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RESEARCH ARTICLE

IMAGING IN DENTAL IMPLANTS

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Abstract

Dental implants have gained a lot of popularity among patients as a viable option for tooth replacement. It has recently become a standard treatment plan in many dental practices, and proper treatment planning is required to ensure a satisfactory outcome. As a result, radiography is an indispensable tool in providing information to clinicians so that an appropriate diagnosis and treatment strategy may be devised. Since the emergence of advanced imaging techniques, determining an appropriate implant imaging modality has become a challenge, and many of these modalities are being used for implant imaging. When it comes to imaging, the technique should take into account not only the anatomy but also the dimensional accuracy. As a result, all of the associated advantages and drawbacks should be considered while deciding on the type of imaging modalities.

Introduction

Dental implantology based on osseointegration is widely acknowledged as one of the most significant advancements in dentistry in recent years. The diagnostic imaging determines the outcome of implant surgery and restoration. From presurgical site assessment to postoperative integration evaluation and long-term periodic review of implant status, imaging is useful in all phases of implant treatment. [1] Radiography is the only noninvasive way analysing bone required for implant therapy. It also aids in determining the quantity of bone present, the quality of available bone, and the site of important anatomic structures. It aids in obtaining multiple views of the proposed site in order to properly analyse it. Moreover, it helps in periodic assessment of the post surgical phase to determine the outcome following its placement. [2] Conventional implant imaging techniques are usually deemed inadequate for comprehensive implant evaluation, despite the fact that they are beneficial and cost effective. Newer modalities that permit cross sectional visualization as well as interactive image analysis may be regarded the standard of care, especially in case of complex reconstructions. [3]

Imaging Objectives [4, 5]

The kind of imaging technique to be used is determined by the integration of the following phases:

PHASE 1: Pre-prosthetic implant imaging

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This phase is beneficial for dental implant diagnosis and treatment planning. It is important to assess the patient's edentulous site, the condition of soft tissue, bone mineralization and bone type, bone available in the edentulous site, and the number of dental implants. Any pathology of the soft or hard tissues can also be ruled out.

PHASE 2: Surgical and intra-operative implant imaging

In the surgical phase, the following aspects are evaluated: implant surgical site during surgery and after surgery, evaluation of implant position and angulation, osseo-integration and healing around the implant, relationship of implant abutment with natural teeth and occlusion, the design of temporary and definitive prosthesis and the loading of temporary prosthesis.

PHASE 3: Post prosthetic implant imaging

This phase commences after the implant has been loaded with a definitive prosthesis and consists primarily of dental implant and prosthesis maintenance.The Implantologists assesses the crestal bone loss around an implant, peri implant tissue, bone health, and any pathology using various post-surgical imaging modalities.

The goals of imaging are as follows: [6]

- Determining bone height and width (bone dimensions)
- Evaluating bone quality
- Assessing the long axis of alveolar bone
- Recognizing and containing internal anatomy
- Establishing jaw boundaries
- Identifying any underlying pathology.

IMAGING MODALITIES

INTRAORAL RADIOGRAPHY: [6, 7, 8]

CONVENTIONAL PERIAPICAL RADIOGRAPHS:

During surgery, these radiographs provide information regarding regions of single implants to assess implant angulations and placement, the condition of neighbouring teeth, the dimensions and height of bone available in smaller sections, and dental disease. They offer the following advantages: they are easily accessible, cost - effective, and the radiation exposure is relatively low. However, they are of limited value in displaying the spatial relationship between structure and intended implant site, as well as assessing the quantity and density of the bone. They are generally indicated during treatment planning for single teeth implant, in areas where the width of the bone is sufficient. [9, 10, 5]

DIGITAL RADIOGRAPHY:

Direct digital intraoral imaging enables rapid acquisition, enhancement, storage, retrieval, and transmission of intraoral images to remote sites. The downside is that the sensor's size and thickness, as well as the position of the connecting cord, making it more difficult to position the sensor in areas like those near to tori or the tapered arch form in the canine region. [4]

ELECTRONIC OR CCD IMAGING TECHNIQUES:

Presurgical implant assessment is accurate with charged couple devices (CCDs). They precisely measure implant sites preoperatively; provide more information regarding osseointegration postoperatively than with the film.

Selection of site and determination of bone height is made easy with the use of wire grids. The proposed site can be reconstructed in 2/3-D using multiple images of a site. Thus, prior to placement, the information can be viewed on a video monitor. [4]

DIGITAL SUBTRACTION RADIOGRAPHY:

When compared to periapical, Digital Subtraction Radiography accurately depicts changes, such as bone volume and bone mineralization, as dark or light shades of grey. It also displays changes in the alveolar bone on the buccal and lingual aspects. However, due to the difficulty in obtaining reproducible periapical, its use is limited in clinical practice. [11]

OCCLUSAL RADIOGRAPHY:

For the edentulous mandible/maxilla, occlusal radiographs are important in determining bucco-lingual width and contour. It is also used at individual implant sites and mapping for multidirectional tomography. [4] The main drawback is that only the widest portion of mandible is recorded, leaving less information about the width of the crest, which is of primary concern to the operator, and the degree of trabecular bone mineralization cannot be assessed from this projection.[10,12]

ORTHOPANTOMOGRAM (OPG):

Pre-implant evaluation and various treatment protocols can be properly carried out with the use of OPG. OPG provides sufficient information while reducing radiation exposure and cost. The body of the mandible, maxilla, lower half of the maxillary sinus, inferior alveolar nerve, and nasal fossa are well depicted in panoramic radiography, which is a curved plane tomographic radiograph. OPG offers many advantages which include, initial assessment of vertical height of the bone, preliminary estimation of crestal alveolar bone and cortical boundaries, evaluation of gross anatomy of the jaws and related pathologic finding, the ease, convenience, and speed of the procedure.[13] Few drawbacks include, the inability to assess bone mineralization, poor resolution compared to peri-apical or digital peri-apical radiography, quantitative bone analysis that is inaccurate as a result of magnification, and the need for additional set-up. [10, 5]

ZONOGRAPHY (LIMITED ANGLE LINEAR TOMOGRAPHY):

Zonography is a modified form of the panoramic X-ray machine, which produces a cross-sectional image of the jaws. The tomographic layer is relatively thick. Zonography offers the advantage of allowing appreciation of spatial relationship between the implant site and the critical structures. The downsides include superimpostion of blurred adjacent structures on the image and it's inability to detect the differences in bone densities or presence of disease pathology at the implant site. [10, 6]

COMPUTERIZED TOMOGRAPHY (CT):

It's a three-dimensional (3D) radiograph that shows several views of the implant site, including axial, reconstructed panoramic and cross-sectional views of the jaws, with greatest precision. [4] The coronal sections give enough information regarding the residual ridge. CT offers the following benefits over conventional tomography: uniform magnification, high contrast image, bone grafts or hydroxyapatite materials used in the augmentation of maxillary bone in the region around sinus can be identified with ease, multiple implant sites can be simultaneously assessed as well as the software image analysis. The downsides include higher costs, restricted reconstruction software availability, radiation doses are higher when compared to conventional tomography and Cone Beam Computed

Tomography, and due to metallic streak artifacts, it is unreliable for implant interface follow-up [14]. Microtomograph and multi slice helical CT are few recent advances in CT. [13]

DENTA SCAN IMAGING [10]:

Computed tomographic imaging of the maxilla and mandible in three planes of reference: axial, panoramic, and cross-sectional can be easily achieved with the use of a distinctive computer software program known as Denta-Scan. It can be used for single or multiple implants, ridge augmentation, or edentulous ridges.
Its benefits include determining bone height and width, detecting soft and hard tissue pathologies, locating anatomical structures, and measuring critical quantitative parameters required for implant placement. Radiation exposure is one of its drawbacks, as is the cost.

1) INTERACTIVE COMPUTED TOMOGRAPHY (ICT):

Images can be transferred to the clinician as a computer file using ICT. In addition to this, it aids the clinician in determining the length and width of the alveolus, as well as the quality of the bone. Moreover, both the clinician and the radiologist can perform "electronic surgery" together, which is a key element of ICT. [6]

2) TRANSTOMOGRAPHY OR SECTIONAL TOMOGRAPHY:

An amalgamation of the translational movement and the pendular movement of the beam as well as the detector in advanced panoramic machines, in order to obtain direct digital transtomographic images has been explained by Welander et al in 2004. It has the advantage of being able to obtain faster results utilising a computer programme intra-operatively (particularly during blind surgical interventions) and obtaining measurements on the screen, which is facilitated by orienting the patient with the help of an individualized silicon key. This, in fact, allows for less image distortion than conventional tomographs and CT scans.

TURNED APERTURE COMPUTED TOMOGRAPHY (TACT):

Based on optical aperture theory, TACT is an innovative, promising, and alternative technology for dento-alveolar imaging to film-based tomography and CT. It can map sequentially gathered data into a single three-dimensional matrix, as well as separate images of desired structures at specific depths. Moreover, It can accommodate the patient's movement between exposures. It also features a range of contrast and resolution adjustment options. [14, 4]

CONE BEAM COMPUTED TOMOGRAPHY (CBCT):

The diagnosis and treatment planning in implantology is made easier with the application of CBCT scanners, which work primarily on the basis of Volumetric tomography, in which 2D extended digital array is paired with a 3D Xray beam, thus producing 3D volumetric data set. [12] As a result, primary reconstruction images are obtained in three orthogonal planes (axial, sagittal and coronal). They are helpful in determining the best possible site for prosthesis, occlusion, and supporting implants.

Measurement of height and width of the bone, assessment of the quality of the bone with the aid of comparative density analysis done in three long axes of the alveolar bone and jaw boundaries, detection of critical internal structures which include nerves and sinus cavities, pathology in 3D scale and complexity, transmission of data regarding radiographic diagnosis and planning, obtaining multiple images of the proposed site in one scan for each implant site are all possible with the help of CBCT scan. As a result, the procedure is minimally invasive with minimal postoperative complications and quick recovery. [14, 6] It has the following benefits: high resolution, lower

radiation dose, minimal interference from metal artifacts, relatively low cost, and ease of access and manipulation. Low contrast range, small detector size, resulting in limited visual field, scanned volume, and internal soft tissue formation are some of its drawbacks.

MAGNETIC RESONANCE IMAGING (MRI):

Nuclear magnetic resonance is the mechanism that has been used in MRI (NMRI). When primary imaging techniques such as CT and CBCT fail, MRI is employed as a secondary imaging tool. The fat in trabecular bone is visible on MRI, and the inferior alveolar canal and neurovascular bundle are distinguished from the adjoining trabecular bone.The vital structures and the implant site are easily distinguished with oriented MRI imaging of the mandible in the posterior region. The positives are that it exposes the patient to less radiation than a CT scan. Patients who have ferromagnetic implants in their bodies should avoid MRI. [4, 5]

Conclusion:

When it comes to imaging in implant therapy, conventional radiography is of little use. Despite this, panoramic radiography is still the preferred technique because of its lower cost. MRI can be useful for identifying the exact position of critical structures; however it is vulnerable to artefacts, geometric distortion, and signal loss. Its use is best indicated, when soft tissue delineation is also necessary.[8] Quantitative and qualitative analyses of bone for placing implants are now possible with the CT. Multi-slice helical CT has an advantage over conventional CT in that it can obtain a wider anatomic area a lot quicker, while minimizing patient motion. A 3D model and a surgical template can be fabricated with the help of software that is used along with CT or MRI. CBCT is a revolutionary technology for dental implant imaging that allows for quick data capture while exposing patients to less radiation. It creates images that are similar to those seen in clinical practise on a regular basis. As a result, CBCT is the preferred approach for implant imaging because of greater benefits that it offers compared to other techniques. [15]

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