TECHNOLOGY ARTICLE

Computer Guided Implant Surgery: A Clinical Report

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Abstract

The conventional practice of implant site preparation and implant placement is carried out freehand after treatment planning based on interpretation from a two-dimensional IOPA (Intraoral periapical radiograph) or OPG (Orthopantamograph) and by a wise clinical judgment. Much is left to guessing till the actual surgical appointment where we may be greeted by uncertainties related to soft tissue thickness, bone volume, bone density, proximity to anatomic structures, etc.

Computer guided implant surgery is a CAD-CAM (Computer aided designing – Computer aided milling) solution to avoid such surprises. Here a virtual surgery based on a CT (computerized tomographic) scan and a surgical template made in accordance to it guides the depth, diameter and orientation of the implant. The surgery may be done flapless and requires minimum time. This article illustrates the use of an alternative for highly demanding surgical cases with the use of computer-guided implant placement on a 48 years old female patient, who was referred for placing implants in both maxilla and mandible. This technique optimizes implant placement and soft tissue esthetics while providing the patient with a fixed restoration. Computer-guided technology enhances accuracy and precision of the surgical procedure, minimizes complications and facilitates surgery in challenging anatomical locations.

Keywords: Computer guided implant surgery, guided surgery, simplant, nobel guide.

INTRODUCTION

The goal of implant dentistry is to return to patients the proper oral form, esthetics and function. In the pursuit of these objectives numerous techniques and technologies have been developed to help provide predictable results.[9] Implant placement is done based on available residual bone, which often leads to a buccal or lingual positioning, ending with difficult and impossible esthetic problems to solve.[4,10] Likewise, implants that are not working in their long axes were exposed to detrimental lateral forces, resulting in various biomechanical problems and breakages.[8,11,15]

Since implant placement is a technique sensitive process it is performed in conjunction with various diagnostic and guidance procedures. In the area of diagnosis, radiographic templates, (CT) scans and surgical simulation templates are unparalleled.[7,9]

Preoperative radiographic imaging of recipient sites for implant placement is imperative to obtain a functional and esthetic implant-supported prosthesis. Computerized tomography, a precise and noninvasive surveying technique provides cross-sectional radiographic images that facilitate proper assessment of potential recipient sites for implant placement.

CT scanning, when coupled with scannographic templates worn at the scanning visit also improve presurgical evaluation. In addition to visualization and other diagnostic tools such as the evaluation of bone density, these software programs allow for placement of virtual implants to further assist the surgeon in foreseeing positioning and size of implants prior to surgery.[2] Nevertheless, transfer of a sophisticated plan to the surgical field remains difficult.

To overcome this issue, one of the several novel approaches that have been developed in the computer-aided manufacturing (CAM) technique to generate osseous-supported surgical guides as well as anatomical models.[2] CAD/CAM systems used for decades in restorative dentistry have expanded its application to implant dentistry. As the earlier diagnostic techniques failed to address the requirements of the concept of prosthetically driven implantology, new scanning appliance designs were introduced.

Figs 1A and B: Residual alveolar ridge before implant surgery

The goal of this paper is to highlight a clinical situation in which implant treatment planning and placement was carried out with computer guided surgical technique. The superiority of this technique over the usual osteotomy technique is also described here.

CASE REPORT

The patient presented in this paper is a 48 years old female, who was referred for placing implants in both maxilla and mandible. Radiological and oral examination has showed that a conventional surgical approach was possible. She has had no history of allergies, no diabetes and had well-healed residual alveolar ridge with well-keratinized alveolar mucosa (Figs 1A and B).

The patient wanted a minimal invasive surgery with little postoperative discomfort. Bearing this in mind, it was decided to use the CAD/DCAM technique and a hapless surgical approach for placing implants. To perform this, it was decided to follow the protocols of the Nobel Guide set by the Nobel Biocare Company. The steps undertaken are as summarized below.

A radiographic template of her maxilla and mandible was made with gutta-percha filled into spaces created by a round burr into her existing dentures (Figs 2A and B). A dual scan was done making 0.5 mm slices in a DICOM format. The information was read in a virtual implant planner and the surgical sites, the diameter, length , angulation of implants, the location and depth of anchor pins were determined relative to the anatomical landmarks and the information sent to the rapid prototyping center in Sweden (as Nobel Biocare Implants were used in this case).

Figs 2A and B: Radiographic stent

The maxillary surgical stent (Fig. 3) with sleeves for implant placement was secured first on the edentulous maxilla with the horizontal anchor pins (Fig. 4). Implant osteotomy (Fig. 5) was carried out with a series of specialized drills and implants placed and cover screws secured effortlessly (Fig. 6). Six Narrow Platform (NP) implants and two regular platform (RP) implants from the Nobel Biocare implant company were placed in the maxilla.

Fig. 3: The maxillary surgical stent

Fig. 4: The maxillary surgical stent secured with anchor pins

Fig. 5: Intraoperatively (maxilla)

The same procedure was carried out in the mandible (Figs 7 to 10), and an OPG revealing the precise placement of the implants at the virtually planned sites was made
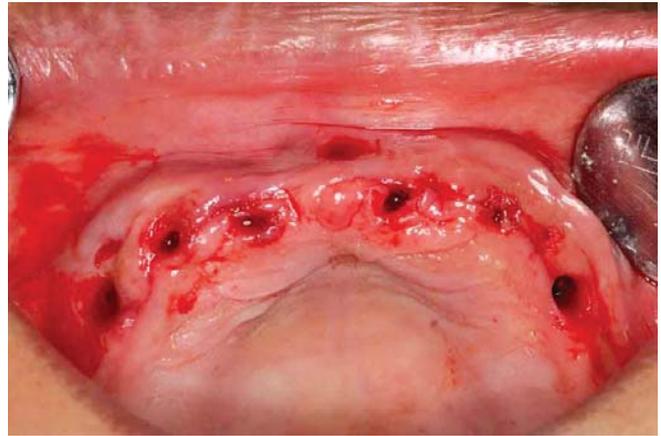

Fig. 6: Postsurgical (maxilla)

(Fig. 11). Two RP and two NP implants were placed in the mandible.

The surgical time was very minimum with no incision, no sutures, minimal bleeding and a faster uneventful healing achieved (Figs 12A and B).

CT ACQUISITION PROTOCOL

The first step here is to make a stent containing the tooth/ teeth to be replaced. It is converted into a radiographic guide that is readable by the scanner by incorporating gutta-percha markers into the stent. In an edentulous patient, the patient's complete denture or a duplicate of it may be marked with gutta-percha to be used as a radiographic guide.

The scan is called a dual scan. An initial CT scan with the radiographic guide placed intraorally and another scan of the radiographic guide alone is made. From these CT

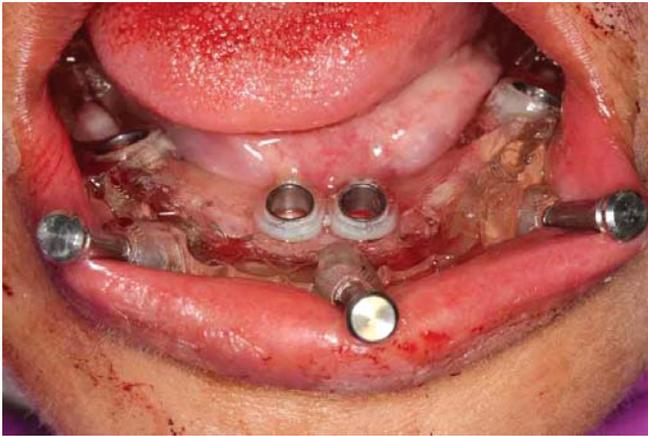**Fig. 7:** The mandibular surgical stent

Fig. 8: The mandibular surgical stent secured with anchor pins

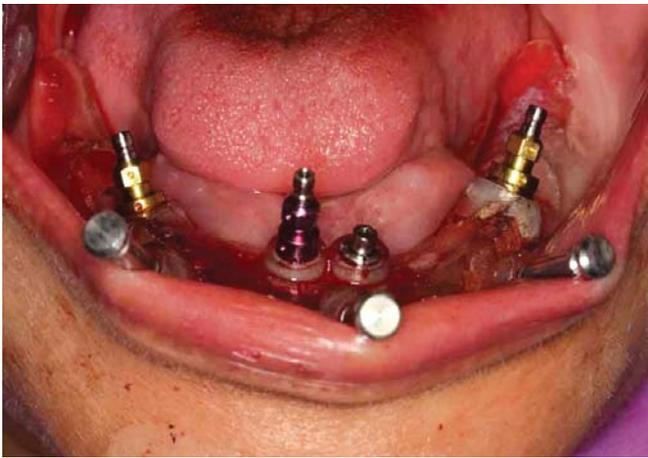**Fig. 10:** Postsurgical (mandible)

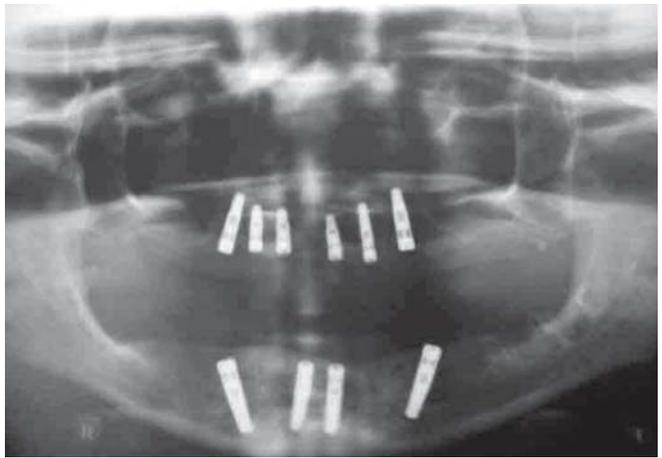**Fig. 9:** Intraoperatively (mandible)

Fig. 11: Postsurgical OPG

Figs 12A and B: Well-healed ridges

scans, the radiologist provides the dentist with a computer disk of DICOM (Digital imaging and communication in medicine) images, which are loaded into the 3D (Three dimensional) planning software program. The program joins the radiographic guide with the patient's bony anatomy using the gutta-percha markers that were incorporated into the radiographic guide. This allows the practitioner to precisely visualize 3D images of the patient's bone and adjacent teeth, the planned tooth or teeth to be replaced, the important anatomical structures and the proximity to them, the bone density, width and height of available bone. The double scanning technique (of the radiographic guide and the patient) allows each element to be viewed together or separately. The machine used for this case was a SIEMENS 64 slice spiral CT, where in 0.5 mm slices in DICOM format according to Nobel Biocare protocol.

The 3D planning software made by Nobel Biocare is called Nobel Guide (Procera Software) and that by Materialise dental is called the Simplant. This software contains a library of implants and abutments from which the dentist may select the best one for the particular site. The dentist, using this software precisely plans the implant placement relative to the bone, soft tissue, and tooth/teeth to be replaced. The diameter, position and angulations of the implants are selected. A virtual surgery is carried out and the type of the prosthesis is planned. The need for bone grafting and the graft volume may be determined. Safety zone indicators and warning messages in the system ensure 100% safety avoiding collisions between implants, between implant and the nerve and between restorative spaces.

The planning information is e-mailed to the rapid prototyping center in Sweden (for Nobel Biocare) or in Belgium (for Sim Plant). Here the information is converted into a STL (Stereolithographic) file and a stereolithographic surgical template incorporating precision titanium drilling sleeves is fabricated. The sleeves incorporate all of the planning for implant trajectory and vertical position and will guide the osteotomy drills precisely in the previously planned path.

In the implant placement appointment, the surgical template is secured to place with surgical index and anchor pins. Then using a series of specially designed burs and drilling guides which precisely fit into the sleeves of the surgical template, the implant site is prepared flapless through the soft tissue and the implant (or implants) is placed exactly in the position as planned in the 3D software.

From this surgical template, the laboratory is able to fabricate an accurate stone model incorporating soft tissue anatomy and implant position using implant replicas. This model may be used to fabricate a temporary or definitive prosthesis for immediate placement at the implant insertion appointment.

The restoration may be placed immediately or at a later date according to the planning.

DISCUSSION

Every computer-aided surgery (CAS) system for dental implant planning contains its characteristic advantages, disadvantages and error sources. The main objective of these systems is the attainment of maximal surgical safety on the basis of an exact diagnosis, virtual planning and high accuracy for the surgical transfer.

Computer guided implant surgery minimizes the risk of iatrogenic injury to vital anatomical structures in the maxilla and mandible[14] by direct virtual three-dimensional visualization of the anatomic landmarks through the system, thus avoiding uncertainties during the actual surgery.

This precision imaging helps not only in determining the best probable implant sites but also permit the assessment of need for bone augmentation that can optimize predictability ratios.[13] The entire process of assessment, treatment planning, selection of implant system and final restoration is achieved "virtually" even before treatment has begun and in the absence of the patient. Patients benefit from being able to visualize fully the current state of need and final outcome possibilities based on their choice of restoration components.[13] Moreover a minimally invasive surgery can be performed without a flap with minimum trauma with no fear of losing drill orientation and an immediate delivery of the functional prosthesis can be delivered[6] along with the reduction of overall treatment time, less bleeding and faster healing.[16] The laboratory time is also decreased.[6]

Some of the demerits would be the fact that some computer guided implant surgery is system specific. Since the drills in guided surgery are 10 mm longer than standard drills, adequate mouth opening is mandatory to accommodate the additional length.[3,6] Moreover, it requires expensive, sophisticated digital/optical scanners and computer software programs to capture and manipulate the vast amount of data required.[3,5] It also requires knowledge and skills in imaging, three-dimensional planning and use of surgical navigation systems.

The meta-analysis of clinical studies regarding accuracy of computer guided implant surgery revealed mean horizontal deviations of 1.1-1.6 mm. The guided implantology system provides highly accurate implant positioning with less than 0.73 mm error and allows the surgeon to precisely transfer the presurgical plan to the patient.[1] P Weismann and U Meger[17] has stated that the image guided insertion of dental implants is significantly more accurate than manual free-hand insertion. It is seen that the survival rate of implants placed with computer-guided technology is comparable to conventionally placed implants ranging from 91 to 100% after an observation time of 12-60 months.[12] Early surgical complications were observed in 9.1%, early prosthetic complications in 18.8% and late prosthetic complications in 12% of the patients.[12] However, limited data and relatively short observation periods are available in literature.

Newer technologies in the field of implant placement has emerged. Robotic drilling for implant surgery through specially designed mechanical drilling template has been commercialized as MED 3D (Media lab software company, Germany), CAD implant (France), DDent (Allovision Eurogroup, Germany). More recently, a novel approach with a different concept called 'tactile imaging and registration' has come up.[18] Other systems, including magnetic tracking systems and robot with a mechanical arm have also been tried but never commercialized. Further research should involve clinical studies with long-term follow-up and strive for an improvement of the systems and procedures regarding accuracy, predictability and reproducibility of implant placement as well as surgical and prosthetic outcomes.

CONCLUSION

Computer guided implant surgery represents a giant step ahead in the replacement of teeth with dental implants. 3D imaging and scanning techniques facilitates precise decision making in implant prosthodontic treatment thereby eliminating the guesswork involved in deciding which area of the jawbone offer the best sites for dental implant placement. This improves the predictability of treatment goal, allows for an enhanced risk management, and provides added information for the patient. Nevertheless; it provides greater patient satisfaction and simplifies the overall dental implant treatment process. The technique illustrated in this paper has the potential to be more predictable and safer than conventional surgery, especially in difficult anatomical regions. The superior quality of computer guided implant surgery to eliminate the possible manual placement errors and to emphasize reproducible treatment success rather than its cost is considered here.

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