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Radiographic Advances in Implant Treatment Planning

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ABSTRACT
Over the past 25 years, dental implants have transformed the field of dentistry. The use of implant-supported oral restorations as a treatment option for patients with partial or complete tooth loss has increased. For the purpose of determining the bone support for endosseous dental implants, radiographic assessment is crucial. For evaluating the implant recipient site, a variety of intraoral and extraoral radiography techniques are used. The ability to see the implant site in the mesio-distal, bucco-lingual, and superior dimensions; the capability to take precise measurements; the capacity to assess cortical thickness and trabecular bone density; reasonable patient access and cost; and minimum radiation risk.
Keywords: *Treatment Planning, Radiography, Digital Radiography, OPG, MRI.*

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INTRODUCTION

Over the past 25 years, dental implants have transformed the field of dentistry. The use of implant-supported oral restorations as a treatment option for patients with partial or complete tooth loss, severe bone loss, and in areas that were previously thought to be not appropriate for the placement of implant. Techniques for bone augmentation, regeneration, and soft tissue regeneration have made this conceivable [1]. Patient assessment and thoughtful treatment planning are directly related to the successful use of dental implants in patient care [2]. To support a dental prosthesis, a dental implant connects with the bone of the jaw or skull. Patient assessment and thoughtful treatment planning are directly related to the success of dental implants in the treatment of patients.

For the purpose of determining the bone support for end osseous dental implants, radiographic assessment is crucial. For evaluating the implant recipient site, various intra and extra-oral radiographic techniques, such as periapical, occlusal, panoramic, and motion tomography, are frequently accessible. However, the data is based on geometric bi-dimensional (2D) projections. The following key qualities should be present in the optimum imaging approach for pre-implant bone evaluation: Seeing site of the implant in regions like mesiodistal, buccolingual, and superior dimensions; the capability to take precise dimensions; the ability to assess cortical thickness and trabecular bone density; reasonable patient access and cost; and minimum radiation risk [3-4].

IMAGING OBJECTIVES

The integration of the phases listed below determines the kind of imaging technique to be used: [5]

PHASE 1: Imaging of pre-prosthetic implants planning the dental implant's diagnosis and therapy can be done during this time. It is necessary to evaluate the patient's toothless site, soft tissue health and bone quality, the amount of accessible bone in the edentulous area, and the required number of dental implants. You can also rule out any pathology of the soft tissues or the bones.

PHASE 2: Intraoperative as well as surgical implant imaging In the surgical phase, the following are assessed: the surgical site for the implant both during and after the procedure, osseo-integration and strength around the implant, the relationship between the implant abutment and the natural teeth and occlusion, the design of the temporary and permanent prosthesis, and the loading of the short term prosthesis.

PHASE 3: Post prosthetic implant imaging after implant loading with a denitive prosthesis, this phase is initiated. This phase includes dental implant and prosthesis maintenance. The implantologist assesses: Using a variety of post-operative imaging technologies imaging technologies, as well as periimplant tissue, crestal bone loss around the implant, and bone health.

For evaluating the implant recipient site, a variety of intra oral and extra oral radiography techniques, such as motion tomography, periapical, occlusal, panoramic, are frequently accessible. However, the data is based on bi-dimensional (2D) projections. 6 Cone beam computed tomography (CBCT), which has lately replaced dental computed tomography (CT), is the most preferred method for preoperative assessment of dental implants. The available bone's quality can be seen with little distortion using multiplanar CT and CBCT, along with the location of significant nearby structures. By doing away with the limitations of traditional X-ray procedures such anatomic lay over and distortion, potential consequences like injury to the neurovascular bundle and maxillary sinus perforation can be avoided.

Due to its excellent spatial resolution and noninvasive nature, CBCT/CT imaging can precisely assess the alveolar ridge's length and width [6]. Finding locations that are advantageous for osseointegration and implant placement, determining the dimensions of the necessary implant(s), and preoperatively identifying regions that require presurgical modifications in order to assist implant placement are also made possible [7-8].

ANATOMIC CONSIDERATIONS

Important structures in the maxilla:

- Alveolar process of maxilla.
- Maxillary sinuses.
- Nasal fossa.
- Nasopalatine canal
- Nasopalatine foramen

Important structures in the mandible:

- Mandibular or inferior alveolar canal.
- Mental foramen.
- Incisive canal.
- Mylohyoid ridge.
- Genial tubercules.

VARIOUS RADIOGRAPHY METHODS:

CONVENTIONAL PERIAPICAL RADIOGRAPHS: It gives precise details on the areas of single implants to determine the position and alignment of the implant, the condition of neighbouring teeth, the size and accessible bone height in small pieces. They offer the benefits of being easily accessible, reasonably priced, and radiation-free. They are of restricted use in illustrating the spatial link between the intended implant location and the structure, as well as in calculating amount and bone density. In areas with ample bone breadth, they are typically advised for treatment planning for single teeth implants [9-10].

DIGITAL RADIOGRAPHY: Direct digital intraoral imaging enables quick intraoral image acquisition, enhancement, transmission to far-off locations, retrieval, and. The downside is that putting the sensor in locations like those next to tori or either adjacent to the tapering arch in the area of the bicuspids is made more challenging by the sensor's size, thickness, and location of the connecting cord[11]

ELECTRONIC OR CCD IMAGING TECHNIQUES: Presurgical implant assessment is accurate with charged couple devices (CCDs). Preoperatively, CCDs provide precise assessment of implant sites; postoperatively, they offer more details regarding osseointegration, and the ply of wire grids aids in determination along with evaluation of bone height. It is possible to rebuild a site's 2/3-D geometry using many photos. Additionally, it makes it possible to see the data on a visual monitor before insertion

DIGITAL SUBTRACTION RADIOGRAPHY: Compared to periapical, it is more accurate in representing dark or light shades of grey, such as changes in bone volume and mineralization. Alveolar bone alterations in the buccal and lingual regions are also shown. However, because to the difficulties in obtaining reproducible periapical, this procedure is only occasionally used in clinical practice [12].

OCCLUSAL RADIOGRAPHY: It is helpful in learning about the width and contour of the toothless site in mandible/maxilla. Additionally, it is used for mapping for multidirectional tomography and at specific implant sites. The drawback is that it only records the largest region of the lower jaw; Very less information is given about the breadth of the bone, which is actually of primary relevance to the surgeon; and the projection cannot be used to gauge the degree of mineralization of trabecular bone [13].

ORTHOPANTOMOGRAM (OPG): Pre-implant evaluation and therapy methods frequently use OPG. OPG uses less radiation and costs less while providing appropriate information. The lower portion of the maxillary sinus, the inferior alveolar nerve, the nasal fossa, and the body of the jaw are all visible on panoramic radiography, which is a curved plane tomographic radiograph. The following benefits of OPG include the ability to assess the initial vertical height of the bone, preliminary estimates of the crestal bone and cortical boundaries, convenience, and procedure's speed , and evaluation of the anatomy of the jaws and associated pathologic findings.[14] OPG has several drawbacks, including an inability to assess

bone mineralization, a lower resolution than traditional or digital peri-apical radiography, inaccurate analysis of the quantitative bone as a result of magnification, and additional setup

ZONOGRAPHY (LIMITED ANGLE LINEAR TOMOGRAPHY): A modification of the radiographic machine is zonography (LIMITED ANGLE LINEAR TOMOGRAPHY). A fragmentary picture of the arches is produced. The layer used for tomography is approximately thick. Zonography has the advantage of enabling understanding of the interaction amongst important structures and the implant site. The drawbacks include the superimposition of indistinct neighbouring structures on the image and the inability to discern between different levels of bone density or the presence of pathology near the implant.[15]

CONVENTIONAL TOMOGRAPHY (BODY SECTION RADIOGRAPHY): Constructed as a cross-sectional imaging technique, conventional tomography aims to produce distinct images of structures present inside a plane of interest [15]. When combined with a cephalostat, uniform magnification, and readily accessible cross-sectional views, it produces predictable imaging geometry. The drawbacks include restricted availability, a longer production time than with conventional panoramic radiography, and a significant requirement for knowledge and training for interpretation of the images. It can be used with one tooth or numerous dental implants in a small space [16].

COMPUTERIZED TOMOGRAPHY (CT):

This advanced radiographic technique offers uniform field of magnification with high contrast images. CT also offers the advantage of easy identification of bone graft sites. In comparison to conventional tomography, CT has the following advantages: uniform magnification, high contrast images, easier recognition of materials associated with bone grafts used in the augmentation of maxillary bone in the region of sinus, contemporaneous multiple implant sites can be studied, as well as software image analysis. The drawbacks include high costs, a dearth of reconstruction software, and higher radiation exposure levels than with traditional tomography.

DENTA SCAN IMAGING10: The mandible and maxilla can be imaged using computed tomography in three different planes of reference: axial, panoramic, and cross-sectional. This unique computer software package is called Denta-Scan. It can be used for ridge augmentation and edentulous ridge, as well as single and multiple implants. Its benefits include the ability to measure crucial quantitative measurements required for implant placement, detection of soft and hard tissue pathologies, localization of anatomical structures, and measurement of bone height and width. Cost and radiation exposure are its drawbacks.

INTERACTIVE COMPUTED TOMOGRAPHY (ICT): ICT stands for INTERACTIVE COMPUTER TOMOGRAPHY, which enables the physician to view images on a computer screen. Additionally, it aids the clinician in determining the alveolus' length and width as well as the quality of the bone. The ability of the doctor and radiologist to collaborate to perform "electronic surgery" is a key component of ICT

TRANSTOMOGRAPHY OR SECTIONAL TOMOGRAPHY: Cutting-edge panoramic machines can provide direct digital transtomographic images by fusing the translational and pendular movements of the beam and detector. Its benefit is that measurements may be taken on the screen and instant outcomes can be retrieved intraoperatively with the aid of a computer programme. This is accomplished by situating the individual using a unique silicon key, which allows for a reduced amount of image distortion in comparison to traditional tomographs and CT scans

TURNED APERTURE COMPUTED TOMOGRAPHY (TACT): (TACT), which is built on the optical aperture theory, is a brand-new, prospective substitute for CT and lm-based dento-alveolar imaging using tomography, which is based on the optical aperture principle. TACT can distinguish the images of required structures limited to specific depths and map the gradually gathered data into a single three-dimensional matrix. It can account for patient movement in between exposures. It has a lot of flexibility when it comes to adjusting resolution and contrast

CBCT (CONE BEAM COMPUTED TOMOGRAPHY): the scanners implemented in the use of CBCT are specifically designed in order to cover the diagnostic and treatment aspects in dental implant therapy. Volumetric tomography is the foundational aspect of scanners used in CBCT 13. They employ the usage of 2D extended digital array and a three-dimensional X-ray beam to create set of 3D volumetric data. It helps in locating the prosthesis and the occlusion related to it. It also impacts the way the implant is placed that is helps in placement of dental implants. CBCT is also helpful in locating jaw anomalies and gives vital information on the bone height, width, and bone quality in a single scan. 9,14,16 benefits of CBCT include: 1) include high resolution, 2)low dose of radiation , 3) less interference made of metal artefacts, 4) lower cost, 5) ease of handling, and accessibility.

MAGNETIC RESONANCE IMAGING (MRI): MRI acts as prominent backup tool, when advanced techniques such as CT and CBCT are inadequate. MRI makes it possible to discriminate amid the canal of the inferior alveolar and the neurovascular bundle and the neighboring trabecular bone. MRI imaging of the posterior jaw permits for visualisation of spatial separation between essential structures as well as intended implant site. The radiation and exposure rate is less in an MRI scan as compared to the traditional

techniques of radiology. Patients who have ferromagnetic implants in their bodies should not have an MRI.

CONCLUSION

The advancements in imaging modalities that exist today, one can enhance the success of implant placement. Depending on the kind and quantity of implants, their site, and the arroximating anatomy and the right imaging modality should be chosen. Before choosing the imaging approach that is best for each patient, like with all imaging procedures, adequate selection criteria must be used.

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