



Review Article

Have conventional dental radiographs lost its charm to modern techniques?

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ABSTRACT

For any dental implant procedure that is being carried out, the success will depend on a thorough pre-operative investigation. The quality, quantity and the volume of available bone at the planned implant site has to be assessed properly when planning a dental implant placement. When we speak of the fore-mentioned aspects pre-surgical imaging and its co-relation to clinical findings help assess the relation to the amount of bone available from underlying vital parts namely the sinus cavities, nasal floor, nerves, teeth and vessels. Different radiographic modalities have been advocated for its assessment. Intra Oral Peri-apical radiograph (two-dimensional) is one such modality that has lost its importance after the introduction of more advanced techniques like Cone Beam Tomography (three-dimensional). This article will help us understand how two-dimensional and three-dimensional imaging modalities go hand in hand while treating dental patients. It will also explain why the conventional imaging technologies are still required in this era of modern methods of imaging.

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1. Introduction

An implant is a breakthrough invention in the field of medicine which helps replace the lost root structure of teeth. An individual artificial tooth structure or a partial or complete denture can be attached to these in order to re-establish oral functions.¹ Careful planning before the procedures have to be done to achieve success of an implant treatment plan. A detailed information has to be gathered regarding the quality, quantity and the volume of available bone at the planned implant site. The amount of bone available from underlying vital parts namely the sinus cavities, nasal floor, nerves, teeth and vessels has to be assessed for minimal trauma or damage. The fore-mentioned factors can only be assessed by a thorough radiographic and clinical examination.¹

The stages of implant imaging can be divided into the following:²

1. Pre-surgical phase.
2. On-going surgical phase.
3. Pre-prosthetic phase.
4. Post – prosthetic phase to assess any complication.

In the of first stage, the main aim is to identify critical structures, quality, quantity and angulation of bone in the planned implant sites.² A thorough literature search shows that several imaging techniques are used in implantology, which include: two dimensional modalities - intra-oral periapical radiography (IOPA), ortho pantomograms (OPG), cephalometric radiography; and three-dimensional modalities conventional computed tomography (CT), spiral computed tomography, cone beam computed tomography (CBCT).³

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2. Materials and Methods

2.1. Intra-Oral Periapical radiograph (IOPA)

Intraoral periapical radiographs provide one of the most definite and detailed images of a site among two-dimensional modalities. An IOPAR is used as the first imaging modality in most clinical establishments to find any underlying pathology, the position of anatomic structures such as mental foramen and also to understand the trabecular bone quality.⁴ Intraoral periapical radiographs give the clinician information regarding the bone density, pattern and ridge height.

The long cone paralleling technique has been considered as a preferable choice when taking a periapical radiograph, for its minimal magnification or distortion of the relationship between the bone height and adjacent teeth, the reduced chances of super-imposition of the zygomatic process over the maxillary molar area as well as reduction of the amount of dose to the skin.⁵

The use of proper film holders and placement of a grid gives an easy method for calculating the measurement of the proposed site from anatomical structures.

In Digital Radiography (DR), the conventional film is replaced by a sensor to get the required information. The exposure is done on this sensor, whose recordings are displayed on the computer screen. A sensor can be either made up of charged coupled device or complementary metal oxide semi-conductors.⁶

A subjective visualization or digital subtraction method can be used to compare the digital images in digital radiography. The computerised process of digital subtraction of sequential films helps the operator assess the regions of bone deposition or resorption. This is possible because this process can rebuild the image geometry for subsequent examinations.²

Digitalisation offers the clinician many advantages as compared to a conventional technique. First and foremost, there is no need of a film or any developing solution, thus giving the user an image instantly. Secondly, manipulation of the images (like contrast, density, magnification and image inversion) help in proper diagnosis. Thirdly, the images are digitally stored which prevent any change in their quality. Finally, the radiation dose during exposure is much less.^{7,8}

2.2. Orthopantomogram (OPG)

The orthopantomograms are commonly used in adjunct to Intraoral periapical radiographs in various phases of implant placement procedures. By this imaging method, the maxilla, the body of the mandible and the maxillary sinuses are easily viewed in a single screen, the images produced have sections of variable magnification as well as thickness.⁹

In implant treatment planning, the panoramic radiographs have become an important radiological

tool for implant site assessment, as they are more affordable and readily available.¹

Digital panoramic radiography offers several advantages to conventional techniques (Zonographs). A charge-coupled device (CCD) or a phosphor imaging plate is used to capture the digital images. Compared to conventional film imaging, there is a variety of image magnification tools, enhanced resolution with better characteristic and enhanced linear response over several orders of magnitude which is reproducible in digital imaging. In addition, there is no need of a dark room, hence the processing time is reduced.¹⁰⁻¹²

The panoramic radiographs have a draw-back of magnification error and overlapping of images which reduces its accuracy. For elimination of magnification error, the simplest method makes use of a radiographic marker or a steel ball bearing of known diameter during imaging.

The actual available height can be calculated using the following formula:¹³

$$\frac{\text{Actual height of the bone}}{\text{Radiographic length of the bone}} = \frac{\text{Actual diameter of the marker}}{\text{Radiographic diameter of the marker}}$$

2.3. Computed Tomography (CT)

Computed tomography is a three-dimensional imaging of the dental structures. As the name suggests, it creates tomographic sections, that is neither superimposed by structures above it nor below it. The images obtained are by mathematical calculations in a digital field.

A computed tomography clinician a high contrast image which has negligible magnification errors. The high-definition images are free of superimpositions of the soft and hard tissues helps in easy quantification and differentiation.¹⁴ In computed tomography, the accuracy of assessment of bone height and alveolar ridge width is higher than conventional techniques. They give the option of a three-dimensional reconstruction when multiple implants sites are being studied. With the help of digitalised computed tomography, the clinician can easily identify bone augmentation materials in the sinus region.¹⁵

2.4. Single – photon emission computed tomography (SPECT)

This method provides the clinician cross-sections of the imaged site that can be altered or re-formatted as needed by the clinician for the particular procedure. This method of imaging gained popularity after having produced a precise calculated reproduction of captured osteoblastic actions.¹⁶

The highest accuracy of imaging among computed tomography (Sensitivity – 93% and Specificity- 100%) has been shown by Multi Detector Computed Tomography. This imaging modality helps assess the bone density accurately. In computed tomography the measured bone density is expressed in Hounsfield Units.¹⁷

2.5. DentaScan

Is a software that provides programmed reformation and organization of the images.^{18,19} DentaScan, produces three-dimensional images of the arch, the images produced, have a panoramic/tangential cross-sectional pattern that is referenced. For optimal results, a diagnostic template is necessary.⁹

In DentaScan, the images (cross-sectional) are perpendicular to the axial imaging plane, so the angulation or tilt of the patient's head during the procedure is of utmost importance. In this method, the images that are produced have a limited range of diagnostic gray scale. The images obtained are not always accurate in proportion due to magnification which usually requires certain compensation.^{9,14}

Higher radiation dose to the patient as compared to conventional tomography, metallic streak artifacts in implant interface during follow-up radiographs, unavailability of particular reconstructive software's and difference in needs between clinician and radiologist or technician during interpretation or acquiring of the radiograph are certain disadvantages of computed tomography.^{6,15} Moreover, the procedure is very expensive.

2.6. Cone Beam Computed Tomography (CBCT)

Computed tomography and Magnetic resonance imaging (MRI) play a key role in the imaging of head and neck regions. However, the financial burden of investments in equipment's and operational charges limits their availability.²⁰ Moreover, computed tomography exposes the patient to a higher radiation dose.

Cone beam computed tomography was initially used for angiography, but more recent applications include radiotherapy guidance and mammography.²

What makes CBCT different from other types of tomographic imaging, is its characteristic rapid volumetric image acquisition from a single dose.²¹ The volumetric image reconstruction of this tomographic system, has been regarded as a game changer in the field of dentistry.¹⁷ Depending on the type of scanner, multiple continuous slices of thickness varying from 1mm to 5mm can be produced. On top of that, in a single full field of view (FOV) around 300 individual images can be produced.²

Cone beam computed tomography offers several advantages when compared to computed tomography. The images produced are at par to computed tomography, though the radiation doses are much lower, and is more pocket friendly. The images produced have a higher definition of the oral structures.²⁰

As mentioned earlier, computed tomography has a lot of scattered radiation and metallic artifact interference. These are reduced considerably in cone beam computed tomography. CBCT has a lesser scan time – less than thirty

seconds. CBCT also has the advantage of requiring a smaller equipment space, so it can be easily set-up in dental OPD or clinics.²²

3. Conclusion

The literature review makes it quite clear that computed tomography or cone beam computed tomography help the clinician understand the prospective implant sites better, pre and post operatively. This is possible because of their definite depth and spatial resolution thus improving the over-all success of dental implants. Even then, when a clinician advises additional radiographs, the potential risk vs perceived benefits should be weighed. The ALARA principle (as low as reasonably achievable) should be assessed when a radiographic technique is chosen.¹⁴

Though two - dimensional radiographic modalities are not at par with three dimensional techniques, it still stands out to be the first choice of radiographic assessment of potential sites given the factors of radiation dose, cost and type of information assessed. Hence, the risk-to-benefit ratio should always be assessed for greater success of dental implant treatment.

4. Conflicts of Interest

All contributing authors declare no conflicts of interest.

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