Review Article

Techniques of imaging used in implant dentistry – A review

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ABSTRACT

Dental implants are becoming extremely popular and are accepted worldwide as they not only replace lost teeth but also they do not interfere with oral function or speech and enhance the self-esteem of patients. Implants improve the quality of life for patients as they resemble natural teeth and are esthetically appeasing. The key to successful implant placement is an effective pre-operative assessment. Proper pre-surgical imaging and treatment planning make the placement of implant relatively easy and predictable. This article aims at providing a comprehensive review of the various imaging techniques in implant dentistry.

KEY WORDS: Imaging techniques, Implants, Radiographs

INTRODUCTION

Over the past decades, various advancements have been brought in the field of implant dentistry. Beyond replacing lost tooth, it improves the esthetic satisfaction of the patient, life expectancy and esthetic concerns accelerate the wide acceptance of implantology.[1] For successful implant placement, several factors such as quality and topography of the bone, and anatomical landmarks at the site of implant placement such as nerves, blood vessels, nasal floor, maxillary sinus, and teeth[2] play a pivotal role for the surgical placement of implant. In addition to that, success of implant placement depends on the careful case selection and patient preparation.[3] Imaging is the integral part of pre-operative implant assessment as it is one of the most accurate methods to assess the morphological features of the proposed implant fixture sites.[4] Several imaging techniques are currently available for the pre-surgical and post-surgical evaluation of the implant site. These include both intraoral and extraoral conventional film and digital radiography. A combination of techniques is usually used to obtain the necessary diagnostic information.[5]

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Website: jprsolutions.info | ISSN: 0975-7619

Purpose of Radiography

The purpose of implant imaging is to visualize the location of vital anatomical structures, to assess bone quantity, to identify the pathological conditions, to analyze the length and width of the implant to be placed, and also to locate and orient the implants. It is also greatly helpful to assess any possible additional treatment options such as bone augmentation before the treatment.[5-9]

Imaging Modalities

Intraoral periapical radiographs

Intraoral periapical radiographs provide high resolution images of a limited area of the jaws. They are used to rule out the presence of periapical pathology, location of anatomic structures in relation to the proposed implant site,[3] height of the alveolar bone, and trabecular pattern of the bone and also determine bone quality.[10] The radiation exposure is limited in periapical radiographs and is cost effective. The main disadvantages are distortion and magnification errors.

Occlusal radiographs

Occlusal radiographs are planar radiographs of high resolution used for the edentulous patients to obtain information regarding buccolingual width and contour[3] of the alveolar process of maxilla or mandible. The main drawback of this radiographic technique is

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Received on: 16-01-2019; Revised on: 21-02-2019; Accepted on: 09-03-2019

that the medial and lateral extent of the cortical bone is not clearly delineated. The lack of delineation of medial and lateral extent of the cortical bone and lack of determination of mineralization of trabecular bone is an additional limitation of this technique.

Cephalometric radiography

Cephalometric radiographs provide details such as the angulation of the bone, its thickness, vertical bone height, interjaw relationships, and soft tissue profile.[11] Along with periapical radiographs, this radiograph provides quantitative information to demonstrate the topography of implant site and the spatial relationship between implant site and vital structures such as the floor of nasal cavity, maxillary sinus, and the nasal palatine canal.[12]

Panoramic radiography

Panoramic radiographs are used for the assessment of the success of the implant by assessing the normal anatomic structures, the topography of the bone at the implant site, path of insertion of the implant, and in post-operative evaluation. Panoramic images provide a broader visualization of the maxilla and mandible and adjacent anatomic structures. They are also used to assess the crestal alveolar bone, the mandibular canal, maxillary sinus, and nasal fossa.[10] The main disadvantage of panoramic radiographs is magnification errors. This can be eliminated with the usage of radiographic stent with ball bearings embedded in acrylic dentures to minimize the magnification factor.

Digital radiography

Digital intraoral radiographic technique allows rapid acquisition of intraoral images, enhancement, storage, retrieval, and transfer. The height and width can be measured directly by utilizing the digital tools. The major flaw of digital imaging is the operator's skills to manipulate the image.

Digital periapical radiography

Digital periapical image receptors enable instantaneous image acquisition, produce image quality similar to that of dental film, and enable the surgical procedure to proceed without any delay. Image enhancement and digital measuring techniques can enable in establishing the optimum depth and orientation of the implants.[13] The image can be manipulated to change the density and contrast and also to measure the bone density at specific sites.[3]

Intraoral imaging using electronic or charge-coupled devices (CCDs) imaging techniques

CCDs allow accurate pre-operative measurement of implant sites and provide more information about osseointegration postoperatively than conventional radiographs. The wire grids help in implant site selection and bone height determination. Multiple images of the site allow two- and three-dimensional (3D) reconstruction of the proposed implant site and allow viewing the information before placement.[14]

Zonography

A variant of the panoramic X-ray machine was developed to make a cross-sectional image of the jaws. They employ limited angle linear tomography. The tomographic layers are quite thick and have adjacent structures that are superimposed on the image, limiting the usefulness of this technique for individual sites, mainly in the anterior region where the geometry of the alveolus changes relatively rapidly. This technique is not useful for determining the differences in most of the bone densities or in identifying disease at implant site.[15]

Cross-sectional imaging

Cross-sectional imaging includes:

- Conventional tomography.
- Computed tomography (CT).
- Magnetic resonance imaging (MRI).

Conventional tomography

Conventional film-based tomography is designed to obtain clear images of the structures within a plane of interest.[4] It is used for accurate assessment of alveolar bone height, width, and inclination. It can be used to determine both the quality and quantity of the bone.

CT

In CT implant imaging, multiple thin axial slices of the jaws are obtained, and then, the data are reformatted using special software packages to produce cross-sectional and panoramic images. Various computer software programs are available to analyze the reformatted images and aid in treatment planning with electronically simulated fixtures, to measure the distance from the alveolar crest to vital structures.[16] Computer-assisted tomography has become increasingly popular in implant and temporomandibular joint imaging with the advent of precise positioning techniques that are controlled by computer workstations. The complex motion tomographic machines incorporate the complex motions of tomography namely circular, trispiral, elliptical, and hypocycloidal.[17]

Cone-beam CT (CBCT)

CBCT is a relatively new modality, specifically designed for maxillofacial imaging and was introduced in the late 1990s. It is characterized by volumetric data acquisition obtained during one rotation of the X-ray source. It produces a 3D image that can be formatted using software for customized visualization of the anatomy. It gives all the information of CT at 1/8th the radiation dosage and at a lower cost.[14]

Tuned-aperture CT (TACT)

TACT is a new method for dentoalveolar imaging which is based on optical aperture theory. This technique obtains information by passing a radiograph beam through an object from several different angles. TACT can map the data into a single 3D matrix image. It can isolate the images of desired structures to certain depths.[18]

MRI

MRI is based on the phenomenon of nuclear magnetic resonance. MRI is used only as a secondary imaging technique when all the other primary imaging techniques fail to provide the desired result. MRI visualizes the fat present in the trabecular bone and differentiates the inferior alveolar canal and the neurovascular bundle from the adjacent trabecular bone.[16]

The main advantage is that MRI can sharply delineate the soft and hard tissues, differentiate between cancellous and cortical bone, zero radiation dosage, and good soft tissue details with less artifacts. The major disadvantages are that they are expensive, no special software is available for specific usage in implantology and an expert radiologist is required to interpret the image.

Post-surgical assessment

The purpose of post-surgical implant imaging is to evaluate the status of the dental implant. The bone adjacent to the dental implant should be evaluated for successful osseointegration, fibrous tissue interface, inflammation, or infection, loss of crestal bone adjacent to the dental implant, and excessive functional or parafunctional loading. Conventional intraoral and panoramic radiographs are most widely used for post-surgical assessment of the implant.

CONCLUSION

Many radiographic methods are available for implant imaging. Intraoral, panoramic, and cephalometric radiographs may be used during the initial phase of patient evaluation. Once the decision for implant placement has been made, the proposed site must be evaluated using conventional tomography or CT. MRI is not commonly used for implant imaging because bony detail cannot be appreciated readily. As in the case of all imaging, appropriate selection criteria must be applied to each patient. To conclude, proper case selection is important for the success of implant placement and these imaging techniques should be used as an adjunct to clinical decision-making.

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Source of support: Nil; Conflict of interest: None Declared