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Digital Implantology: A Review of Radiographic Assessment

Pal Ankita[1], Vashist Shairy[2], Singh Vanshika[3], Yadav Kunal[4], Jha Divya UK[5], Bhardwaj Anupam[6]

[1]Reader, Department of prosthodontics and Crown & bridge, Santosh Dental College and Hospital, Santosh Deemed to be University Ghaziabad

[2]Assistant Professor, Department of Prosthodontics and Crown & Bridge, School of Dental Sciences, Sharda University

[3]Post Graduate Student, Department of Prosthodontics and Crown & Bridge, School of Dental Sciences, Sharda University

[4] Private Practitioner and Consultant, Department of pedodontics and Preventive Dentistry, Varanasi

[5] Private Practitioner and Consultant, Department of Prosthodontics and Crown & Bridge, Noida

[6]Assistant Professor, Department of Oral and Maxillofacial Surgery, Santosh Dental College and Hospital, Santosh Deemed to be University Ghaziabad

Corresponding Author:

Dr. Anupam Bharadwaj, Assistant Professor, Department of Oral and Maxillofacial Surgery, Santosh Dental College and Hospital, Santosh Deemed to be University Ghaziabad.

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KEYWORDS

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ABSTRACT:

Imaging techniques used in dentistry are an essential section of comprehensive patient care. Diagnostic imaging is an indispensable component of implant treatment planning. The protocol for an efficacious implant is one that determines osseointegrationas well as optimal position of the implant for the fabrication of an esthetic and functional restoration. It has long been documented that meticulous presurgical evaluation andplanning are essential to attain predictable results. This becomes possible with the help of radiographs(intraoral and extraoral), computed tomography, magnetic resonance imaging. Imagingtechniques enable the dental professional to recognize many conditions that may otherwise go undetected clinically. The use of tomography and computed tomography (CT) provided practitioners with the ability to assess the quantity and quality of bone and critical anatomic structures before surgery. This review will highpoint the importance of digital radiography in placement of implants, assessing the location, length, width of implant along with the density of the bone related to the implant placement.

INTRODUCTION

Diagnostic imaging is an essential component of implant treatment planning. Until the late 1980s, conventional radiographic techniques such as intraoral, cephalometric and panoramic views have been the accepted standard. Since then, developments in cross-sectional imaging techniques, such as spiral tomography and reformatted computerize tomograms have become increasingly popular in the preoperative assessment and planning of implant patients.[1]

Imaging techniques used in dentistry are a necessary component of comprehensive patient care. This becomes possible with the help of radiographs(intraoral and extraoral), computed tomography, magnetic resonance imaging. Imaging techniques enable the dental professional to identify many conditions that may otherwise go undetected clinically.

General uses are to detect lesions, disease and conditions of teeth and surrounding structures that cannot be identified clinically to confirm and classify or foreign objects, to localize lesions or foreign objects to provide information during dental procedures, to evaluate growth and development, to document the condition of patient at a specific point of time. [2]

The protocol for a successful implant is one that demonstrates osseointegration as well as optimal position of the implant for the fabrication of an esthetic and functional restoration. It has long been recognized that meticulous presurgical evaluation andplanning are essential to achieve predictable results. First, implants were placed by useof simple periapical and panoramic radiographs.[3] The use of tomography and computed tomography (CT) provided practitioners with the ability to assess the quantity and quality of bone and critical anatomic structures before surgery.

With CT scans, patients were scanned with an intra-oral template containing radiopaque markers indicating the relationship of available bone to the final prosthesis. Initially, intracoronal markers such as ball bearings and gutta percha were incorporated into the template to assist in identifying the pending implant site and to calculate the percentage of radiographic magnification. Later, barium sulfate was incorporated into the acrylic resin templates, and intracoronal cylinders (Stent guide tubes; Implant Innovations, West Palm Beach, Fla.) were used to guide the surgeon during placement.[2]

The current literature will highlight the importance of digital radiography in placement of implants, assessing the location, length, width of implant along with the density of the bone related to the implant placement site, and will also discuss the parameter of implant placement in relation to prosthetic design and critical anatomical landmarks.

TYPES OF DIGITAL IMAGING

- **RADIOVISIOGRAPHY (RVG)**

The radiovisiography (RVG) was the very first imaging system introduced in digital dental radiography[4]. Digital radiography is a technique which produces radiographic image using a sensor with solid-state technology, breaking it into electronic pieces, displaying and storing the image using software in computer system. Three types of digital radiography systems have been promoted in dental imaging:

- CCD-Charge Coupled Device (direct system).
- CMOS Complementary Metal Oxide Semiconductor (direct system).
- (PSP-photo-stimulable phosphor (indirect system).

Radiation dose reduction (up to 80%, when compared with conventional plain film radiography) is considered to be one of the most advantageous outcomes of digital radiography.[5] The dose reduction for intraoral digital x-ray has been reported in the range of 50% -60% [6, 7] when compared to E-speed film and for extra-oral digital x- ray, it is found up to 50% -70%, when compared to film-screen combinations.[8,9]

TOMOGRAPHY

- **COMPUTED TOMOGRAPHY (CT)**

This is a body section radiography technique that enables visualization of a section of the patient's anatomy by blurring regions of the patient's anatomy above and below the section of interest. Panoramic imaging produces a single tomographic imagecovering broad areas of the jaws and associated structures, this also helps to identify any pathologic condition during the treatment procedure in implantology.[14]

CT was invented by Sir Hounsfield and was announced to the imaging world in1972. CT produces axial images of a patient's anatomy. Axial images are produced perpendicular to the long axis of the body. CT is a prospectively digital imaging technique. The x-ray source is attached rigidly to a fan-beam geometry detector array, which rotates 360 degrees around the patient and collects data.[11]

The individual element of the CT image is called a voxel, which has a value, referred to in Hounsfield units, that describes the density of the CT image at that point. Each voxel contains 12 bits of data and ranges from -1000 (air) to +3000 (enamel dental materials) Hounsfield units.[12]

CT scanner system is containing a radiographic tube connected to a series of scintillation detectors or ionization chambers. The patient is moved inside the circular aperture in the center of the gantry. The tube head and reciprocal detectors within the gantry either rotate synchronously around the patient, or the detectors may form a continuous ring around the patient and the X-ray tube may move in a circle within

the detector ring.[10] In spiral CT, the patient is moved continuously through the rotating gantry and image data are obtained as a “spiral” or “helix” rather than in the form of aseries of slices. Spiral CT may help in interpretation of the close relationship between maxillary sinus disease and adjacent periodontal defects and their treatment. Also, CT scan can accurately differentiate between intrinsic and extrinsic salivary tumors and is used for tumor’s staging.[10,13]

In contrast to hard copies of the scans, one of the advantages of the computer- based image software programs (eg Simplant) are that it is possible to produce images of implants (and their restorative components) which can then be ‘placed’ within the CT scan. When used in conjunction with a radiographic stent the possibility of reproducing the orientation envisaged at the planning stage is greatly increased.[14]

Tissue Characterization

Tissue	**Hounsfield Units**
Air	1000
Water	0
Muscle	35-70
Fibrous tissue	60-90
Cartilage	80-130
Trabecular bone	150-900
Cortical bone	900-1800
Dentin	1600-2400
Enamel	2500-3000

Density	**Hounsfield Units**	**Region of Interest**
D1	1250	Anterior Mandible
D2	850-1250	Posterior Mandible / AnteriorMaxilla
D3	350-850	Posterior Mandible / AnteriorMaxilla
D4	150-350	Posterior Maxilla
D5	<150	Tuberosity Region

CT enables the evaluation of proposed implant sites and provides diagnostic information that other imaging or combinations of imaging techniques cannot provide. The utility of CT for dental implant treatment planning was evident, but the access to these imaging techniques was limited.

- **DENTASCAN**

DentaScan is a computed tomography (CT) software program that allows the mandible and maxilla to be imaged in three planes: axial, panoramic and cross-sectional introduced in the mid-1980s, DentaScan offered improvements in the evaluation of theosseous mandible and maxilla and has been reported to be useful in head and neck surgery.[15]

The radiologist or technologist simply indicates the curvature of themandibular or maxillary arch and the computer is programmed to generate referenced cross-sectional and tangential/panoramic images of the alveolus along with three- dimensional images of the arch.[14]

This technique provides a wealth of diagnostic information that is accurate, detailed, and specific. Usually, a diagnostic template is necessary to take full advantageof the technique. CT-enables identification of disease, determination of bone quantity, determination ofbone quality, identification of critical structures at the proposed regions, and determination of the position and orientation of the dental implants.[14]

- **TUNED APERTURE COMPUTED TOMOGRAPHY (TACT)**

TACT is comparatively a simple, faster method for reconstructing tomographic images, introduced by Webber and colleagues. It utilizes the mechanism of

tomosynthesis and optical-aperture theory. TACT needs 2-D periapical radiographs obtained from different projection angles as base images and allows retrospective creation of longitudinal tomographic slices (TACT-S) lining up in the Z axis of the concerned area. It generally results true 3-D data from any number of arbitrarily oriented 2-D projections. It does not produce artifacts like starburst patterns as seen with metallic restorations in case of CT. It has also been proved that TACT can be a better option for analyzing trauma induced radicular fractures and mandibular fractures.TACT can also be alternative to CT for pre-surgical implant assessment.[10]

- **SCAN-ORA**

Scan ora is an example of a new generation of sophisticated tomographic devices most similar to conventional DPT machines, but with facilities to generate highquality sectional images. In contrast to CT scanning where the sectional images are software generated, the Scan Ora produces a tomographic image directly onto film. It uses complex broad beam spiral tomography and is able to scan in multiple planes. The scans are computer controlled with automatic execution but still rely heavily on good patient positioning and experience in using the machine. The patient's head is carefullyaligned within the device and this position recorded with skin markers and light beams.A DPT image is produced from which the sites which require sectional tomographic data are determined. The patient is repositioned in exactly the same alignment and the appropriate tomographic programmed selected for the chosen region of the jaw.[14]

The Scan Ora magnification is ´1.3 or ´1.7 for routine DPTs but is ´1.7 for all sectional images. Tomographic sections are normally 2 mm or 4 mm in thickness. As with all tomograms the image produced includes adjacent structures which are not within the focal trough which therefore appear blurred and out of focus. Because the scan sections are thicker and fewer the overall patient dose is much less than a CT scan.The amount of detailed information provided is considerably less than a CT scan but isusually sufficient for all but the most complex cases.[8]

- **CONE BEAM COMPUTED TOMOGRAPHY (CBCT)**

In CBCT systems, the x-ray beam forms a conical geometry between the source(apex) and the detector (base). This is in contrast to conventional fan-beam geometry, in which the collimator restricts the x-ray beam to approximately 2D geometry. In a fan-beam single-detector arc geometry, data acquisition requires both rotation and z- direction translation of the gantry to eventually construct an image set composed of multiple axial sections. In CBCT systems using a 2D FPD, however, an entire volumetric dataset can be acquired with a single rotation of the gantry. Incident photonson multiple-row detectors in MDCT actually fall on a 2D area of detectors, as with flat- panel detection; indeed, with increasing numbers of rows in MDCT detector arrays, the acquisition geometry actually approximates that of a conebeam system.

Radiation dose of one CBCT scan equals 3-20% that of a conventional CT scan,depending on the equipment used and the area scanned. X-ray tubes of CBCT cost veryless when compared to conventional CT.

Discrete digital model, which is stored as a large 3D array of unit volume elements (**voxels**) **graphics**, an emerging subfield **computer graphics**. Since a pixel (picture element) defines point in two-dimensional space with its x and y coordinates, third z coordinate is needed the word **voxel** derived from words volumetric. Images ofCBCT results in isotropic voxels that can be as small as 0.125 mm. CBCT provides a high spatial resolution of bone and teeth which permits definite understanding of the relationship of the adjacent structures. CBCT has wide applications in dentistry. Highresolution of CBCT imaging determines variety of cysts, tumors, infections, developmental anomalies and traumatic injuries involving the maxillo-facial tissues plus evaluating dental and osseous disease in the jaws and temporo-mandibular joints and treatment planning for dental implants.[10]

Conebeam CT (CBCT) is an advancement in CT imaging that has begun to emerge as a potentially low-dose cross-sectional technique for visualizing bony structures in the head and neck. These systems are distinguished by a conical x-ray beam geometry and the use of 3D reconstruction algorithms; most recent

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models are also fit with FPDs. As they are employed for specific imaging tasks in restricted anatomic regions such as the head and neck, preliminary research suggests that they can produce images with high isotropic spatial resolution while delivering a relatively lowpatient dose.[14]

MAGNETIC RESONANCE IMAGING (MRI)

MRI is a technique developed in medical imaging that is probably the most innovative and revolutionary other than CT. MRI is a technique the protons of the body using magnetic fields, radio frequencies, electromagnetic detectors, and computers. The technique was announced first by **Lauterbur in 1972**.[16]

MRI is a three-dimensional imaging technique with an electronic image acquisition process and a resulting digital image. The image sequences used to obtain magnetic resonance images can be varied to obtain fat, water, or balanced imaging of the patient's anatomy. Resulting magnetic resonance images are the antithesis of CT images with cortical bone appearing dark or black and fat or water appearing bright orwhite. Like CT, MRI is a quantitatively accurate technique with exact tomographic sections and no distortion.[17]
The MRI has high contrast sensitivity to soft tissue differences as hydrogen isfound in abundance in soft tissue, but is lacking in most hard tissues and this is the main reason behind MRI replacing the CT for soft tissues imaging. A recent introduction in MRI technology is called Sweep Imaging with Fourier Transform to assess the dental structures. It can simultaneously image both hard and soft dental tissues with high resolution with less scan time.

MRI is used in implant imaging as a secondary imaging technique when primaryimaging techniques such as complex tomography, CT, or ICT fai1.53,5%omplex tomography fails to differentiate the inferior alveolar canal in 60% of implant cases, and CT fails to differentiate the inferior alveolar canal in about 2% of implant cases. Failure to differentiate the inferior alveolar canal may be caused by osteoporotic trabecular bone and poorly corticated inferior alveolar canal.[14]

MRI visualizes the fat in trabecular bone and differentiates the inferior alveolar canal and neurovascular bundle from the adjacent trabecular bone. Double-scout MRI protocols with volume and oriented cross-sectional imaging of the mandible produce orthogonal quantitative contiguous images of the proposed implant sites. Oriented MRI of the posterior mandible is dimensionally quantitative and enables spatial differentiation between critical structures and the proposed implant site. MRI is not useful in characterizing bone mineralization or as a high-yield technique for identifying bone or dental disease.[14]

PERIAPICAL RADIOGRAPH

It is commonly used. The use of a digital sensor with a standard long cone parallel technique yields useful information during implant osteotomy preparation, especially when adjacent to existing natural teeth or other vital structures. (inferior alveolar nerve, roots, maxillary antrurn,) patient generally can be imaged at chairside with periapical radiography to determine implant/osteotomy depth, position, and orientation.[14]

Corrections for magnification similar are necessary to quantify the depth of the osteotomy. Digital periapical image receptors enable virtually instantaneous image acquisition, produce image quality similar to that of dental film, and enable the surgical procedure to proceed without undue delay. In addition, the digital images acquired can be viewed with considerable magnification on a video monitor in the surgery suite.[27]

Additional features of digital imaging, such as image enhancement and the use of digital measuring techniques, can help the surgeon in establishing the optimum depthand orientation of implants the Digital periapical and film periapical radiographs provide images of a small region of the patient's anatomy.

For extensive implant procedures that may involve the entire jaw, both jaws, large donor graft sites are sinus graft augmentation, panoramic radiography provides a more global view of patient’s anatomy.[14]

Periapical radiography is used to find the presence of pathosis and location of anatomic structures around the implant site, and evaluate implants postoperatively. It is

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used to determine vertical height of the edentulous region, architecture, and bone quality. For the edentulous and resorbed jawbone, however, this technique can be difficult as adequate support for positioning the instrument is not available. Attaching a film holder to the tube, while carefully positioning the jaw bone under investigation parallel to the film, may offer a solution.

CEPHALOMETRIC RADIOGRAPHY

Lateral cephalometric radiography helps in the analysis of the quality of the bony site (ratio of compact to cancellous bone), especially in the anterior region of the mandible. Though it gives limited information about the symphyseal area, the inclination and buccolingual dimensions of the anterior jawbone region can be obtained. These images do not provide useful information when planning placement of implants lateral to the mid-sagittal plane. Overly optimistic bone volume assessmentsare created due to the presence of genial tubercles.[18]

The advantage of lateral cephalometric radiographs is that they outline the geometry of the alveolus in the anterior region and the relationship of the lingual plate to the patient's skeletal anatomy.

The disadvantages of this technique are that it is not useful for demonstrating the bone quality and only demonstrates a cross-sectional image of the alveolus where the central rays of the X-ray device are tangent to the alveolus. Other disadvantages include low power magnification and superimposition of images (lack of distinctiveness of the image due to overlapping of the structures)

PANORAMIC RADIOGRAPHY

These are narrow beam rotational tomographs, which use two or more centers of rotation with a predefined focal trough, to produce an image of both the upper and lower jaws. Optimal patient positioning is crucial in this procedure because jawpositioning errors in the sagittal plane can occur easily, especially in the edentulous patient. It provides an approximation of bone height, vital structures, and any pathological conditions that may be present. Advantages of panoramic radiography are that they provide information on opposing landmarks, vertical height of the bone, assess crestal alveolar bone and cortical boundaries, and evaluate gross anatomy of the jaws and related pathologic conditions. Disadvantages of this modality are distortion of the visualized structures, low level of reproducibility, 1.1-1.7 times magnification of the structures, difficulty in assessing hard tissue morphology and density of the bone, littleinformation about the buccolingual cross-sectional dimension, inadequate identification of critical structures, and no data of spatial relationships between the structures.

Disadvantages of panaromic radiography:

- Patient must leave the surgical theatre and stand or still for the panoramic procedure.
- Also has less resolution than periapical or digital periapical radiography and suffers from magnification and distortion.[14]

Periapical radiographs are helpful to assess proper connection of the implant components and to identify crestal bone level changes during the early loading phasesof treatment. Baseline radiographs then can be used for comparison and monitoring ofpreimplant bone levels.[14]

A radiographic examination also is performed to determine whether the metal framework or final restoration is seated completely and whether the margins are acceptable around the implants and teeth. The important portion to image is the crestalaspect of the implant, not the apex.[14]

ZONOGRAPHY

Zonography is a modification of the panoramic X-ray machine and generates cross-sectional image of the jaws. The tomographic layer is around 5 mm. Zonographyallows appreciation of spatial relationship between the critical structures and theimplant site.

However, the disadvantages are presence of relatively thick tomographic layers, blurred adjacent structures superimposed on the image, and inability to identify the differences in bone densities or presence of disease pathology at the implant site.

IMPORTANCE OF IMAGING TECHNIQUE IN IMPLANTOLOGY

Endosseous dental implant therapy rapidly has become the prosthetic standard of care for a vast array of clinical

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applications, we are faced with the challenge of developing dynamic treatment planning protocols.[18] When considering implant treatment in a particular case, the practitioner has to evaluate whether oral implants areindicated: (i) for this particular patient; (ii) in this specific oral situation; and (iii) within the framework of a comprehensive reconstructive treatment planning. However, reports about alarming implant failures are emerging in the **literature** which is mainly related to implant malpositioning as a result of poor treatment planning. The application of a systematic patient assessment and a straight forward diagnostic planning procedure facilitates an optimal treatment recommendation and helps to avoid failures and complications.[17]

Implant dentistry is similar to conventional dentistry in that the first step of theprocess consists of collection of data. A systemic approach to patient assessment is required. Diagnostic imaging and technique help to develop and implement a cohesiveand comprehensive treatment plan for the implant procedure. Implant placement largelydepends on presurgical evaluation and treatment planning. It is the step that determinesthe outcome of the case and influences the final success. One can use a number of toolsfor this purpose. Imaging is an irreplaceable part of this armamentarium. Today both filmand filmless imaging techniques are used. In combination with clinical examination, they may provide enough information to plan treatment without resorting to more complex techniques. Diagnostic imaging and techniques help develop and implement a cohesive and comprehensive treatment plan for the implant team and the patient.

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 accuratemeans by which the clinician can assess the morphologic features of the proposed fixture site, select implant of appropriate size and evaluate the fixture periodically afterits placement.[14] The assessment includes: appraisal of proposed implant site, determination of bone quantity and quality, assessing inclination of alveolar process, location of adjacentanatomic structures and to detect existing pathology.

Imaging Objectives

The objectives of diagnostic imaging depend on a number of factors, includingthe amount and type of information required and the time period of the treatment rendered. The decision of when to image along with which imaging modality to use depends on the integration of these factors and can be organized into three phases.[14]

Phase one is termed ***preprosthetic implant imaging*** and involves all pastradiologic examinations along with new radiologic examinations chosen to assist the implant team in determining the patient's final and comprehensive treatment plan. Theobjectives of this phase of imaging include all necessary surgical and prosthetic information to determine the quantity, quality, and angulations of bone; the relationship of critical structures to the prospective implant sites; and the presence or absence of disease at the proposed surgery sites.[14]
Phase two is termed ***surgical and interventional implant imaging*** and isfocused on assisting in the surgical and prosthetic intervention of the patient. The objectives of this phase of imaging are to evaluate the surgery sites during and immediately after surgery, assist in the optimal position and orientation of dental implants, evaluate the healing and integration phase of implant surgery, and ensure thatabutment position and prosthesis fabrication are correct.[14]

Phase three is termed *postprosthetic implant imaging:* This phase commences just after the prosthesis placement and continues as long as the implants remain in the jaws. The objectives of this phase of imaging are to evaluate the long-term maintenanceof implant rigid fixation and function, including the crestal bone levels around each implant, and to evaluate the implant complex.[14]

Imaging modalities

The decision to image the patient is based on the patient's clinical needs. Once a decision had been made to obtain images, the imaging modality is used that yields thenecessary diagnostic information related to the patient's clinical needs and results in theleast radiologic risk. Maximizing the ratio of benefit to risk for imaging examinations is a fundamental tenet of radiology.

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Examinations known to produce this result are not necessarily the examinations that cost the least, are in proximity to the dentist, or produce the lowest radiation exposure. However, they enable the dentist to provide theproper care or treatment for the patient.[14]

Imaging modalities includes[14] Periapical radiograph, Panoramic radiography, Occlusal radiography, Cephalometric radiography, tomographic radiography, computed tomography, magnetic resonance imaging (MRI), interactive computedtomography (ICT), Cone Beam Computed Tomography (CBCT). These imaging modalities can be described as analog or digital and two- or three- dimensional. Most dentists are more familiar with analog two- dimensional imaging.

Analog imaging modalities are two-dimensional systems that use x-ray film or intensifying screens as the image receptors. The image quality of these systems is characterized by resolution/modulation transfer function, contrast1H and D curve, noiselweiner spectrum, and sensitivity.[14]

A digital three-dimensional image is described by an image matrix that has individual image/picture elements called ***voxels***. A digital three-dimensional image is described not only by its width and height and pixels (i.e., 512 x 512) but also by its depth thickness. An imaging volume or three-dimensional characterization of thepatient is produced by contiguous images, which produce a three-dimensional structureof volume elements (i.e., CT, MRI, and ICT). Each volume element has a value that describes its intensity level. Typically, three-dimensional modalities have an intensity scale of 12 bits or 4096 values.[14]

PREPROSTHETIC IMAGING

The global objective of this phase of treatment is to Develop and implement a treatment plan for the patient that enables restoration of the patient's function and esthetics by the accurate and strategic placement of dental implants.[14]

The *specific objectives* of pre prosthetic imaging (screening radiography) are to: identify disease, determine bone quantity, determine bone density, identify critical structures at the proposed implant regions, determine the optimum position of implant placement relative to occlusal loads, The overall status of teeth and supporting bone, the sites where it is possible to place implants using a straight-forward protocol, Those sites where it is unlikely that implants can be placed without using complex procedures such as grafting, the sites where it is inadvisable to recommend implants.[8]

PLANAR IMAGING

MODALITIES

Planar imaging modalities include periapical, bite-wing, occlusal, and cephalometric imaging and are simply two-dimensional projections of the patient's anatomy.[14]

Quasi-three-dimensional imaging modalities include x-ray tomography and some cross-sectional panoramic imaging techniques. These techniques produce a number ofclosely spaced tomographic images, and the three-dimensional perspective of the patient's anatomy is developed by viewing each image and mentally filling in the gaps.

Three-dimensional imaging techniques include CT and MRI and enable the dentist toview a volume of the patient's anatomy. These techniques are quantitatively accurate, and three-dimensional models of the patient's anatomy can be derived from the image data and used to produce stereotactic surgical guides and prosthetic frameworks.[8]

DIAGNOSTIC TEMPLATES

The purpose of diagnostic radiographic templates is to incorporate the patient'sproposed treatment plan into the radiographic examination. This requires development of tentative treatment plan before the imaging procedure. The diagnostic template a useful tool and many times the determining factor in the final treatment plan of the patient. The preprosthetic imaging procedure enables evaluation of the proposedimplant site at the ideal position and orientation identified by radiographic markers incorporated into the template.[14]

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SURGICAL AND INTERVENTIONAL IMAGING

Surgical and interventional imaging involves imaging the patient during and after surgical procedure and during placement of prosthesis.[14] The important aspect of postprosthetic implant imaging is to evaluate the status and prognosis of the dental implant. The bone adjacent to the dental implant should be evaluated regularly, for changes in mineralization or bone volume. Changes in bone mineralization in the region of bone adjacent to the dental implant may indicate successful integration, fibrous tissue interfaces, inflammation, infection, loss of crestal bone volume adjacent to the dental implant, excessive functional loading, or parafunctional loading.[14]

Loss of cylindrical bone volume adjacent to the implant surface may indicate excessive axial or shear loading, bone damage during implant placement, integration failure with an epithelial bone implant interface, inflammation, or infection. During theprosthetic phase it is essential to ensure full seating of components and frameworks. This may not be possible by direct vision because of the soft tissues, and radiographs provide the only method of checking fit.[14]

CONCLUSION

Implant imaging provides accurate and reliable diagnostic information of the patient's anatomy at the proposed implant site. Standard projections include intra-oral (periapical, occlusal) and extra-oral (panoramic, lateral cephalometric) radiographs. More complex imaging techniques include conventional X-rays, computed tomography (CT), and cone beam computed tomography (CBCT). Multiple factors influence the selection of radiographic techniques for a particular case including cost, availability, radiation exposure, and patient's anatomy.

Literature suggests that when evaluating the alveolar ridge, the radiologist should also determine the angle that the ridge makes with the vertical axis. This is important because the occlusal force vector that acts upon the fixture should be parallelto the vertical axis through the alveolar ridge. If excess angulation exists between the vertical axis through the fixture than that through the alveolar ridge, the resultant forcevector may fall in an area which is unable to withstand the occlusal forces and breakdown of the surrounding bone may occur. The various radiographic methods detailed here have their unique characteristics and each of these applied judiciously, where required, will help the diagnostician as well as the clinician to accurately plan, execute, and evaluate implant treatment.

Communication among clinicians and experts for second opinion and/or interaction during planning of oral implants could also benefit from data transfer through any type of network. The choice of pre-implant imaging must be considered carefully due to the radiation dose, the cost of each examination and the anticipated information that may be provided by the imaging study. The risk-to-benefit ratio should be determined on an individual basis so as to maximize success. With the excellent imaging modalities that exist today, one can enhance the success of implant placement. Selection of an appropriate imaging modality should be made based on thetype and number of implants, location of the implant, and surrounding anatomy. As in the case of all imaging techniques, appropriate selection criteria must be applied before selecting one which is most suitable for each patient.

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