Virtual Implant Planning Using Magnetic Resonance Imaging

FLÜGGE, T1; LUDWIG, U2; HÖVENER, JB3; KOHAL, R4; WISMEUER, D5; 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. 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.

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 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).

Conclusions

Magnetic Resonance Imaging allows for virtual implant planning and guided 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.