LETTER TO EDITOR

CT-derived planning and surgery for implant dentistry

In the recent years, a number of treatment options have been involved in dentistry as well as medicine, which require detailed pre-treatment evaluation and planning. One of the modalities most affected by this new concept is dental implant treatment in which a metal object is directly inserted into the bone in regard to teeth replacement. Although this modality has many advantages for both the patient and the dentist, many of the implants inserted with conventional treatment procedures were positioned in poor locations, creating severe problems for the restorative dentist to properly proceed. In fact, the inherent problem of drilling tends surgeons to place implants where the greatest amount of bone is present, with less regard to placement of the definitive restoration, which can result in eventual injury or possible damaging of sensitive anatomical structures such as the arteries and nerves. It was clearly demonstrated that to be more successful, implantology requires both permanent integration of the titanium fixture into the bone, and a good aesthetic restoration of the teeth and gums as well. In order to circumvent these, it was proposed that pre-surgical planning must be based on very accurate imaging techniques. During the past two decades, Computed Tomography (CT) was increasingly employed to plan the surgical phase of treatment in implant dentistry. This is mainly due to its accuracy, precision and freedom from geometrical

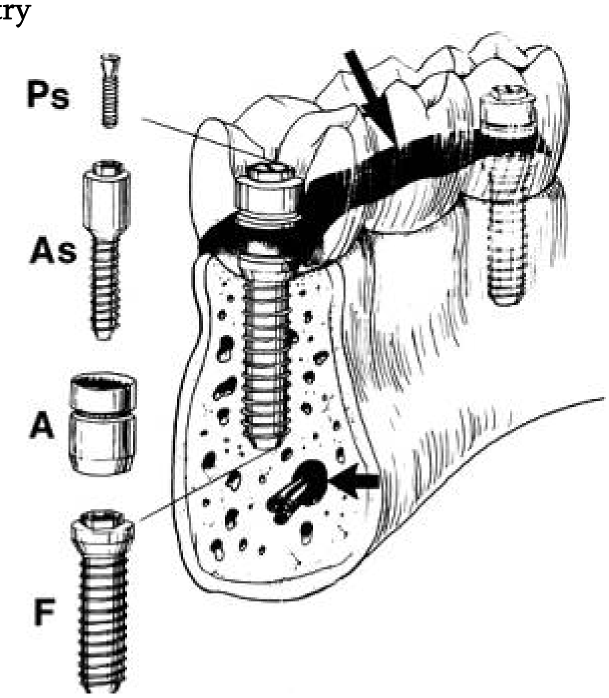
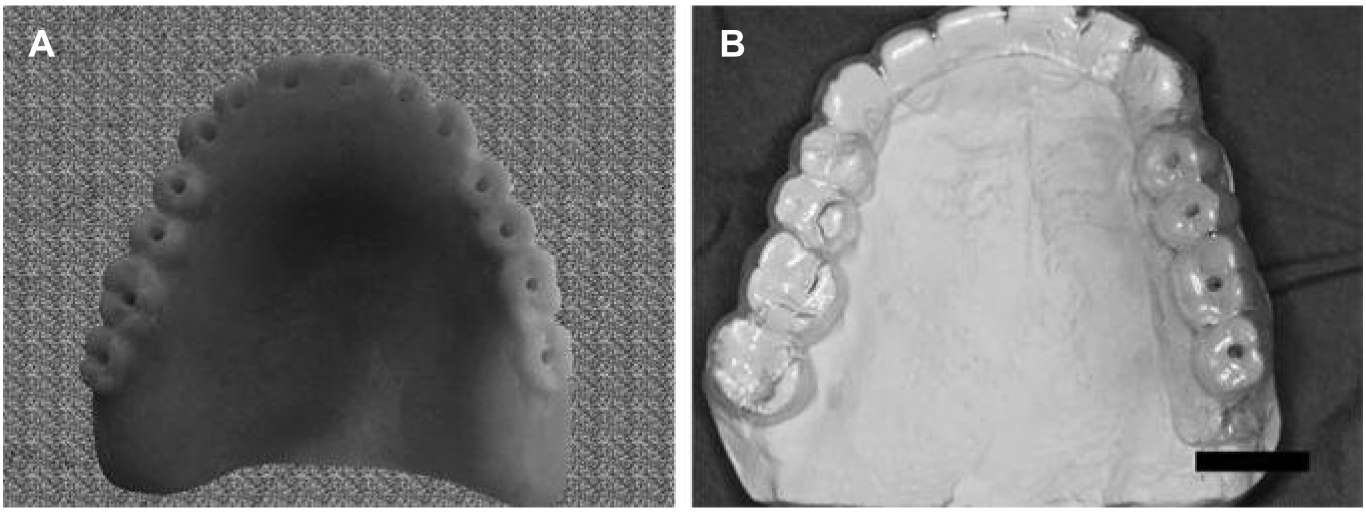


Fig. 1. Illustration of the components of a screw retained prosthesis (Ps), abutment screw (As), abutment (A), and fixture (implant) (F)—and two dental implants supporting three-tooth prosthesis. Black portion (long arrow) represents the metal framework within the prosthesis. Note how the location of the neurovascular bundle in the mandibular canal (short arrow) must be established to prevent injury during implant placement.



Figs. 2A & B. The two commonly used "scannographic-radiopaque guides". The guide on the right is used for partially edentulous cases and the one on the left is useful in completely edentulous cases. These guides are usually prepared by mixing pre-weighted amounts of barium sulphate powder materials and polyacrylate resins.

Fig. 3. The cranial implant (bottom right) is actually a replica made on a nylon model after a post operative CT scan was done. The original was made from PMMA resin, and in two pieces, one for the cranial defect, and the other connecting for the orbit and zygomatic arch replacement. The top illustrations indicate the situation of the patient before surgery. The illustrations on the bottom show the patient's model surgery and condition after surgical intervention and placement of implant. (From Materialise, Belgium)

distortion. The latest generation of CT scanners can image the complete mandible or maxilla at modest radiation doses and with high spatial resolution in both the trans-axial and the paraxial directions. It is now well documented that successful implant treatment is totally dependent on intimate co-operation of the implant team; including the radiologist, the implant surgeon, the restorative dentist and the dental laboratory technician in the detailed pre-operative planning.[4,5] This intimate co-operation necessitates precise transfer of the plan to the operative site, customized radiographic template, degree of visibility of this template in the images and distortion-free image acquisition as a routine part of treatment.[4,6-9]

From simple 2D to more accurate 3D

Despite the many advantages gained by advanced imaging techniques, one more problem exists, which requires attention; the potential for linking the visualization on the film is limited if there are no indicators for the ultimate position of the tooth or the final restorative goal. Moreover, the images obtained from CT are really 2D printing, requiring a process of mental integration of multiple sections by the observer to derive 3D information. This problem is discussed in detail in the literature.[1] These 2D views are easier to show on the computer, but they are basically a digitized version of printed images. So, it is less predictable for the 3D implant size needed and poor for anatomical complications.[2] To overcome these shortcomings, we need systems that allow simultaneous visualization of 2D reformatted images as well as 3D derived bone surface representations. In this way, we have the opportunity for interactive placement of the implant like CAD models on the images obtained from CT data. Since the 1990s, many medical research teams have approached the problem of implant planning with the assistance of interactive computer applications.[3]

By commercializing the software program (i.e. SIM/PLANT ™,Columbia, Maryland, USA) initially in 1993, the clinicians have had the ability to view and interact with the CT scan data to pre-surgically place the 3D implant body and visualize the prosthodontic implications at the same time. In this way and for the first time, it was possible to reformat the CT scans in such a way to provide an accurate 3D view of

Fig. 4. The CAD/CAM model of maxilla with the surgical guide positioned on it for dental implant site osteotomy. These models are prepared by the processing of CT scan images using interactive CT software through a process called stereolithography.

the implants in relation to anatomy of the bone. Although this utility gives many opportunities to the clinician, transferring the computer plan into actual patient treatment seems to have a missing link which quickly found revolutionary; CAD/CAM technique.

One of the most promising developments in the field of implant treatment is the possibility to use CT images for CAD modeling. Several novel approaches, which completely overcome the problem of transferring prosthetic plans to surgical environments, have been recently developed. One of them utilizes a computer-aided manufacturing (CAM) technique to generate osseous, mucosa or tooth-supported surgical guides as well as anatomic models (SurgiGuide; Materialise Dental, Leuven, Belgium). In this technique, transmission of the DICOMs (Digital Imaging and COmmunication in Medicine) files and the clinician's implant planning are utilized to design the surgical guides by the aid of a computer software program such as Simplant (Materialise, Leuven, Belgium). A special 3D transparent resin model called SurgiGuide ™ that can fit intimately with the hard and/or soft tissue surface is then processed. A computer-guided laser beam passes through a photosensitive bath of special liquid polymer, which causes layer-by-layer polymerization (stereolithography). Once hardened, the polymeric prototype contains spaces for stainless steel or titanium drill-guiding tubes. The metal cylinders are then glued into the spaces, and the guides are ready for clinical use.[10] It was shown that these bur guiding cylinders allow intra-operative real-time tracking of the drill according to the planned trajectory (Fig.4).[11-13]

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