A new imaging modality for intraoperative evaluation of sinus floor augmentation


Abstract. The aim of this report was to demonstrate the practicability of a new imaging modality, which allows three-dimensional intraoperative imaging and verification of bone-graft position, and to compare it to the currently available imaging systems. The ARCADIS Orbic 3D, a C-arm-based cone-beam computed tomography scanner developed for intraoperative imaging, was used to examine a previously augmented sinus floor, in order to verify the height and width of the augmentation and to determine whether any of the autogenous and synthetic bone-substitute mixture had penetrated the sinus membrane. Visualization of the entire sinus was possible with the aid of multiplanar reconstructions. Data acquisition and processing took 5 min.

Generalized atrophy of the alveolar crest is compounded by pneumatization of the maxillary sinus, often rendering only a few millimetres of bone available for implant insertion. Augmentation procedures have been developed. Sinus floor elevation plays an increasingly important role in oral surgery. Early reports by Tatum and Boyne & James described the lateral window technique. The terminology is misleading, as the procedure does not involve the maxillary sinus per se, which is left unscathed. The aim is to reverse the pneumatization and increase the quantity of bone which is below the sinus membrane.

Accidental sinus membrane penetration is undesirable, as it may lead to the development of acute or chronic sinusitis with subsequent graft resorption. A defect can either be seen clinically or by means of intraoperative endoscopy. The introduction of C-arm-based cone-beam computed tomography (CBCT) scanners opened new avenues in intraoperative three-dimensional imaging, and this imaging method is finding increasing acceptance in dental and maxillofacial surgery. Here, the ARCADIS Orbic 3D (Siemens Medical Solutions, Erlangen, Germany), a 2nd generation mobile C-arm-based CBCT scanner, was used during a sinus floor augmentation procedure.

Materials and methods

In a 55-year-old female patient suffering from atrophy of the lateral maxilla, intraoperative images were acquired and processed using the ARCADIS Orbic 3D. Preoperatively, a panoramic and lateral cephalometric radiograph was made. A two-step approach was planned, i.e. delayed insertion of dental implants following augmentation. Under general anaesthesia, a corticocancellous bone graft was harvested from the iliac crest.

Vertical ridge and sinus floor elevation were performed bilaterally. Preparation of the sinus floor and reflection cranially allowing inspection of the sinus floor, adaptation of a block graft and fixation with screws that projected into the subantral cavity. Obliteration of this subantral cavity was carried out with a mixture of cancellous bone and β-tri-calciumphosphate (Bioresorb, Oraltronics, Germany), in a ratio of 80:20. The mid-face was imaged using the ARCADIS
Orbic 3D prior to wound closure and under sterile conditions. An operation room table (BETASTAR; Maquet, Rastatt, Germany) composed of a carbon plate and head holder was used. The ARCADIS Orbic 3D was used in ‘slow mode’, performing 100 single projections in 60 s while rotating around the patient, to provide the primary fluoroscopic image on which the 3D data set was based (Fig. 1). The operative results were immediately verified using secondary reconstructions generated with the help of the SYNGO software (Siemens Medical Solutions). Following imaging (Fig. 2a and b), the lateral windows were covered with a collagen membrane (Bio-Gide 25 mm × 25 mm; Geistlich, Wolhusen, Switzerland) and the mucosa sutured with non-adsorbable 4/0 sutures (Mersilene 4/0, Ethicon, Germany). On the 3rd postoperative day, the panoramic radiograph was used (Fig. 3) to allow comparison of the images.

Results

Intraoperative imaging was possible, with the data acquisition lasting 5 min. The images confirmed that no large perforations of the sinus membrane were present which would have led to bone particles being mistakenly introduced into the maxillary sinus. The intraoperative visualization of the augmentation together with measuring tools demonstrated a sufficient volume for later insertion of endosseous implants exceeding 15 mm in length.
Discussion

Intraoperative implementation of the ARCADIS Orbic 3D provides images which allow visualization of the entire maxilla, maxillary sinus and orbit. The delivered software immediately converts the data into images, which are displayed on the monitor in sagittal, axial or frontal slice images, or if desired creates a three-dimensional reconstruction of the data. Positioning the C-arm, data acquisition and processing to the point of providing the surgeon with feasible images encompassed a time period of 5 min. The intraoperative visualization of the volume of the augmentation, together with the height of the onlay bone graft, demonstrated a surgical result sufficient for the later implantation of endosseous implants as planned.

For the first time, intraoperative 3D imaging of a sinus floor augmentation is possible with the use of a C-arm that produces images of CT-like quality with a fraction of the radiation dose\(^5,9\). Being devised for intraoperative imaging, the C-arm allows expedient imaging of the region of interest. It can easily be moved by a single person and does not require the presence of radiological staff, which is mandatory for CT or magnetic resonance imaging scanners.

Although CT imaging plays a major role in diagnosing pathologiacal processes of the paranasal sinuses\(^8\), a CT scan involves a large degree of radiation exposure and the apparatus is huge and typically immobile. This imaging modality also necessitates substantial financial investment limiting routine use to hospitals and large radiological offices. CT as well as magnetic resonance images have proved suitable for preoperative planning and postoperative verification, but to date play only a minor role in intraoperative imaging, limited to special indications\(^4,11\). Numerous authors have compared the two imaging modalities and investigated their usefulness for portraying the maxillary sinus prior to sinus floor elevation and implantation\(^7\).

Initial experience with the presented novel intraoperative imaging modality indicates that it will find great acceptance and increasing application in intricate oral and maxillofacial operations, in which intraoperative verification of the surgical result is vital. This is further supported by the increasing propagation of fixed CBCT scanners in dentistry, with numerous systems being currently available and widely accepted. Although the radiation exposure associated with a CBCT scanner exceeds that of cephalograms (radiation dose of 4 cephalograms is equivalent to 1 CBCT image with the system used here)\(^9\), this application seems justified in the light of the increasing implementation of preoperative CT scans for implant planning. One disadvantage is the fact that the field of view cannot be altered in this system, resulting in imaging of areas that are not of primary interest.

References


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