Virtual Implant Planning Using Magnetic Resonance Imaging



FLÜGGE, T¹; LUDWIG, U²; HÖVENER, JB²; KOHAL, R⁴; WISMEIJER, D³; NELSON, K¹.

¹ University Medical Center Freiburg, Department of Oral and Maxillofacial Surgery, Freiburg, Germany ² University Medical Center Freiburg, Department of Radiology, Medical Physics, Freiburg, Germany ³ Academisch Centrum Tandheelkunde Amsterdam, Department of Implantology and Prosthodontics, Amsterdam, Netherlands

⁴ University Medical Center Freiburg, Department of Prosthetic Dentistry, Freiburg, Germany

Aims

The workflow of virtual implant planning and guided implant surgery hitherto requires the use of (Cone Beam-) Computed Tomography (CT/CBCT) and virtual dental models acquired with either intraoral optical impression or extraoral model scanning.

Results

MR images displayed relevant anatomical structures for dental implant planning such as cortical and spongious bone, inferior alveolar nerve and neighboring teeth. Unlike with conventional radiography, mineralized structures such as cortical bone

Three-dimensional radiographic imaging exposes the patient to a considerable amount of ionizing radiation (1, 2). Its use, and yet the use of image-guided surgery, is therefore limited to carefully selected indications (3). Additionally, insufficient image quality of conventional radiography (CT/CBCT) due to dental restorations may preclude accurate virtual implant planning and transfer to the surgical site with CAD/CAM drilling guides (4, 5).

Magnetic Resonance Imaging (MRI) was used for virtual implant planning and the complete workflow of image guided surgery was performed without the use of (CB-)CT.

Materials and Methods

A patient scheduled for implant placement in the right mandible was scanned in a standard MRI setting (PRISMA 3T, Siemens, Germany) using a head coil and an individualized MR imaging sequence (6). CBCT imaging was performed to serve as a control (Figure 1).

MR images and virtual dental models, capturing both the initial situation and the prosthetic setup, respectively, were imported in a virtual implant planning software (coDiagnostiX, Dentalwings, Canada). The virtual dental models were aligned with a three-dimensional reconstruction of MR images, similar to the workflow when performed with conventional radiographic data. Two implants were virtually placed in the mandible (region 46 and 47) with regard to hard- and soft tissue anatomy and prosthetic planning (Figure 2). A drilling guide was designed on the virtual dental model (CAD) and manufactured with a three-dimensional printing device (CAM). Guided implant surgery and implant placement was performed using the drilling guide.

and teeth were displayed in dark contrast and soft tissues were displayed with light contrast. The grey scales were adjusted to the MR images, however a compromised image quality was observed using the implant planning software (Figure 2) compared to a clinical image processing software (Osirix, Pixmeo, Switzerland) (Figure 1).



Figure 2: Virtual planning of two implants in region 46 and 47 is performed in multiplanar MR cross-sections. The prosthetic set-up (red outline) and the hard and soft tissue anatomy is displayed. Camlog implants (Camlog Guide, Screw line) with diameter 4.3 mm and lengths 11 mm are selected.





Figure 3: The complete workflow of virtual implant planning is displayed. The three-dimensional model reproduced form MR images is aligned with the initial intraoral situation (a); and the prosthetic set-up (b). The implant are selected and positioned with respect to anatomy including the intrabony course of the inferior alveolar nerve (c and d). The virtual model of the initial intraoral situation with implants (e) is used for the design of a driving guide (f).

Conclusions

Magnetic Resonance Imaging allows for virtual implant planning and guided

Figure 1: (B) Axial (left), sagittal (middle) and transverse (right) cross-sections of magnetic resonance imaging of the lower jaw acquired in vivo with a head coil and Turbo Spin Echo sequences at 3T with the following parameters: 600 µm³ resolution, 320x320mm field of view, acquisition time 4:57 min. (A) Axial (left), sagittal (middle) and transverse (right) crosssections of in vivo cone beam computed tomography of the lower jaw (3D Accuitomo 170, Morita, Japan, nominal resolution 250 µm, 90 kV, 201 images).

implant without non-ionizing imaging modalities. As an alternative imaging method to conventional CBCT imaging, MRI might broaden the use of virtual implant planning to patients and indications that are not yet within reach of diagnostic imaging. The visibility of different hard and soft tissues qualities may improve the workflow of virtual implant planning and guided implant surgery. However, further in vitro and in vivo studies are needed to evaluate accuracy and practicability of MRI for dental implantology.

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Corresponding Address: Dr. Tabea Flügge, Freiburg, tabea.fluegge@uniklinik-freiburg.de