Review Article

Imaging in implantology

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Success in implant placement largely depends on presurgical evaluation and treatment planning. One can use a number of tools for this purpose. Imaging is an irreplaceable part of this armentarium. Today both film and filmless imaging techniques are used. This article highlights the evolution of various implant-imaging modalities from plain film radiography to the present 3D imaging.

Key words: Computed tomography, implant, magnetic resonance imaging, radiograph

The success of any surgical implant procedure depends on careful selection and preparation of the patient. Imaging is an irrefutable part of preoperative implant assessment to determine feasibility of fixture installment. It is one of the most accurate means by which the clinician can assess the morphologic features of the proposed fixture site, select implant of appropriate size and evaluate the fixture periodically after its placement.

The assessment includes

- appraisal of proposed implant site,
- determination of bone quantity and quality,
- assessing inclination of alveolar process,
- location of adjacent anatomic structures,
- detect existing pathology.[1-3]

This paper gives a brief insight into the various imaging modalities, which have been applied in implantology.

PLAIN FILM RADIOGRAPHY

It is still the most widely used modality for pre and postoperative implant assessment. Both periapical [Figure 1] and occlusal radiographs [Figure 2] are known to provide the best image details with minimal geometric distortion of all the available modalities.[1,4] They can resolve more than 20 pairs of lines per millimeter which is twice the resolving power of extraoral radiograph.

PERIAPICAL RADIOGRAPH

Features

- Provide detailed information regarding the dimensions in length and height of available bone in small sections.
- They are indicated for single tooth replacement.

Disadvantages

- It is difficult to locate the inferior alveolar canal in the first molar region.
- Correct positioning of film is difficult in edentulous region.

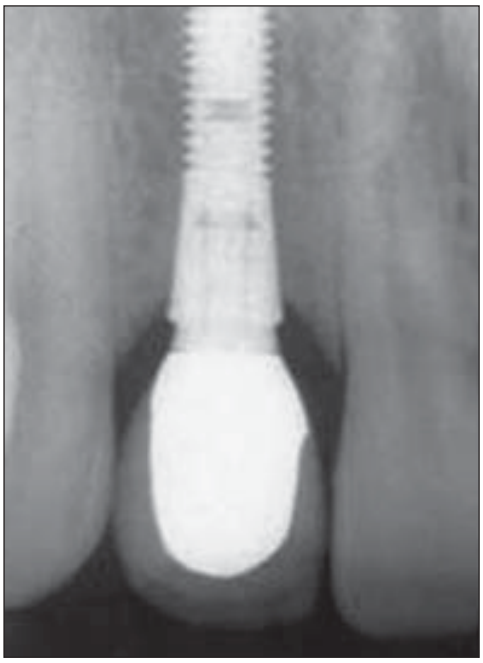

Figure 1: Intraoral periapical radiograph displaying the implant placed at the site of 11, and its relation to adjacent structures

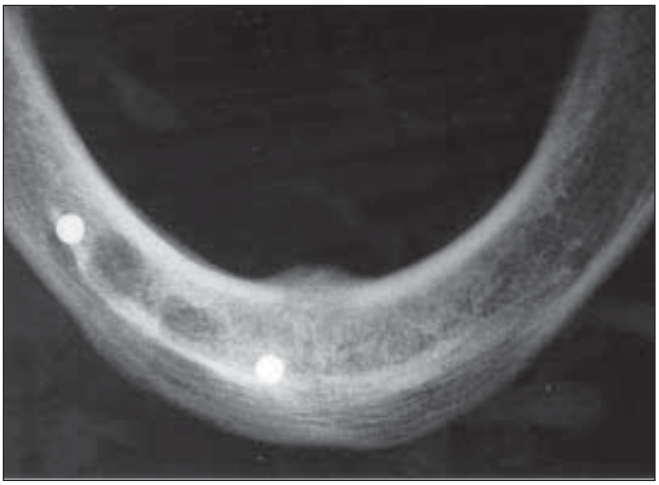

Figure 2: Occlusal radiograph taken with the surgical guide in place. Proposed implant site is identified using the radiopaque marker incorporated in the guide

- They do not give information regarding the buccolingual dimension.
- This modality is limited by its 2D nature.

OCCLUSAL RADIOGRAPH

Features

- Usually used in conjunction with the periapical radiographs.
- They show the buccolingual width between the extremes of buccal and lingual cortical plates.

Disadvantages

It fails to show the medial and lateral extent of cortical bone delineating the alveolar process as it displays only the extremes of the cortical plate.

- This modality is limited by its 2D nature.

PANORAMIC RADIOGRAPH

They display image slices through the jaws by producing a single image of the maxilla and mandible and their supporting structures in a frontal plane [Figure 3].

Features

- They display anatomic structures like nasal cavity, maxillary sinus, inferior alveolar canal and mental foramen.
- Indicated when multiple implant placements are planned.

Disadvantages

- The resolution is lesser when compared to intraoral radiograph.
- A 10-20% image magnification occurs, which is nonuniform. This magnification is undesirable for both implant selection and implant site assessments.
- Geometric distortion and overlapping of images of teeth can occur.
- Overlapping of anterior region by vertebral column occurs.[5]

CEPHALOMETRIC RADIOGRAPH

It displays an image of the skull and facial bones in the mid-saggital plane [Figure 4].

Features

- It provides more accurately the information on inclination, height and width of alveolar bone at the midline, when compared to panoramic radiographs.[1]

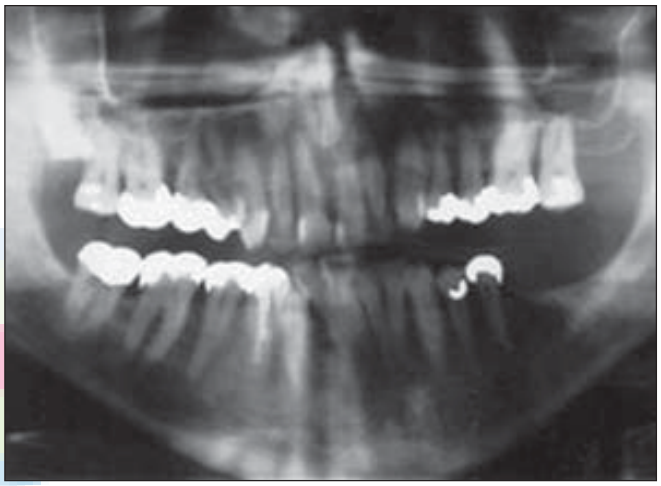

Figure 3: Preoperative panoramic radiograph

Figure 4: Preoperative lateral cephalometric radiograph

- 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.

Disadvantages

- A 6-15% image magnification occurs which is undesirable as it leads to measurement errors of implant site.
- Image resolution is less when compared to intraoral radiographs.[2]

CONVENTIONAL TOMOGRAPHY

Conventional film-based tomography is designed to obtain clear images of structures lying within a plane of interest.

Features

- It has been successfully applied to dental implant diagnostics for accurate assessment of alveolar bone height, width and inclination.
- It can assess both the quality and the quantity of bone.
- It gives information regarding the spatial relationship of vital structures.

Disadvantages

- Insufficient contrast when compared to intraoral radiographs.
- It is an expensive modality.
- An expert radiologist is needed to interpret the image.[3]

DIGITAL RADIOGRAPHY

It was first introduced in 1987 and became popular very soon. In this modality, the conventional film has been replaced by a 'charged couple device' (CCD).

Features

- It allows rapid acquisition of images.
- Postacquisition enhancement is possible.
- Ease of storage, retrieval and transmission of images to remote site from the database.[1,6]

Disadvantages

- Digital radiography lacks the resolution of film radiography.
- It has a much smaller active image area (17 × 26 mm) when compared to IOPA film (32 × 41 mm).
- There are very few studies on the use of this technique for presurgical site evaluation.

COMPUTED TOMOGRAPHY

Considering the new age tool, it blends the concept of thin layer radiography (tomography) with computer synthesis of image.[7] 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 [Figure 5].

Features

- 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.
- The information provided is a life size image, which is highly desirable for ease of measurements.[2,5,7,8]

Disadvantages

- It is an expensive modality.
- An expert radiologist required to interpret the image.
- Highradiation dosage when compared to conventional radiographic technique.
- Patient's head position must remain constant throughout the entire imaging process of about 15-20 min.

Recent advances in computed tomography

Cone beam CT is a relatively newer modality. It uses a conical beam and reconstructs the image in any

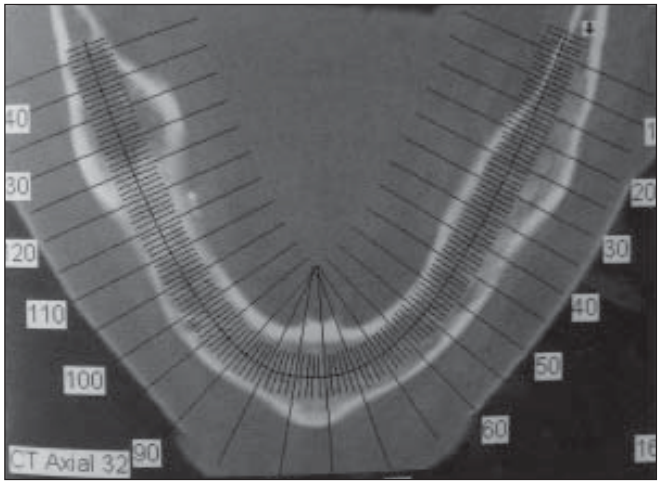

Figure 5: The CT image reformatted in an axial plane

direction using special software. It gives all the information of a CT but, at 1/8th the radiation dose and at a lower cost 9.

Microtomograph, another modification of CT is especially useful in acquiring serial sections of bone-implant interface.[9]

Multislice helical CT offers higher accuracy of images when compared to CT.[10]

TUNED APERTURE COMPUTED TOMOGRAPHY

It's a new and promising imaging modality, which is based on the principles of digital tomosynthesis.[11] The tuned aperture computed tomography (TACT) can selectively examine small segments without exposing entire axial plane[12] [Figure 6].

Features

- It can isolate images of desired structures limited to certain depths.
- It has the ability to accommodate patients' motion between exposures (unlike CT).
- Flexibility to adjust contrast and resolution.[5,6,8]

Disadvantages

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

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging (MRI) is based on the phenomenon of nuclear magnetic resonance (NMR). First described in 1946, its application in implantology is however of recent origin.[13]

Features

- 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.

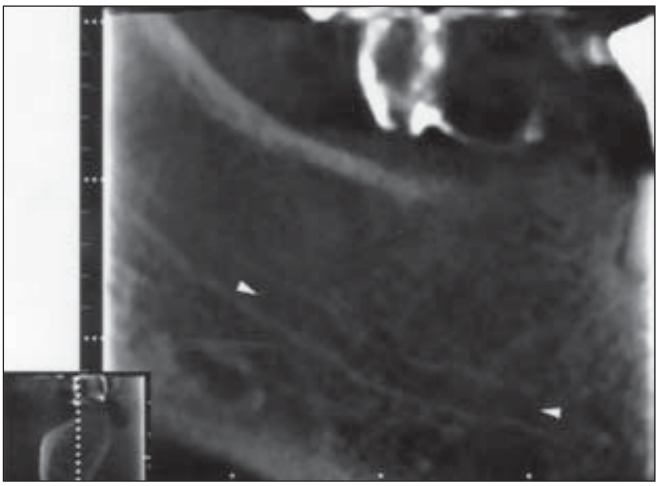

Figure 6: Tuned aperture tomography image displaying the inferior alveolar canal and it's distance from proposed implant site

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.[2]

CONCLUSION

Today's clinician has a wide array of diagnostic tools at his disposal. The CT gives the best information of the available modalities.[14] More commonly though a combination of intraoral periapical radiograph and a panoramic radiograph is used. To date no modality has been deemed perfect. So, the clinician has to carefully weight the pros and cons of each modality. The future for further development of imaging techniques specific for application in implantology is bright. We can definitely expect much more accurate, faster and safer modalities at lower cost to come into the field soon.

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