**Advantages of 3-D planning for implants**

**Authors** Drs A. Grandoch & P. Ehrl, Germany

**Introduction**

Implantology is predominantly a surgical and prosthetic subject area. Its aim is both functional and aesthetic restoration. Today, one can place an implant in the jawbone with a high probability of success if there is good bone support. There are, however, concerns with regard to bone defects, optimum aesthetic and functional positioning of the implant and the soft-tissue situation, possible requiring partial reconstruction. The ideal number of implants for large superstructures is still a matter of debate.

Functionality, durability and aesthetics are aims that should, in general, be achieved as simply as possible using favourable and conditionally reversible techniques with minimal damage, even in problematic cases. Restoring teeth today has become easier to achieve but whether the cost–benefit ratio is satisfactory must be established for each case. There is still no consensus on these aims and perhaps success can be defined only individually. Expectations regarding implantological solutions have increased owing to significant technological advances. One may distinguish between general success criteria valid for all implants and criteria for special indications. While some scientific societies recommend replacing lost teeth with implants as the optimal treatment, and bearing in mind that the goal is restoration of natural conditions, one has to ascertain whether this is valid for single-tooth and multiple-tooth replacement for each case. Reasons for suboptimal solutions are manifold, ranging from poor initial conditions associated with a higher treatment risk to socio-economic limitations.

One cannot write about implant treatment in general, as too many parameters play a role, particularly because each case differs from another. Moreover, there are no general recommendations with regard to methodology. This is hardly surprising, since various methods are used, of which many have limited application and quickly become out of date. There is no widely agreed upon gold standard.

**Methods**

In 2000, CBCT was introduced to our clinic with hesitation initially and limited to more extensive problems and progressive diseases. It was used increasingly and has been used for almost all implant surgeries since 2008. Three-dimensional diagnostics undisputedly offer greater insight, thus increasing the quality of the treatment. Three-dimensional planning, however, always means considering the prosthetic planning and the anatomical substratum. This is done digitally or via conventional casts.

Even before the introduction of 3-D technologies, backward planning\(^2\) demonstrated that viewing the desired treatment result is helpful in achieving the result. Here too, we initially applied backward planning to cases requiring extensive treatment at first, until we learned that planning is useful for single-tooth replacement too. Each of these techniques—conventional casts and CBCT scans—can be helpful, contributing to a distinct improvement in the treatment results in the hands of the experienced implantologist. The next step would therefore be to connect these two techniques. After purely digitally controlled navigation was found to be inaccurate, surgical guide systems, based on planning software, became available.
43rd International Annual Congress of the DGZI

"Practice-Oriented Implantology"

October 4–5, 2013 / Berlin, Germany / Hotel Palace Berlin

Congress President / Prof. Dr. Dr. Frank Palm / DE
Scientific Director / Dr. Roland Hille / DE

FAX REPLY // +49 341 48474-390

Please send me further information on the 43rd International Annual Congress of the DGZI on October 4–5, 2013, in Berlin, Germany.
Currently, we are making the step from plaster cast and wax-up to digital model and digital reconstruction. This interesting new approach has to prove its worth in the practice first. Therefore, we have to determine which of the many digital features are essential in treatment of the patient.

**Main features of 3-D planning**

Only by the evaluation of 3-D data does a preoperative decision on how the desired prosthetic result can be obtained become possible. With the final result in view and mind, a solid basis for deciding upon the necessity and type of augmentation and whether removable fixed dentures are indicated in edentulous jaws is provided. There are often bone defects, whose extent must be evaluated. They are classified according to Fallschüssel and Atwood and the classification demonstrates that, as a rule, horizontal bone loss occurs first, while vertical bone is lost gradually.

Restoring horizontal bone is important for prosthetic restoration primarily for aesthetic reasons in the anterior area and primarily for functional reasons in the lateral areas concerning the position of the implant in the dental arch. These defects can be optimally corrected via surgical restoration of the original bone volume. For each case, measurements for positioning the implant (such as inclination—to be performed by the surgeon) and measurements for the prosthesis (to be done by the dental technician) must be taken. The latter, for example, buccal crown overhangs or mucosal facings, prevent hygienic design of the superstructure and quite often result in aesthetic deficiencies.

If restoration of vertical bone volume is necessary, for instance with Fallschüssel Class 4 frontal or 2 lateral or Atwood Class 4 defects, a more costly two-step technique has to be followed in most cases. At this point, it should be noted that almost all the atrophy patterns mentioned only involve the jaw and do not concern the functional components of the dental arches. Arutinov et al. postulate that this must be compensated for by angled implants. Kinsel et al. conclude that only the length of the implant is significant for implant loss. This means that as great a bone volume as possible must be used. All of the above-mentioned planning decisions can only be made soundly if information about both the 3-D anatomy and the desired prosthetic solution is available.

The guidelines of the European Association of Dental Implantologists offer a critical discussion of angled and short implants. Angled implants require a bone quality above 3. 3-D planning and guided implantation, among others. Planning based on an impression with fabrication of a planning cast is critical for the final outcome of implant placement and thus for the procedure. This will determine the required treatment steps and desired treatment outcome. Quite often, this step is not accorded the necessary importance in daily practice. Adequate planning should be done by the dentist and a special appointment with the patient should be made to obtain consent. With two-step procedures, repeating planning after augmentation and a second 3-D radiograph may become necessary.

**Digital 3-D planning**

Today’s prosthetic planning possibilities offer alternatives to conventional casts. Two digital prosthetic planning tools will be discussed here: SimPlant (Materialise Dental) and SICAT/CEREC (Sirona). Both these tools are alternatives to the conventional approach described above via digital planning. With both methods, the surface of the neighbouring teeth and soft tissue is scanned and matched to the radiological 3-D data. This can be done from a cast (SimPlant and SICAT) or an intra-oral scan (SICAT Optiguide procedure). Then, a digital cast is created with the prosthetic planning programme. The objectives of these methods are simplification and shortening of the workflow (Graphs I & II).
The precision of these methods is particularly noteworthy and figures for the overlap of the radiographic data and the optical scan obtained with the SICAT CAD/CAM method are available. The difference between CBCT data and the optical surface scan is between 0.03 (0.33) and 0.14 (0.18) mm. After scanning, crowns can be planned with the help of the CEREC crowns and bridges planning software. The precision of the digital SICAT method depends on the resolution of the respective data. For analogue impression techniques, for example, a precision between 0.1 and a maximum of 0.2 mm is required, as well as a gap of 0.027 to 0.101 mm between the crown and natural tooth.

The precision of the two methods therefore is similar. This holds true if all error sources are taken into account: CBCT scan, the transfer to the surgical guide, the repositioning of the guide, the play of the drill and deviation when placing the implant. The surface scan improves precision. The advantage of this procedure is that the production of a planning cast is unnecessary (Graph II). The OPTIGUIDE method makes an important step towards the digitisation of prosthetic and implant planning, resulting in greater planning reliability and precision. Unfortunately, there are restrictions concerning partially edentulous jaws and cases with extensive metal artefacts.

**Single-tooth replacement**

Expectations are high with single-tooth replacement. The target is to achieve a state equal to the conditions before tooth loss. Tooth replacement in the aesthetic region is particularly demanding. Anatomical prerequisites primarily determine the treatment method. For example, an implant may be placed into a particular alveolus immediately without 3-D planning. For delayed implantation, a cast and 3-D radiograph should be used. By planning the implant inclination and relation to the neighbouring teeth, the emergence profile and the positioning of the crown can be favourably planned. Guided implantation is particularly helpful in individual implants when several individual implants have to be placed or neighbouring teeth are endangered where there is only limited space. In addition, the patient’s wish to see the expected outcome can be met. However, visualising optimum results involves the danger of arousing expectations that cannot be guaranteed. Figures 1a to f show the two-step reconstruction of a horizontal defect with 3-D planning.

**Shortened row of teeth**

In reconstruction of a shortened row of teeth, the function and particularly the support of the tem-

Figs. 4a & b. Three-dimensional planning in an edentulous maxilla (a). Prosthetic loading with good initial conditions (b).
Figs. 5a–f. Two-step technique in a case of advanced atrophy of the alveolar process before and prior to fixed prostheses. Horizontal and vertical augmentation lintra-operatively, fixed bone block (left) and covered with membrane cover (right a). Healed post-augmentation (b). Post-implantation (c). Radiograph after placement of the bridge (d). Prosthetic result, lip reposition (e). Prosthetic result, lip raised (f). Despite augmentation, long crowns are still required.

poromandibular joint is important. The number of teeth necessary for prostheses has not been determined definitively. Within the last few years, reconstructing up to the first molar, and up to the second premolar in cases with an extension, has been usual. Generally, alveolar atrophy progresses most rapidly horizontally in the lateral jaw area, starting buccally, and frequently is later followed by atrophy of the vertical dimension.

If one avoids augmentation or performs only minor augmentation, longer prostheses are necessary for short implants, which are situated more linguually than the natural teeth. The use of short implants in the lateral jaw is subject to several restrictions, such as good bone quality, primarily connected crowns or caps, no extension bridges, no lateral excursion contacts and no para-functional habits. Angulation is limited to 20 degrees. Furthermore, angled implants are not recommended for a shortened row of teeth according to the guidelines of the European Association of Dental Implantologists. If alignment is carried out with respect to antagonists in the natural dentition, positioning the new implant-borne crowns will not lead to any functional losses, unless the antagonists were not functionally situated in the dental arches originally.

Space towards the cheeks must be regained, even if patients with a long case history sometimes complain about spontaneous cheek biting and bolus retention. One must choose carefully between the more pleasant approach of using short and angled implants with long crowns and the more difficult approach of bone augmentation. Three-dimensional planning provides indispensable information in cases like these. With reference to typical defect patterns, Figure 2 demonstrates that restoring bone volume for very different defects can be problematic. A typical reconstruction using a surgical guide for pilot drillings in a shortened row of teeth with good initial conditions is depicted in Figures 3a and b.

**Edentulous jaw**

Three-dimensional planning is of vital importance for determining the treatment approach for implantation in edentulous jaws. For instance, one has to decide upon whether and which augmentative measures are required and whether a removable or fixed prosthesis is suitable. With regard to the last point, it must also be decided whether extensive single-tooth replacement is possible, whether small or large bridges must be used, and whether a greater intermaxillary distance must be filled prosthetically by longer crowns or by a mucosa substitute.

The number of implants for fixed dental prostheses include the All-on-4 concept (Nobel Biocare), the consensus conference recommendations of six im-
plants in the mandible and eight in the maxilla, and
Tooth-by-tooth reconstruction up to the first molar.
The multitude of planning information and treatment
possibilities requires a great deal of planning, which is
always justified because of its significant conse-
quences. Planning based on digital casts is not appro-
priate in these cases, since the support of the cheeks
and lips by the prosthesis is important and this can
only be determined with the help of and for each pa-
tient. Here, the advantages of prosthetic planning are
particularly evident.

Edentulous jaws often require a special approach
(see Figs. 4a & b for an example). Extensive augmen-
tation is frequently necessary (Figs. 5a–f). The re-
quired length of the teeth, however, has to be clarified
with the patient before treatment and depends on the
amount of tooth displayed during lip repose (Fig. 5e).
Quite frequently, implants are placed inter-forami-
nally in the mandible, often because extensive aug-
mentation is still problematic in the lateral mandible.
Figures 6a and b show a patient with six implants and
an extension bridge.

Even in cases of seemingly simple implantation for
removable dentures in an edentulous jaw, 3-D plan-
ning and a planning cast are needed to verify func-
tional reconstruction and soft-tissue support. In ad-
dition, they can aid determination of the positions of
the implants in consultation with the dentist and plan-
ing for adequate space for the attach-
ment box.

Discussion

Three-dimensional planning for implants holds the
advantage of higher quality owing to (a) risk identifi-
cation; (b) planning reliability; (c) production of near-
natural structures; (d) targeted and fast work; (e) pa-
tient compliance; and (f) cost transparency. These ad-

dvantages are largely due to the greater amount and
quality of information gained. Three-dimensional di-
agnostic tools enable us to obtain reliable information
about the condition of the alveolar process and im-
portant anatomical structures. With the additional
planning cast, information about the restoration of
function and aesthetics is obtained. Combining both
information sources will result in optimal treatment
planning. In addition, an experienced surgeon can ad-
dress surprises if the patient is flexible. Intra-operative
decision-making may also need to be made if unexpected sit-
uations arise. Knowledge of 3-D data permits plan-
ing, which entails devising a well-considered pro-
dure and obtaining the necessary tools and substitute
material, for example suitable implants and bone sub-

dstitutes. Owing to the traceability of diagnosis and
treatment, as well as the resulting safety, patients will
regard the procedure particularly positively.

A disadvantage is the higher initial outlay, but this
is balanced by increasing use owing to targeted and
quieter workflow and thus less reworking. Implanta-
tion always requires a 3-D radiograph. These new
techniques have greater logistical requirements than
conventional dental procedures do and require exten-
sive involvement of the teams involved in order to
achieve treatment success.

It should be borne in mind that every surgery is ac-
companied by a certain risk in spite of the safety pre-
cautions taken. In addition, too much confidence in
methodologies may lead to carelessness. Errors may

even arise with 3D planning, which may lead nega-
tive consequences for treatment. Therefore, it is im-
portant to be familiar with each step and error source
and thus expert training is crucial. In addition, main-
taining a critical attitude throughout treatment is
necessary to avoid errors. The advantages of 3D plan-
ing are so significant that it has become indispensa-
ble.

Editorial note: A list of references is available from the
publisher.

Contact

Dr Dr Peter A. Ehrl
andepend
Berlin, Germany
peter.ehrl@andepend.com

implants