Diagnostic imaging in clinical practice

Prosthetically driven implant placement planning requires images on which you can rely

Author: Dr Bart Vandenberghe, Belgium

A sequence of scientific papers has demonstrated the crucial role of cone beam computed tomography (CBCT) in the field of implant dentistry. In 2012, the American Academy of Oral and Maxillofacial Radiology recommended the application of this imaging technology as the preferred method of pre-surgical assessment of intraoral implant sites.

The ability of CBCT imaging to visualize the smallest bony details means that CBCT is superior to CT for evaluating the morphology of the residual alveolar ridge and bone quantity in most cases, while emitting very low doses of radiation. The data can then be used in dedicated CAD/CAM software. Finally, the relatively low cost of CBCT systems makes them economically viable—even more so than conventional CT—for use in everyday clinical practice.

CBCT imaging as preferred method

Until recently, radiographic modalities for diagnosis during implant treatment planning relied upon two-dimensional projections of three-dimensional anatomical structures. With the advent of computed tomography, cross-sectional imaging had evolved from simple, locally produced tomographic sections to more accurate, faster and more versatile 3-D reconstructions computed for maxillofacial diagnostic tasks. However, this came at the cost of relatively high exposure doses.

By the late 1990s, CBCT further advanced the field of dental and maxillofacial radiology by allowing 3-D visualization of anatomical structures and their spatial relationship with a significantly reduced radiation exposure to the patient. In contrast to the fan-shaped beams and multiple detectors used in multi-slice computed tomography (MSCT), CBCT uses a conical X-ray beam to acquire images. The entire volume is imaged in one single rotation using a flat two-dimensional image receptor, thus making it the widely accepted method of choice for the pre-surgical assessment of intraoral implant sites today.

High accuracy and patient satisfaction

The past decade witnessed a paradigm shift from surgically driven to prosthetically driven implant placement planning. No longer just an add-on to the process, CBCT scanning has become the cornerstone of an integrated treatment workflow helping clinicians better execute their treatment plans.

With a single scan, practitioners are able to acquire much more—and more accurate—data at low effective radiation doses that are nearly equivalent to the dose of panoramic exams. The superior radiographic visualization compared with 2-D radiography facilitates better pre-surgical assessment and a better understanding of any oral pathologies. At the same time, the data can be used to optimize virtual treatment planning in 3-D and to prepare for guided surgery, which contributes to optimized treatment tailored for each patient.

Furthermore, less invasive procedures reduce patient discomfort and result in high patient satisfaction, as shown in observational studies on guided flapless implantology.
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A recent study to assess prospective implant sites using panoramic radiography versus panoramic scans combined with CBCT imaging revealed that CBCT increases the accuracy of treatment planning as it makes it possible to predict the actual implant dimensions required at surgery (Mello et al., Braz Oral Res. 2014). Furthermore, performing a CBCT scan during the planning phase increases accurate prediction of implant length as well. The overall outcome is a more predictable surgical and restorative result.

Superior visualization of anatomical structures

Digital imaging can offer clinicians and technicians a highly accurate diagnostic and treatment-planning tool with the potential to reformat the scan data and create virtual models of the patient’s anatomy. There is also the distinct advantage of accurate measurement in any dimension.

The generated 3-D volumetric data sets are essentially distortion-free and can provide primary reconstruction images in multiple planes. One of the main characteristics of CBCT is the ability to depict the fine details of bony structures. It is therefore particularly suited to head and neck diagnostics and dental applications in order to:

- Assess the anatomy, available bone height, width, and relative quality for implant surgery planning, and in the management of suspected implant treatment complications.
- Determine the three-dimensional topography of the alveolar ridge.
- Localize vital anatomical structures in close proximity to the planned surgery sites, i.e., the inferior alveolar nerve, mental foramen, incisive canal, maxillary sinus, sinus ostia and nasal cavity floor.
- Assess the presence of dentoalveolar pathology in the jaws and dentition or even temporomandibular joint (TMJ) pathology that could not be or was not adequately assessed using 2-D radiographic techniques.

The reliability of dimensional measurements is clinically relevant. Conventional radiological data acquisition can lead to millimetre-range deviations from anatomical reality, while CBCT has not only shown the ability to provide sub-millimetre measurements at much higher accuracy, it also provides segmentation accuracy that allows for the creation of accurate 3-D models. In addition, CBCT imaging offers potential for implant follow-up, as it produces considerably fewer metal artefacts than MSCT.

Parameters that affect radiation dose

In practice, higher resolution of bone structures can be obtained with CBCT than with MSCT. Radiation exposure from CBCT is typically considered to be lower than that incurred from common spiral and multi-slice protocols. Depending on the geometrical configuration and the exposure parameters of the system, there is significant variability in the effective radiation dose delivered by CBCT machines. Dose reduction can be achieved by adjusting operating parameters. Crucial parameters include exposure time, tube current, the size of the field of view (FOV) and the angular degree at which the gantry rotates around the patient’s head.

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**Preoperative planning**

**Initial evaluation**
Panoramic radiograph, followed by intraoral radiographs to obtain supplemental information.
Use of cross-sectional imaging discouraged.

**Radiographic exam of implant sites**
Include cross-sectional imaging orthogonal to the site of interest. CBCT considered the imaging modality of choice.

**Bone augmentation**
CBCT if augmentation procedures or site development before placing dental implants are required, and if bone reconstruction and augmentation procedures have been performed prior to implant placement.

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**Postoperative implant assessment**

**Immediate post-op evaluation**
Intraoral radiographs are recommended in the absence of clinical signs or symptoms. Cross-sectional imaging—particularly CBCT—should only be used immediately postoperatively if the patient presents with implant mobility or altered sensation.

**Follow-up examination**
CBCT to be considered if implant retrieval is anticipated. Should not be used for periodic review of clinically asymptomatic implants. Instead, intraoral and, in some cases, panoramic images are adequate for postoperative implant monitoring.

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**Statement on the use of CBCT for research purposes**
Applicable to all scanning procedures. Adhere to the principle of keeping radiation doses As Low As Reasonably Achievable (ALARA).

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**Table 1:** Imaging modalities recommended by The American Academy of Oral and Maxillofacial Radiology.

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