CT-based Planning for Extra-oral Implant Placement Using Customised Drill Guides

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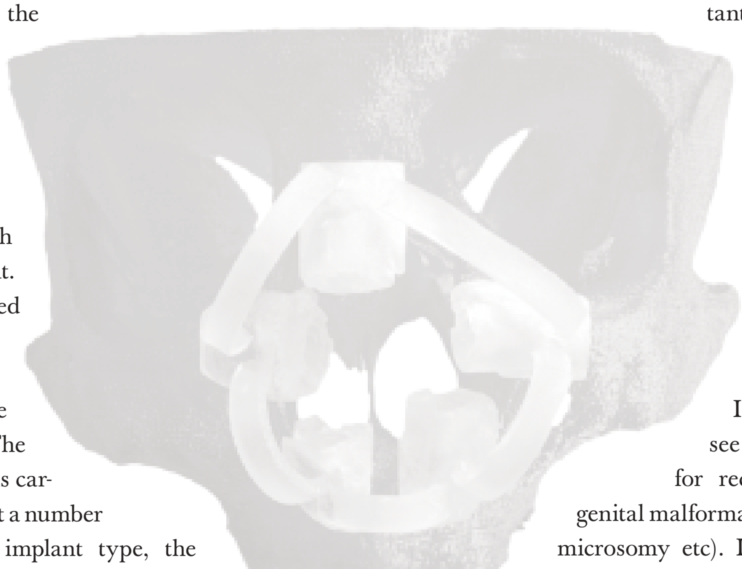
Introduction

At the Department of Oral and Maxillofacial Surgery in Genk we have developed a technique using stereolithographic drill guides for optimal implant placement. Work has been in progress on this project since 1998 and has been carried out in collaboration with a specialist company, Materialise. Stereolithographic models, made out of resin, are fabricated starting from a CT scan of the patient. The technique is used to provide both an anatomic model of the patient as well as the surgical drill guide itself.



The procedure starts with a CT scan of the patient. The CT data is transferred to a piece of planning software where a 3D reconstruction model of the patient is calculated. The planning for the implants is carried out taking into account a number of different parameters; implant type, the desired anatomic position of the implants, underlying anatomical structures and bone density all play a role in the success of the technique. Once planning is completed, the details are emailed back to Materialise where the plan is converted into a stereolithographic drill guide. The whole procedure including the essential software and fabrication of the drill guides is known as the 'SurgiCase System'.

We originally developed the procedure in 1998 for the placement of intra-oral implants. Since then we have expanded the technique to include drilling for zygomaticus implants. We felt that the combination of zygomaticus implants along with computerised planning and the drill guides was a particularly strong tool. By using zygoma implants we were able to avoid using maxillary sinus lifting procedures, thereby reducing the overall treatment time. By using the computerised planning method we were able to select optimal anatomical locations for the implants using CT imaging and taking into account parameters which otherwise are not necessarily accessible to the surgeon e.g. patient anatomy, teeth position, important neurovascular structures, bone densities (Hounsefield values) etc. The surgical drill guide is an individual solution providing the missing link between CT based planning and an effective reproducible transfer of that planning to the patient.

In our department we also see patients who are referred for reconstruction due to congenital malformations (microtia, hemifacial microsomy etc). In addition, we also treat cases where post-traumatic avulsions or oncologic resection have lead to a need for soft tissue reconstruction. In a number of these cases we propose rehabilitation based on an implant supported episthesis. For the last 10 years we have been using Brånemark (Entific) implants for such rehabilitation. Although we have a slow turnover of patients requiring such reconstruction, we have accumulated about 20 patients with implant retained facial prostheses since 1992.

The drill guide project has proved very successful within the context of our intra-oral caseload. We therefore decided to include the technique as a possible tool when considering some of our 'extra-oral' implant patients.

Case Report

A 75-year-old female patient presented with a nasal amputation for malignant melanoma. She had undergone numerous resections and reconstructions which had all failed due to recurrences. Finally a total nasal resection was performed followed by radiotherapy (see fig. 1).

Fig. 1: *Patient with nasal amputation for malignant melanoma*

The patient was tumour free for more than a year and she wanted a reconstruction for the defect. At the time we were already involved in the drill guide project and we decided to explore the possibilities of the surgical drill guide for placement of facial implants.

We followed exactly the same protocol as for the intra-oral implants; taking a CT scan, transferring the data to the PC and making a treatment plan using the SurgiCase technique. The SurgiCase System allows for all types of implants to be defined and stored within a database. The exact morphologic parameters for the extra-oral implants could thus be entered into the system. Once the 3-D models were calculated (see fig. 2), the actual planning could begin. In this case we wanted a nasal epithesis supported by 5 implants; as the SurgiCase System allows for any type or combination of implants we were able to combine the use of 3 extra-oral implants with 2 standard Brånemark implants in the floor of the nose. The implant planning is carried out by selecting regions with high density (Hounsefield value), and by avoiding anatomic structures (e.g. lacrimal sac, lacrimal canal, incisive canal etc). The completed planning (see fig. 3) is then converted into a surgical drill guide. The guide can be designed to have a skeletal support mechanism so that it can be positioned very accurately on top of the bone. (This, however, necessitates a skin incision and meticulous deperiostation). The drill guide itself consists of a resin base plate incorporating steel guiding cylinders which correspond exactly to the 3 dimensional orientation of the planned implants. The steel tubes provide firm stabilisation for the drill (see fig. 4).

After incision and deperiostation, the drill guide fits exactly on top of the bone (see fig. 5). The drill guide can be screwed onto the bone, providing a fixed and immobile drill guiding system. Drilling is then performed through the steel tubes, until the desired depth is achieved. According to surgical preference, one or two sets of drill guides can be manufactured, each set having drill tubes corresponding to the diameter of the drills being used (e.g. twist drills). In this case we only ordered one drill guide, its steel tubes having the same diameter as that of the largest drill. Drilling was carried out using 2 drills (2 and 3 mm diameter). (See fig. 6). The exact drilling depth should be determined in advance as the steel tubes have a length of 5 mm. It can therefore be useful to carry out the procedure in advance on a stereolithographic skull model of the patient so that the orientation and depth for drilling can be confirmed. After drilling is completed, the drill guide is removed and countersinking performed. Direction pins can be inserted into the drill sites to demonstrate final trajectory (see fig. 7). After completion of the implant site preparation, the implants can be inserted as usual (see fig. 8).

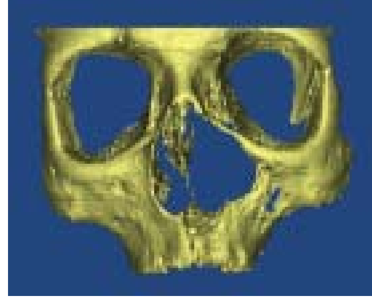


Fig. 2: *3D reconstruction model of the patient*

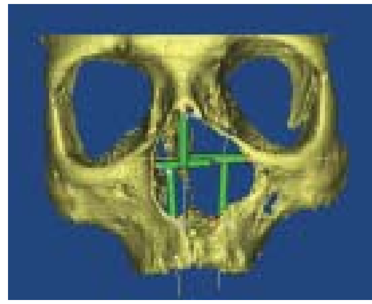


Fig. 3: *Implant treatment plan*

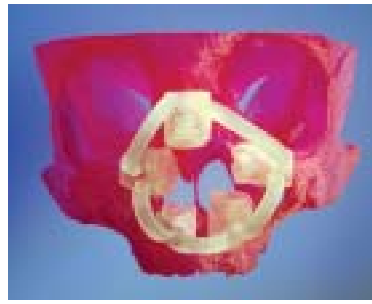


Fig. 4: *Stereolithography model with surgical drill guide in position*

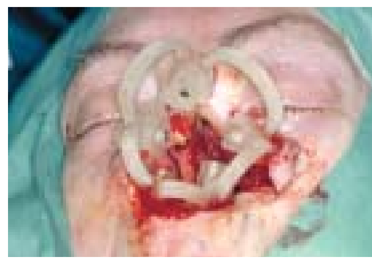


Fig. 5: *Drill guide secured to the bone*

Fig. 6: *Drilling for right infraorbital implant*

Fig. 7: *Direction pins inserted in the drilled trajectories*

Fig. 8: *Inserting an implant in the floor of the nose*

Fig. 9: *Postoperative view after second stage surgery with healing abutments in place*

Fig. 11: *Suprastucture in place on 5 implants*

After implant placement, wound closure and dressing was performed in the normal way. This patient recovered uneventfully and, despite the fact that the area had been irradiated, there were no problems with delayed healing. Our patient underwent second stage surgery 6 months later and after 2 more weeks the healing abutments were replaced with definitive abutments. My colleague, Dr. Dries Vandecapelle, then completed the suprastructure and epithesis (see figs. 9–13).

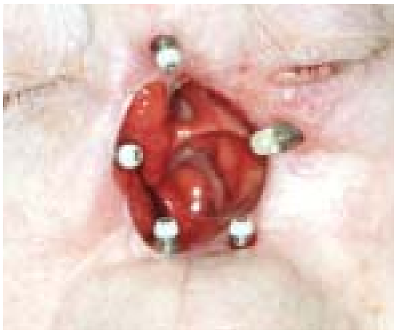


Fig. 10: *Definitive abutments in place*

Fig. 12: *Inner surface of finished epithesis*

Conclusion

In our view this approach using a CT based implant system and derived surgical drill guides has a number of advantages. It allows the surgeon to view the precise underlying anatomic structures and to plan the implant placement taking these into account. By using the CT derived densities (Hounsefield values) the surgeon can orientate the implants towards the more dense bone. The missing link between computer based planning and the act of drilling for implant placement is filled by the use of the surgical drill guide, which allows a controlled physical transfer of the planning to the patient. The described treatment protocol can be used in virtually any situation where implants are to be placed for supporting nasal, orbital or auricular epitheses.

Fig. 13: *Definitive epithesis in place*