Rehabilitation of edentulous patients

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The prosthetic rehabilitation is the last step in implant therapy. The ageing of the population, the demand for aesthetics and functionality at advanced ages, and the establishment of implants as a regular therapy increase the edentulous situations that must be treated yearly. In this study, we examine full-arch treatments with screw-retained fixed prostheses. In Table 1 (see QR Code Tables), a decision tree for deciding whether fixed or removable prostheses are the appropriate solution for the patient is shown. While fixed prostheses are more favourable in the case of sufficient bone volume or only minor bony defects and good patient compliance, removable ones are preferable in the case of major vertical defects or insufficient soft-tissue support (in addition to a lack of compliance). In this study, we treated 23 edentulous jaws. In total, 133 implants were placed, 94 in the maxilla and 39 in the mandible. All of our patients fulfilled the criteria shown in Table 1 (see QR Code Tables): no or low vertical and lateral bone defects, replacement of the teeth was sufficient for soft-tissue support, hygiene was ensured in every case, and implants were placed in the proper prosthetic position.

Manufacturing and implantation

Three jaws received cast frameworks melded at the laboratory, whereas 12 were CAD/CAM-milled at multi-unit abutment level. The remaining eight frameworks were milled at implant level (either with internal geometry or on a scan base abutment). The major implant types used were anonymised into B, I and M, while implant Types Z, C and two others refer to older implants integrated into the new prostheses. Three implants were lost during healing owing to low primary stability and lack of osseointegration. All three implants were replaced immediately with slightly wider ones, since no signs of inflammation were evident.

The All-on-4 protocol (Nobel Biocare) was deliberately avoided, since its limitations influence long-term therapy success. Nevertheless, two patients (both maxilla) received only four implants. Both patients were over 80 years old and in neither of the cases were implants angulated more than 15°. Generally, we tried to avoid angulated implants. In contrast to the All-on-4 concept, we chose to insert the im-

Figs. 1a–h: Multi-unit abutments.

a) Type B straight. b) Type B angled.

c) Type C snap-in. d) Type C straight.

e) Type T straight. f) Type T angled.

g) Type M straight. h) Type M angled.
plants parallel. As a result, only four jaws and eight implants needed angled multi-unit abutments. No second molar was replaced in any case, but one patient received restoration up to the second premolar, since the molars were retained and received regular full-ceramic crowns (Table 2, see QR Code Tables).

Prosthetic components

All of the angled multi-unit abutments were two-piece abutments. The B and C systems offered one- and two-piece straight abutments. System C components had a snap-on function that often simplified their insertion—though not in all cases. All of the systems offered components with anti-rotation between the multi-unit abutment and implant. If components without anti-rotation to the implant were used, they needed to remain inserted after the initial probing. Components with an anti-rotation function between the multi-unit abutment and framework or titanium sleeve were very useful. The insertion of angled abutments was time-consuming without a jig. Angled abutments were inserted with customised titanium sleeves, since no abutment carrier was sufficient for insertion. Special insertion adapters were necessary for almost all manufacturers (apart from Type D implants).

A very practical abutment design was determined for Type I and M implants. Combining platform switching and a concave abutment design offers much space for crestal bone and soft tissue to build a ring around the implant neck, protecting it in the long term. Type M implants offer even more space for crestal bone and soft tissue through the triangular design of the implant neck. Together with the gold-anodised prosthetic components and emergence profile, aesthetics is realised more easily than with other systems (Figs. 1a–h; Table 3, see QR Code Tables).

Manufacturing and milling

Screw-retained full-arch constructions show many advantages over cemented ones. They are easy to realise and repair. From re-entry until final loading of the implants takes three to four appointments and three weeks. Especially in combination with digital impressions and 3-D-printed models, the manufacturing time and costs can be reduced to a minimum. Apart from the re-entry, all other appointments are short, only up to 30 minutes. Cast frameworks (non-milled) are quite expensive and subject to tension. In contrast, milled frameworks showed no tension at all and no steps had to be repeated.

The mandibles were treated with multi-unit abutments. There was only one exception of a mandible being treated with a framework at the implant level, because no milling centre that we worked with was able to mill an internal hexagon geometry of 3 mm. The maxillae were treated with scan bases or directly at the implant level. The maxilla is not mobile and therefore is not subject to torsional forces as the mandible is. Through this solution, we reduced potential weak points to a minimum, having only one, the screw fixing the framework to the implant. In the mandible, there are two potential weak points: the screw to the implant and the screw to the multi-unit abutment. Nevertheless, in this study, two maxillae were treated with multi-unit abutments because either the milling centres were not able to...
mill the required geometry or there was an insufficient conical connection surface between the framework and implant to eliminate transversal forces leading to screw loosening (Table 4, see QR Code Tables).

CAD/CAM-milled superstructure

The digital era of dentistry has reached our practice. A digital workflow is not possible without compromises. Nevertheless, new materials, manufacturers and systems are easily integrated into any workflow or milling system. Also, anatomical findings can often avoid techniques like intraoral scanning.

In this case series, only six cases were performed with intraoral scanning. Owing to the very high soft-tissue quantity that we saw in many cases, scan bodies were not always sufficient for the scanners to perform digital impressions. The matching of an edentulous jaw with a non-edentulous one is possible with additional aid. Even in cases that were scanned intraorally, we manufactured 3-D models to proceed with the jaw matching.

Case 1

In the first case, a female patient with a partially edentulous maxilla was treated. All of the remaining teeth had to be extracted. One implant was an immediate implantation. The patient received a removable provisional prosthesis for two months. Owing to the implant surface of the manufacturer, we decided to re-enter after eight weeks. The final loading took place 12 weeks after implant placement. Although one implant had no optimal angulation, a screw-retained bridge was possible. The prosthesis received a resin layer facing the ceramic bridges in the mandible.

The replacement of the missing teeth with a prosthesis was sufficient for optimal support of the lower face soft tissue. Furthermore, a welcome side effect of such treatment is the decrease of wrinkles through the soft-tissue support. With this, the patient looked ten years younger. A very important focus of the prosthetic rehabilitation was hygiene maintenance. The patient needed to be able to brush and floss each implant easily, giving consideration to the fact that all of the patients in this series were over 60 years old, with an average age of 65 to 70, and some were already in their 80s.

The prostheses were loaded on multi-unit abutments. Although we generally load maxillae at the implant level, the implant system used in this case was very new and milling centres were not able to mill the internal geometry or use other cast scan bases. Nevertheless, loading maxillae at the implant level reduces weak points at the superstructure level. Here, we would have six screws that could loosen. Since the maxilla is not mobile, there are no torsional forces on the implants or the superstructure (Figs. 2–12).

Case 2

In the second case, treatment of a mandible was performed. All of the teeth needed to be extracted; however, initially, three molars were retained for the stability of the provisional prosthesis. Owing to emotional reasons, the last two molars were extracted some months after loading the implants. Four of the five implants were placed immediately. The fifth one, placed in region #46, was a late implantation. We could clearly see that, at the point of loading, there was slight vertical bone resorption at #46. This was not true resorption, but more the establishment of a new biological width. This new biological width is inevitable.

In late defects, biological width is lower if platform-switched implants are used and placed correctly and higher if other platforms are used. Immediate implantations seem to behave more predictably: the transformation of the socket begins with the implant placement and not after the re-entry. With this, we see no vertical bone loss in the first weeks or months after loading the implants. The long-term stability is not affected by the new biological width. The main factors for long-term stability are bone quantity, soft-tissue quantity and quality, prosthetic and masticatory forces, as well as proper oral hygiene at home (Figs. 13–19).
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In this case, we loaded the implants as prescribed in our protocol. We prefer to always load the mandible at the multi-unit abutment level. The reason for this is that the mandible is long bone that experiences torsional forces through mastication. Loading at implant level would transfer these transversal forces to the implants, thereby influencing long-term stability. With multi-unit abutments, the weak point is placed higher, at the connection of the superstructure to the multi-unit abutments. In this way, such forces would cause screw loosening at the superstructure level. This has been seen at recall appointments, where in approximately 5 per cent of the implants placed, screw retention has loosen insertion torque, not 100 per cent but almost 10 Ncm. We also have to consider that these screws are inserted at a torque of 15 to 20 Ncm, while superstructures are directly screwed at implant level at 35 Ncm. Thus, there was no mobility felt at the superstructure level and no patient had such complaints.

**Discussion**

**Digital dentistry**

Modern digital dentistry offers various services to the practitioner. Computer-assisted implantology has been a reality for many years. The digital impression (precision of up to 7–12 μ) is evolving rapidly, allowing additional services, such as the complete planning of the prosthesis, shade matching, mock-ups and fast communication with the laboratory. 3-D printers offer precise (up to 30–50 μ) models and minimise time wastage such as in conventional dentistry. Milling centres are fast in production and use new systems and techniques. The intraoral scanner used in this study needs no powder and is able to scan even in the humid environment of the mouth.

**Data communication**

Yet, there are problems to overcome. Often, it is difficult to implement new data formats in old workflows and convert it into STL format, and this may result in the loss of information. Though not in all cases, the practitioner can avoid master models for manufacturing full-arch frameworks. At the same time, screw-retained full-arch solutions are less favoured in some countries, although implant manufacturers and the industry react very quickly to the needs of the practitioner.

**Full-arch frameworks and materials**

Full-arch frameworks, according to this protocol, are to be loaded on multi-unit abutments when treating the mandible. Owing to the torsional forces, a too-rigid connection of the implants can lead to screw loosening although the framework is free of tension. Such torsional forces occur during mastication or parafunction and can result in overloading of the implants. The maxilla can bear practically any type of framework.

A very interesting alternative to this protocol is frameworks of PEEK or PEEK variants, such as BioHPP (bredent), especially in removable prostheses and in
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Case report

The mandible. They are elastic, can be milled thinly and are comfortable to wear. Also, full-zirconia frameworks on scan bases are experiencing a revival. Nowadays, we can overcome early childhood diseases like framework fracture by removing the weak points coronally by using a zirconia framework prepared like teeth and IPS e.max crowns (Ivoclar Vivadent) on them. In this way, if fractures occur, they instead affect the IPS e.max crown, which can easily be milled and applied in only a few hours.

Complications

In order to eliminate complications, all patients were put on a four- to six-month recall programme. The passive fit of the framework was elementary. Complications were only observed in one case of a mandibular construction at the implant level through screw loosening or framework detachment from the scan base. The prostheses were rebuilt with multi-unit abutments or internal geometry this time. Loosening of the screws retaining a superstructure on multi-unit abutments was not seen as complication and occurred only in mandibles.

Another important issue is the communication between dentist and dental technician. The framework, especially regarding milling at the implant level, must be planned thoroughly. The technician needs exact instructions on how to mill the emergence profile. If, for example, the soft tissue after re-entry is sufficient, but when it comes to the final loading, the emergence profile and the framework are too bulky, gingival recession can occur. This is not true gingival recession, but arises because the part of the framework engaged with the implant is too convex. Reducing this part or even giving it a concave form solves the aesthetic problem through lower pressure on the buccal gingiva.

Prosthetic components and aesthetics

Another important issue is the soft-tissue aesthetics. Concave abutments are preferable. They offer space for the soft tissue to build a ring around the abutment, protecting the crestal bone. The more delicate the abutment, the better the aesthetic outcome. Manipulating soft tissue through implant components is a smart way to optimise prostheses, but leads to recessions if components are too bulky. Angled abutments especially tend to be too bulky. Additionally, they cause pain when inserted because of their pressure on the gingiva.

A proper surgery results in sufficient soft-tissue quantity and quality. However, too much soft tissue can be a hindrance in some prosthetic steps. If, for instance, the amount of soft tissue prohibits an intraoral scan because scan bodies are not long enough, conventional methods must be followed.
All-on-4 or all-on-five to -six?

The follow-up, which was up to six years later, showed a stable hard- and soft-tissue situation with no implant failure. The aesthetic outcome was also stable. These results are similar to those of All-on-4 procedures. The insertion of five to six implants better distributes forces and enables the extension of the prosthesis in case of future complications.

Angled implants were not an issue. We saw no need for long implants of more than 13 mm or angulated ones to enlarge the support polygon distally or the bone-to-implant contact. Since we also do not favour immediate function, regular lengths of at least 8 mm, even with sinus procedures, allowed us to easily reach and impress distal implants, relinquish or reduce counter levers. Implants of 8 mm in length do not show significant differences in long-term stability compared with longer implants. At the same time, very long implants, when extracted, lead to major defects, and if loaded under function immediately, can fail, requiring a re-do of all the planning and a remake of the prostheses. Immediate loading requires at least a 40 Ncm insertion torque.

In such cases, co-axial implants are an interesting alternative, since abutments can be screwed on ortho-radially and aid prosthetic treatment. Yet, there are few manufacturers with such an implant–abutment connection, and the implants are of greater diameter. Our patients have lacked functionality and aesthetics for many years; waiting for another three months to receive the final prostheses has never been an issue. Modern implant surfaces such as the Type M implant seem to offer better and faster osseointegration (owing to the B+ surface; MIS Implants Technologies, which provides higher bone-to-implant contact), which allowed us to load them after eight weeks, compared with regular surfaces that are to be loaded after 12 to 16 weeks.

Implant design

Interesting findings were made on the radiographs after loading implants. Whereas implants with machined collars and no platform switching (Type B, Z and C implants) inserted in late defects tended to show a slight vertical bone loss after six to 12 months (establishment of a new biological width), bone level implants with platform switching (Type I and M implants) showed no similar findings, especially when inserted immediately or early.

A further difficulty encountered was the integration of older implants. These implants were often inserted to support removable prostheses carrying locator or telescopic crowns and were of small diameter or misplaced. All of these implants had to receive customised abutments.

Conclusion

The use of screw-retained full-arch prostheses is fully integrated in everyday practice. They offer fixed solutions that are fast and economical compared with bars or cemented prostheses. The premises for treatment success are mainly that the replacement of the missing teeth must support lower face soft tissue and the hard-tissue defect vertically should not be major. The patient then receives a highly aesthetic full-arch reconstruction, with high functionality and long-term stability of the hard- and soft-tissue, in four to five appointments and within three to four months without the risks that accompany early or immediate loading. Combined with CAD treatment planning and intraoral scanning, the comfort of the treatment is enormous.

Materials used in this case report:
MIS Implants
V3 and C1 Implant Systems
Conical connection, multi-unit abutments

contact

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Fig. 19: Example of a modern implant with platform switching and additional space for hard tissue.