEntee et al. 2005); however, there proved to be a significant difference in the rate of technical complications. Within an observation period of three years, prosthesis fitted with ball-heads required 6.7 repairs, whereas the group of bridge-fitted prosthesis required 0.8 repairs per patient only. Hence, overdenture attachments as fitting elements for removable



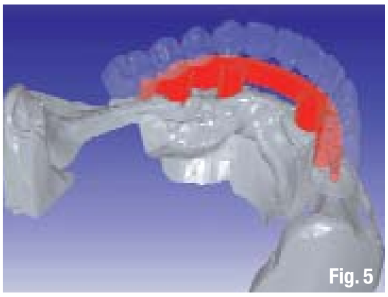


Fig. 2_Fracture of a bar attachment construction manufactured by casting, in the area of the extension.

Fig. 3_Casting of the implants in the pick-up technique with a high-strength casting material.

Fig. 4_Tooth arrangement produced on the work model.

Fig. 5_Virtual construction of the bar attachment construction with distal attachments.

supraconstructions guarantee high patient satisfaction. Thanks to their low rate of technical complications, they require less maintenance effort than alternative fitting elements (MacEntee et al. 2005), which is an important criterion for the long-term success of the prosthesis. High maintenance requirements require more practice visits and take the time of both, the patient and the care provider. Further, if there are technical complications that have led to the failure of supra construction elements, an intervention by a dental technician might be needed for the new construction or the replacement of individual components. This is also connected with further costs in order to maintain the function.

When evaluating overdenture attachment constructions as fitting means, consideration must be given to the various types and forms there are. On the one hand, there are individually shaped bar attachments, and on the other hand, there is the classic round bar, which can be manufactured either by casting or by combination of pre-fabricated elements.

The overdenture attachment sitting on four implants is a classic fitting element for a purely implant-supported coverdenture prosthesis in a toothless upper or lower jaw. A retrospective study with 51 patients compared individually shaped bar attachments and round bars for the fitting of coverdenture prostheses (Krennmair et al.2008). 26 patients were equipped with round bars, while 25 patients received a supraconstruction with an individual bar attachment, on four implants each. After a surveillance period of five years, the survival rate of the implants was 100 %. Larger technical complications, which required a renewal of the mounting elements, occurred in the round bars only, in form of fractures in the extension areas. The fractures on the extensions of the overdenture attachments, which were exposed to high mechanical stress, were due either to porosities in the cast object, or to inhomogeneities in the area of the points of attachment. Further, it was determined that low-grade complications (activation of hanks) would come up three times as often in the round bars as in the bar attachments. Basically, two causes of defects can be derived from that: Firstly, defects due to faults in the manufacturing technique (casting and joining processes), and secondly, defect causatively connected with the design of the supra-construction.

For the fitting of attachments in the toothless upper jaw, the literature describes two versions. The fitting of attachments on four implants in the anterior segment, and the fitting of two attachments on three to four implants on the lateral segments of the toothless upper jaw (mostly after a previous sinus floor augmentation). Also for the application of attachments in the toothless upper jaw data from clinical studies have been published (Krennmair et al. 2008). Both attachment concepts featured almost identical survival rates after five years—98.4 % for the attachments in the anterior segment, and 97.4 % for the attachment fitting on six to eight implants in the lateral segments of the upper jaw.

In particular the fitting by bar attachments seems to be a therapy means with guaranteed success for the fitting of purely implant-supported coverdenture prosthetics in the upper and lower jaw. It excels with a low rate of technical complications and, with that, low maintenance requirements. Hence, bar attachments constitute clinically tested fitting elements for implant-retained and implant-fitted removable supraconstructions in the toothless upper and lower jaw. Clinical data for the fitting of removable supra-constructions in the toothless upper jaw are missing for magnets as well as for ball-head attachments. Also the application of so-called locators for the fitting of removable implant supraconstructions cannot be considered to be based on evidence, according to the current data provided, as no results of clinical studies have been presented by now for this fitting element.

Telescopes as fitting elements for removable supraconstructions are popular particularly in the German-speaking countries, as they are very hygienic and easy to expand. However, these advantages are opposed by the high technical requirements and costs at manufacture. Clinical studies on the suitability of double crowns as fitting elements in implant prosthetics show that they are generally suitable, and they point out the advantage of combining the natural teeth with implants for the fitting of a removable construction, as opposed to attachments.

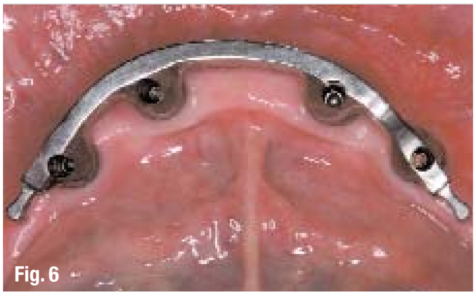


Fig. 6_Compartis ISUS bar attachment made of pure titanium; the attachment could be inserted without manual after-processing.
Fig. 7_Completed implant-retained prosthesis for the lower jaw.
Fig. 8_Good fit with a CAD/CAM produced attachment construction made of pure titanium.

_Optimising the manufacturing technology

Despite of the high and well documented survival rates of attachment constructions, the question arises whether the strategies can be further optimised in order to avoid defects attributable to the technique. The traditional way of manufacturing attachment constructions is by casting. However, the larger the cast object, the more problems use to arise in terms of porosity and warpage which, on the one hand, increase the risk of mechanical failure and, on the other hand, impair the proper fit (Jemt et al.1999; Fig. 2).

Relatively early, the well-known casting problems have led to the establishment of alternative techniques. The application of pre-fabricated implant components, which then were mated by means of soldering or laser welding, was one way to improve the fit; however, in particular with large constructions, this procedure has the disadvantage of very time-consuming manual post-processing. Furthermore, there is the risk that the mechanical ability to cope with pressure may be reduced in the area of the joining point.

In addition to that, from the economical point of view, it would make sense to use largely biocompatible material of sufficient mechanical strength for the manufacture, such as pure titanium or a Co-Cr alloy. However, the processing of such alternative materials does not provide a sufficiently exact fit with the current casting techniques. *In-vitro* examinations of cast implant suprastructures made of non-metallic materials showed gaps of 200 to 300 µm between the suprastructure and the implant arrangement (DeTorres et al. 2007). Compared to that, cast structures made of noble metals featured median gaps of 40 to 50 µm (Takahashi and Gunne 2003). The use of alternative materials therefore requires an alternative processing technology, and be it just to achieve the necessary precision. In the ideal case, the supraconstruction is cut from a prefabricated solid material in order to safely exclude inhomogeneities. With this thought in mind, the manufacture of supraconstructions with cutting technological means utilising the CNC process started already more than ten years ago.

In-vitro examinations with this CAM technology showed that the precision achievable in such constructions, with median gap widths between 20 and 30 µm is better than the accuracy of fit achieved with cast frames made of noble metals (Takahashi and Gunne 2003). Modern scanning and software technology allows expanding this manufacturing principle also to the area of the virtual construction. Hence, the already well-known process of CNC cutting is supplemented with the option of a purely virtual construction. Meanwhile there are several manufacturers offering this technology (e.g. Compartis ISUS of DeguDent).

_Case presentation

The manufacturing process is documented below on the example of an attachment utilising the Compartis ISUS system. After exposure of the implants, the next appointment is devoted, as usual, to making a casting with impression material which has a high final hardness and hence guarantees a secure fixing of the casting posts (e.g. Impregum, 3M ESPE, or Monopren transfer, Kettenbach Dental; Fig. 3).

In the ideal case, the casting appointment will already include the determination of the jaw relations and a casting for the model for the opposite jaw. After that, the work model is manufactured with the help of a removable gingiva mask in the area of the implants. When the first checkbite is taken, a first provisional model can be mounted straight away. Based on this working material a tooth arrangement is prepared from plastic. It is useful if the information about the colour and the shapes of the teeth is already available during this work step (Fig. 4).

The tooth arrangement can be tried on at the next appointment, and corrected if needed. So, the exact jaw relations can be determined, and sufficient information will be collected for the definitive tooth arrangement. At this appointment, also the precision of the casting should be checked with a transfer jig. For this key, the posts on the work model can be blocked with plastic and a metal reinforcement. The key must then fit onto the implants in the mouth without causing tension or shifting around. For the exact determination of the accuracy of the casting fit it makes sense to perform the so-called Scheffield test. For this test, a screw is mounted and fastened on the post on one side of the distal implant. When fastening the screw, the transfer jig must not lift off the other implants.

Further, there must not be any gaps. If the screw can be fastened without making the transfer jig move the conclusion can be drawn that the impression has exactly copied the situation in the mouth. In case that the test has a negative result a transfer defect can be assumed. In such a case, the transfer jig should be separated, and all posts should be fastened with screws, so that a new impression casting can be taken.

Once an exact impression has been secured and the tooth arrangement has been adjusted, the CAD/CAM manufacture of the supraconstruction can begin. First, the work model and the tooth arrangement are sent to a Compartis ISUS Planning Centre. There, the virtual construction of the attachment is made according to the specifications of the dentist(s) and dental technician(s). In the present case, a bar attachment construction made of titanium with distal attachments (Preci-Vertix, CEKA Germany) has been chosen. The tooth arrangement determines the space available for the supraconstruction and the alignment towards the chewing area. This information then constitutes the foundation for computer-assisted design of the supraconstruction, the CAD process. For this purpose, first, special scan posts are screwed into the implants, in order to determine the position of the implants with a first scan. Then a second scan is done with the wax arrangement, in order to determine the available space and the orientation of the supraconstruction. Then, the desired supraconstruction is designed with the help of special software. This constitutes the basis for the manufacture of the supraconstruction utilising the CNC process (Fig. 5).

Dental technicians and care providers will then receive the construction suggestion of the Compartis ISUS Planning Centre by email with the request for release or for advice of possibly required changes. As soon as the release is obtained the manufacture of the attachment begins. The Compartis ISUS system ensures, particularly by applying modern cutting machines and special cutting strategies with all the materials, a perfect quality of the surfaces which dispense with the need for manual after-processing also as far as the retaining elements are concerned (Fig. 6).

Then the dental laboratory can commence with the manufacture of the secondary construction. In the present case, first, a secondary structure was made by means of electroplating (Solaris, DeguDent), and the plastic matrix for the Preci-Vertix retaining elements was incorporated. After that, a cast tertiary structure was made of a cobalt-chromium alloy and bonded with the galvanoplastic structure. The supraconstruction was completed using the already existing tooth arrangement. Several *in-vitro* examinations prove the excellent accuracy of fit in these CAD/CAM manufactured constructions. In a comparison of five different techniques for the manufacture of implant supraconstructions, the CAD/CAM structures showed a median accuracy of fit of 25 µm, while cast structures had median gaps of 78 µm width (Torsello et al. 2008; Fig. 7).

However, the advantage of the CAD/CAM technology is not only the highly precise manufacture of suprastructures made of pure titanium and Co-Cr alloys; there is also its applicability to a broad range of indications. Starting out from the scan data, the virtual construction allows for a wide range of variations in terms of various forms of supraconstructions, from the simple round bar to retaining element attachments or to a bridge frame for fixed constructions. With a CAD/CAM system, it is also possible to virtually incorporate active holding elements such as extracoronal retaining joints, bars and press buttons.

In summary, it can be said that the CAD/CAM technology is also ideal for the processing of alternative materials on titanium and NEM basis. It provides these advantages:

_High mechanical resilience thanks to homogeneous pore-free materials;
_Tension-free fit thanks to precise CNC manufacturing technology;
_Suitability for a large width of indications thanks to individual computer-assisted design.

The integration of the virtual design supplements the trusted manufacturing technology based on cutting and hence opens up possibilities of new indications for using alternative materials in implant prosthodontics._

Editorial note: Bibliographical reference is immediately available for download at www.zwp-online.info/fachgebiete/implantologie.

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