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Diagnostic Imaging In Implantology – A Review

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Abstract
The presurgical evaluation and treatment planning is very important for successful implant placement. For this purpose, many tools are available and among them imaging is one of the irreplaceable armamentariums. In imaging, along with anatomical landmark dimensional accuracy is also provided. Nowadays, both film and filmless techniques are used for imaging. Hence, the decision of imaging technique to be used for presurgical evaluation of implant placement is discussed in this review.

Keywords: implant, cone beam computed tomography

Introduction

The surgical implant procedure and its success depends on case selection and its preparation. Case selection for implant site should be done on certain factors which include complete medical and past dental history, following thorough clinical examination, evaluation of general health of a patient. Imaging is also one of the important factors to determine the feasibility and fixture installment. Imaging gives the accurate details like morphologic features of the proposed fixture site, determination of bone quality and quantity, location of adjacent anatomic structures, appropriate proper implant size and its evaluation after placement.[1]

The diagnostic imaging motivates in precise treatment plan for implant patient. The important role of imaging depends on the selection of type of imaging techniques for achieving best required information with accurate dimensions.[2]

Dental Imaging:

For an implant site determination, imaging helps to identify bony pathologies, bone density, vital anatomical structures, in case of requirement of additional bone treatment, and to estimate the prognosis of implant placement. The ideal imaging helps the clinician by viewing the dental arch in cross-sectional view and also the inclination of alveolar process along with spatial relationship of fixture site and anatomic structures.[3]

Types Of Radiographic Imaging Techniques:

A. Plain Film Radiography

1. Intra-Oral Peri-Apical Radiograph.
2. Occlusal Radiograph
3. Cephalometric Radiograph
4. Panoramic Radiograph
5. Conventional Tomography

B. Digital Radiography

1. Computed Tomography
2. Digital Radiography
3. Tuned Aperture Computed Tomography
4. Magnetic Resonance Imaging.

Following are some limitations of imaging techniques used in oral implantology given by **American Academy of Oral and Maxillofacial Radiology** for imaging the dental implant patient[4]:

Recommendation 1. Panoramic radiography should be used as the imaging modality of choice in the initial evaluation of the dental implant patient.

Recommendation 2. Use intraoral periapical radiography to supplement the preliminary information from panoramic radiography.

Recommendation 3. Do not use cross-sectional imaging, including cone beam computed tomography (CBCT), as an initial diagnostic imaging examination.

Recommendation 4. The radiographic examination of any potential implant site should include cross-sectional imaging orthogonal to the site of interest.

Recommendation 5. CBCT should be considered as the imaging modality of choice for preoperative cross-sectional imaging of potential implant sites.

Recommendation 6. CBCT should be considered when clinical conditions indicate a need for augmentation procedures or site development before placement of dental implants: (1) sinus augmentation, (2) block or particulate bone grafting, (3) ramus or symphysis grafting, (4) assessment of impacted teeth in the field of interest, and (5) evaluation of prior traumatic injury.

Recommendation 7. CBCT imaging should be considered if bone reconstruction and augmentation procedures (e.g., ridge preservation or bone grafting) have been performed to treat bone volume deficiencies before implant placement.

Recommendation 8. In the absence of clinical signs or symptoms, use intraoral periapical radiography for the postoperative assessment of implants. Panoramic radiographs may be indicated for cases requiring more extensive implant therapy.

Recommendation 9. Use cross-sectional imaging (particularly CBCT) immediately postoperatively only if the patient presents with implant mobility or altered sensation, especially if the fixture is in the posterior mandible.

Recommendation 10. Do not use CBCT imaging for periodic review of clinically asymptomatic implants.

Recommendation 11. Cross-sectional imaging, optimally CBCT, should be considered if implant retrieval is anticipated.

Implant imaging can be divided into 3 phases[5]:

1. **Phase I:** Pre-surgical implant imaging.
2. **Phase II:** Surgical and interventional implant imaging.
3. **Phase III:** Post-prosthetic implant imaging.

PHASE I: Pre-surgical implant imaging –

To study the bone quality and quantity and an implant site approximation with surrounding critical structures, if any. This helps in planning implant orientation till the prosthetic information.

PHASE II: Surgical and intra-operative implant imaging –

This is phase where optimal implant position and its orientation is checked. Along with this operator can also evaluate the healing and integration of site. For the planning of abutment and prosthesis fabrication can also be ensured in this phase.

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Fig. 01 Periapical image of a potential implant site in the posterior left maxilla. An imaging guide containing a cylindrical radiopaque marker has been inserted intraorally to depict the desired angle of implant placement.

Phase III: Post-Prosthetic Implant Imaging –

This phase begins with the implant placement till the same remains in the jaw. This phase is followed by recall and maintenance imaging for the evaluation of changes in the alveolar bone.

Plain Film Radiography:

One of the most widely used radiographic technique for pre and post operative implant assessment. The proper image details along with minimal image distortion can be seen in peri-apical and occlusal radiographs.[6]

Intraoral Peri-Apical Radiograph (Iopar)

They provide images with greatest details of a particular site with easily available to the clinician and for patient at a low cost with particular detailing.

Provides detail information including the length and width of available bone in small sections.

In implant placement procedure, IOPAR is used for single tooth implant surgery so that proper dimensions can be measured during pre- and post-surgery evaluation

Fig. 02 showing IOPA

Drawback:

1. Difficult to assess the location of inferior alveolar nerve canal near 1st molar region.
2. Difficulty in placing the film in edentulous region.

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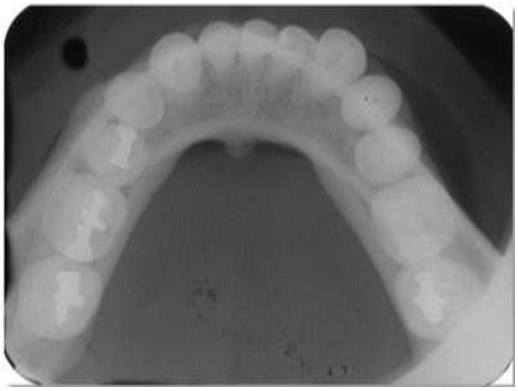
3. Limited to its 2D nature of view, to assess the quality and quantity of bone and its relationship between the vital structures.
4. Fail to assess bucco-lingual dimension

Fig. 03 showing occlusal radiograph of lower arch.



Occlusal Radiograph –

1. They help in visualizing the bucco-lingual width between the extremes of buccal and lingual cortical plates.
2. Occlusal radiograph doesn't show all the views, as it fails to view the medial and lateral extent of cortical bone delineating the alveolar process and salivary gland fossa.
3. It displays only the extremes of cortical bone as this view is limited to its 2D nature.
4. They can demonstrate almost entire alveolar process of both upper and lower arch. (Maxilla and mandible).
5. One of the true cross-sectional views. (Fig. 03)

Fig. 04 showing OPG

Panoramic Radiograph

1. This type of image displays a single image of maxilla and mandible including surrounding anatomical structures in a frontal plane. (Fig. 04)
2. The anatomic structures like maxillary sinus, nasal cavity, mental foramen and inferior alveolar canal.
3. Indicated for multiple implant placement plans, during pre-surgical phase.

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4. The image receptor might be a radiograph film, a digital storage phosphor plate or a digital charge-coupled device receptor.

Drawback:

1. When compared with IOPAR resolution is less.
2. Geometric distortion.
3. Overlapping of images of teeth can occur specially in anterior region.
4. Image magnification is about 10-20% which is nonuniform. For the placement of implant or its site assessment, this magnification is undesirable.

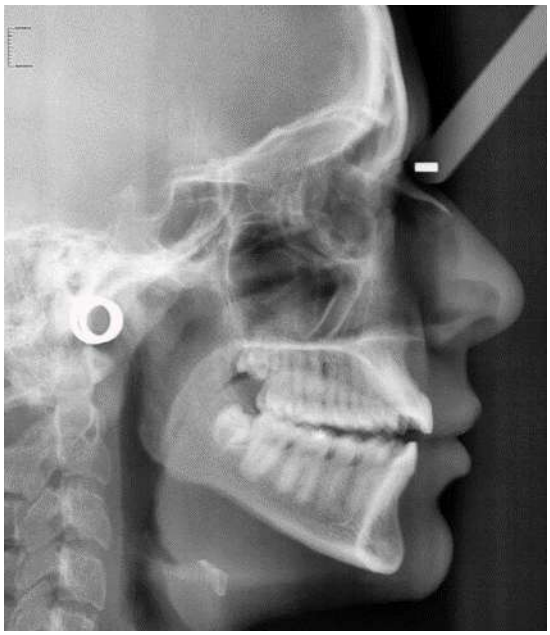

Fig. 05 showing Lateral Cephalometric radiograph.

Cephalometric Radiograph –

1. This view helps in determining the relationship between aesthetics and occlusion along with accuracy in determination of bone quantity. (Fig. 05)
2. The relationship of the lingual plate to the skeletal anatomy along with the geometry of the alveolus in the mid-anterior region.
3. This helps to assess the bone height using the cross-sectional image, crown to implant ratio, soft tissue profile, skeletal-arch inter-relationships.
4. This technique is operator technique-sensitive and, if improperly positioned, it will result in a distorted view.
5. The resolution and sharpness of this radiographs are compromised because of use of intensifying screens.

Conventional Tomography

1. Tomography is derived from the Greek words “Tomo” (slice) and “Graph” (picture).
2. CT was introduced in medicine in early 1970s, to study the cranium, which showed computer-processed image of anatomical structures in axial plane. Later in 1980s, the equipment developed which was capable of producing contiguous or overlapping axial images 1.5 – 2 mm thick.[6]
3. This point of resolution helps in viewing the cortical border of inferior alveolar canal and trabecular pattern of the medullary bone of maxilla and mandible.[6]
4. This is a film-based tomography which is designed for clear images of structures.
5. This technique develops 3-D cross-sectional views from multiple projections which have been taken at various different angles of the patient.

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6. For dental implant diagnosis, it gives accurate dimensions of alveolar bone height, width and inclination.
7. Also gives information about surrounding vital structures and its spatial relationship with implant.

Drawback:

1. Expensive.
2. Need an expert radiologist.

DIGITAL RADIOGRAPHY:

1. Computed Tomography:

1. It was introduced in 1972, and invented by Sir Godfrey Hounsfield.
2. This helps in giving high density image resolution along with soft tissue visualization.
3. The CT scan provides tangential and cross-sectional tomographic images for the implant site.
4. In computed tomography, multiple thin axial slices are obtained are obtained at small distances through the jaws and the data is reformatted with special software package which produces 3D, cross-sectional and panoramic images.
5. The 3D images help in locating vital structures accurately. It also helps in determining the bone density in any region of the jaw.
6. It helps in calculating the bone height and width in the specific required region.
7. In dental implantology, computed tomography is used in critical situations of anatomy where implant placement can be planned in an ideal position in bone by using CT scanning software which helps in eliminating possible manual errors and also helps to match the planned prosthetic requirements. This gives comprehensive assessment of bone morphology and measurement of dental implant.

Fig. 06. The CT image in an axial plane

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Advances In Ct Scans:

1. **Cone beam computed tomography** is a new modality which uses a conical beam and the image is reconstructed in any direction with the help of a software. In this, all detail information is given in a1/8th radiation dose.
2. **Microtomograph,** is a modification of computed tomograph used in acquiring serial sections of bone-implant interface.[7]
3. **Multislice helical computed tomograph** offers higher accuracy of images compared to computed tomograph.[8]

2. Tuned Aperture Computed Tomography

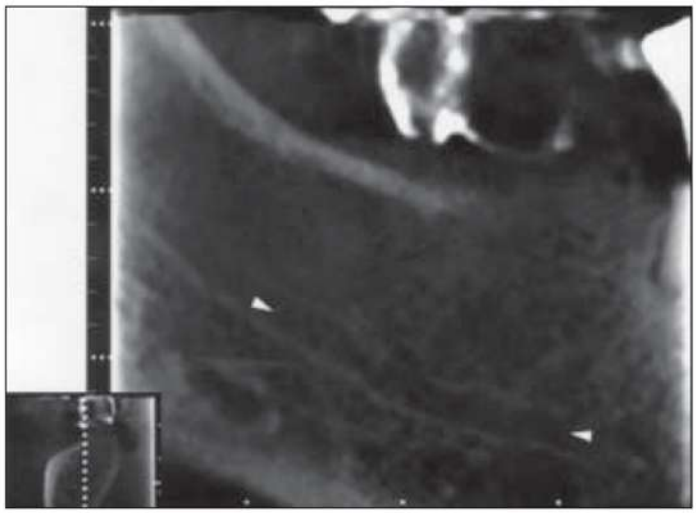

Fig. 07. Tuned aperture tomography image displaying the inferior alveolar and its distance from proposed implant site.

This is one of the newest imaging modality, based on the principle of digital tomosynthesis. It helps in examining selectively small segments without exposing entire axial plane.[9]

Characteristic Feature:

1. The images of desired structures can be isolated limited to certain depths.
2. Adjust the contrast and resolution.

Disadvantage:

1. Limited information available
2. Application of this technique is still in research phase.

3. Magnetic Resonance Imaging:

Magnetic resonance imaging (MRI) was first described in 1946, by Lauterbur, based on the phenomenon of nuclear magnetic resonance. In the field of dental implantology, its application is still a recent origin.

MRI differentiates the inferior alveolar canal and neurovascular bundle from adjacent trabecular bone, and visualizes the fat in the trabecular bone.[10] The radiation hazard in this is also avoided. Pre-surgical assessment was proposed by Tesla.

Contraindication:

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In patients with ferromagnetic implants as there is a risk of dislodgement.

First trimester of pregnancy.

Patient with cardiac pacemaker.

Conclusion:

In the recent years, the dental implant treatment has shown many new successful changes. Probably, this success is attributed after increasing imaging technology that can help in all phases of surgery. In future, this imaging technology is expected to be at low cost so that it will be easy for clinicians to plan complete implant treatment.

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