

Imaging Techniques in Dental Implantology

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ABSTRACT

Background: In this current era of dentistry, widespread use of dental implants in partially and completely edentulous patients has brought about a need for an accurate implant imaging technique to depict the bone, contour and location of vital anatomical structures by proper radiographic examination. Many imaging modalities are available for imaging the implant site. Hence look for the advantages and disadvantages of the required technique depending on the case and the clinician's judgement to interpret the image acquired. Different imaging technique which will be broadly discussed in this review that best suits for the different clinical situation.

Keywords: Dental Implants, Computed Tomography(CT), Radiography, Cone Beam Computed Tomography(CBCT).

INTRODUCTION

X-rays are weightless packages of pure energy (photons) that have no electrical charge & travel in waves with specific frequency at a speed of 3×10^8 m/sec. Their energies depend on the frequency of their wavelengths. The greater the frequency of wavelength, the greater the energy of the photon, the more readily it will penetrate the matter. Radiography offers the sole method of noninvasive analysis of bone required for implant therapy. It helps the clinician determine the quantity of bone present, quality of bone available & location of critical anatomic structures. It helps to obtain multiple views of the proposed site to assess it adequately and to evaluate the post-surgical phase periodically to determine the success after implant placement.¹

The conventional methods of implant imaging generally are considered inadequate for comprehensive implant evaluation, although they are useful for pre-diagnosis and are more cost-effective comparatively. Newer techniques that permit cross sectional visualization & interactive image analysis may be considered the standard of care, especially for complex reconstructions.

OBJECTIVES OF IMAGING

1. It should provide the clinician with cross-sectional views of the dental arch for visualization of spatial relationship of internal structures.
2. Minimal image distortion to permit accurate measurements.

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3. The images should allow evaluation of the density of trabecular bone and thickness of the cortical plates(bone quality).²

4. Spatial relationship of the cross sectional views of mandible & maxilla to one another.

5. To identify the presence or absence of pathosis.

6. It should provide the minimal radiation exposure to patient.

7. It should be readily assessable at a reasonable cost to the patient.

Types of Radiography

Plain film radiography

Digital radiography

Plain film radiography comprises of Intra-oral radiography, Cephalometric radiography, Panoramic radiography, Film tomography, and on the other hand Digital radiography comprises of Intra-oral radiography, Computed tomography.³

INTRA-ORAL RADIOGRAPHY:

It is still the most widely used modality for pre and postoperative implant assessment. Both periapical and occlusal radiographs are known to provide the best image details with minimal geometric distortion of all the available modalities. Periapical Radiographs provide detailed information regarding the dimensions in length and height of available bone in small sections. They are indicated for single tooth replacement.²

Advantages:

- Approximate vertical height of alveolar ridge can be determined

- Accurate image detail with minimal image distortion

- Location of some critical anatomic structures (mental foramen, inferior dental nerve canal & maxillary sinus).

- Information about bone quality (density, trabecular pattern) and presence/absence of pathosis is revealed.

- Films readily available to clinician.

- Low cost to patient

Disadvantages:

- Correct positioning of film is difficult in edentulous region (The film plane can rarely be placed parallel with the alveolar process).

- They do not give information regarding the bucco-lingual dimension.

- This modality is limited by its 2D nature-accuracy is a necessary requirement for an imaging modality to be used in implant diagnostics.

CEPHALOMETRIC RADIOGRAPH:

It provides more accurately the information on inclination, height and width of alveolar bone at the midline, when compared to panoramic radiographs.⁴

It provides information regarding the relationship of the jaws when image is taken with teeth in occlusion.

Position and relationship of mental foramen, nasal fossa and maxillary sinus to the adjacent structures can be assessed.

Advantages:

- Height/width information is revealed in the anterior mandible/maxilla

- Images are cross-sectional images

- Low radiation dose; low cost to patient

PANORAMIC RADIOGRAPH

It is also called pantomography, a radiologic technique for producing a single image of facial structures that includes both maxillary & mandibular dental arches & their supporting structures.⁵

They display anatomic structures like nasal cavity, maxillary sinus, inferior alveolar canal and mental foramen.

It is indicated when multiple implant placements are planned.

Advantages:

- Excellent "screening" film for pre-surgical implant planning.

- Readily accessible: low cost to patient.

- Minimal radiation dose.

-Demonstrates presence/absence of pathoses.

-Indication of anatomic spatial relationship.

Disadvantages:

-The resolution is lesser when compared to intraoral radiograph.

-A 10-20% image magnification occurs, which is non-uniform. This magnification is undesirable for both implant selection and implant site assessment.

-Geometric distortion and overlapping of images of teeth can occur.

-Overlapping of anterior region by vertebral column occurs.

TOMOGRAPHIC UNIT

Metal rods are retained within an acrylic imaging stent, to indicate the planned implant sites. Panoramic radiograph used to orient the subsequent Tomograms. Cross sectional tomograms are appropriate for measuring the height & width of the alveolar ridge & axial orientation of the proposed implant.

-It is a successful diagnostic tool for assessing accurately the alveolar bone height, width and inclination which further aids in implant placement.

-It can assess both the quality and the quantity of bone.

-It gives information regarding the spatial relationship of vital structures.

Advantages:

-Produces cross-sectional images of specific proposed implant sites

- Assessment of bone height, width and inclination of ridge

- Assessment of bone quality

- Determination of anatomic spatial relationship

-Exact imaging and detailed view of specific implant site

-Little or no superimposition

- Selection of varying slice thickness and slice location

-Relatively low exposure to patient

- Development of treatment planning software for certain imaging systems.

Disadvantages:

-Insufficient contrast when compared to intraoral radiographs.

-It is an expensive modality.

- An expert radiologist is needed to interpret the image.

Digital radiography

Even though the x-ray film is versatile (serves as the recording, display & storage medium for diagnostic images) it is relatively inefficient as a detector of radiation, requiring relatively high doses for exposure, & it requires chemical processing by solutions that are potentially allergenic & polluting.⁶

The application of computer technology to radiography has allowed image acquisition, manipulation, storage, retrieval, & transmission to remote sites in a digital Format.

Digital imaging requires the following components:

1. Electronic sensor.

2. A computer with an analog-to-digital Converter.

3. A monitor for image display.

The image is captured on a CCD(charged coupled device) in the patient's mouth. The signal from the CCD is sent to the computer, where it is digitalized. The image can then be displayed on the monitor, where it can be enhanced by varying the density and contrast. The image may also be stored for future use, printed if a hard copy is required ,or transmitted electronically to a remote site.⁷

Disadvantages:

-Digital radiography lacks the resolution of film radiography.

- This technique is useful for pre-surgical site evaluation.

COMPUTED TOMOGRAPHY

Considering the new age tool, it blends the concept of thin layer radiography (tomography) with

computer synthesis of image. It was first applied successfully in implantology in the 1980s. In computed tomography (CT), multiple thin axial slices at small distances are obtained through the jaws and data is reformatted with special software package to produce cross-sectional, panoramic and 3D images.⁸ The CT always images entire arch, and normally is not used for single tooth replacements. It can determine bone density in any region of the jaw. The 3D image helps in accurately locating the vital structures. Operator has an access to full range of contrasts. It automatically calculates bone height and width in a specified region.

Slice thickness ranges from 2-10mm and even smaller slices (1.0mm)-TSS Tomography on the micrometer level- Microtomography.

Disadvantages:

- It is an expensive modality.
- An expert radiologist required to interpret the image.
- High radiation dosage when compared to conventional radiographic technique.

TACT (TUNED APERTURE COMPUTED TOMOGRAPHY)

In CT it is not possible to examine selectively small segments of anatomy. To improve image quality, better sampling & display parameters are needed, but it increases radiation dose & cost. TACT is based on optical aperture theory, it uses information collected by passing a radiographic beam through an object from several different angles. It can map the incrementally collected data into a single 3-D matrix.⁹ Because projection geometry can be calculated after individual exposures, problems of patient movement are of less significance than in other modalities. There is considerable flexibility adjusting contrast & resolution to answer specific questions. Radiation dose levels are comparatively low.

Disadvantages:

- Information available about this modality is limited and restricted to very few studies.
- It's application to implantology is still in research phase.

CONE BEAM CT SCANNING

There are many advantages over traditional CT scans. First, with cone beam CT scanning the patient is subjected to far less radiation, because a focused beam is used with a larger sensor allowing to capture all the axial slices covering the face and the jaws in one scan. The entire volume is captured with one scan.¹⁰ There is no redundant overlap of slices, resulting in major reduction of radiation

A cone beam CT scan, provides a true reproduction of the patient's anatomy. The dimensions represented in the cone beam imaging correspond exactly to the patient. There is no distortion. The dimensions are accurate. Cone Beam 3-D Imaging System produces immediate 3-D images of patients' critical anatomy, typically in a minute.

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging (MRI) is based on the phenomenon of nuclear magnetic resonance (NMR). First described in 1970's, its application in implantology is however of recent origin. The MRI can sharply delineate soft and hard tissues. It can differentiate between cortical and cancellous bones. The biggest advantage of MRI is 'zero radiation dose'. Flexibility of plane acquisition. Gives good soft tissue details. Low level of imaging artifacts.

Disadvantages:

- It is an expensive tool.
- At present no special software is available for specific use in implantology.
- An expert radiologist is required to interpret the image.
- The MRI application in implantology is still in its experimental phase.

CONCLUSION

Imaging modalities are readily available from conventional techniques to the digital techniques. Each one of them have their advantages and disadvantages. Choice of their use are dependable on the clinician's choice and availability. Some of the modalities are expensive but they provide more accurate data to interpret. Imaging modalities not only help in establishing the proper diagnosis but also guides the clinician for accurate implant placement, thus playing an important role in the

success of the treatment. Moreover, post-operative evaluation can indicate the future needs of the patients.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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