# Role of CBCT in Implants

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**Abstract:** Cone-beam CT is 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. Currently, several commercial systems for CBCT dedicated to dentomaxillofacial imaging are available for dental diagnosis and treatment planning.

**Keywords :** CBCT, implant, dentomaxillofacial.

## INTRODUCTION

Imaging is an important diagnostic adjunct to the clinical assessment of the dental patient.[1] Ever since the 'dental X ray pioneers' took the first radiographs of teeth in early 1896, radiology has become an integral component in the assessment of dental patient.[2]

Radiographic evaluation and diagnosis has undergone enormous changes in the last 20 years. New technologies are being developed and are becoming readily available to the medical and dental field. With the expanding array of imaging modalities, dental radiology has played revolutionary role in determining diagnosis, treatment plan and prognostic value.[3]

Present day intraoral and extraoral procedures used individually or in combination, suffer from the same inherent limitations of all planar 2 dimensional projections: magnification, distortion, superimposition and misrepresentation of structures. Numerous efforts have been made towards three dimensional (3D) radiographic images such as stereoscopy, computed tomography. Their application in dentistry is limited because of cost, access and dose considerations. The introduction of Cone beam computed tomography (CBCT) specifically dedicated to imaging the maxillofacial region heralds a true paradigm shift.[1]

CBCT also referred to as cone beam volumetric imaging (CBVI), Cone beam volumetric tomography (CBVT).[4]

The advent of this technology has evolved into an indispensible diagnostic tool that can be used for a variety of different clinical applications that include, but are not limited to : dental implant site evaluation, alveolar bone defect and bone augmentation procedures, impacted teeth, orthodontics, endodontics, temporomandibular joint diagnostics, sinus augmentation procedures and orthognathic surgical interventions.[5]

## EVOLUTION OF CBCT

CBCT was first adapted for potential use in 1982 at the Mayo clinic Biodynamics Research laboratory. CBCT was initially developed for angiography, but more recent medical applications have included radiotherapy guidance and mammography.[6, 7]

The first CBCT system became commercially available for dentomaxillofacial imaging in 2001 (New Tom QR DVT 9000 : Quantitative radiology, Verona, Italy).[6]

Cone beam computed tomography is a recent technology initially developed for angiography in 1982 and subsequently applied to maxillofacial imaging. It uses a divergent or cone shaped source of ionizing radiation and a 2 dimensional area detector fixed on a rotating gantry to acquire multiple sequential projection images in one complete scan around the area of interest.[8]

**PRINCIPLE OF CBCT**

During a CBCT scan, the scanner rotates $360^0$ around a rotation fulcrum fixed within the centre of the region of interest to obtain multiple images. Because the exposure incorporates the entire region of interest (ROI), only one rotational scan of the gantry is necessary to acquire enough data for image reconstruction. The scan time can range between five and forty seconds. After the scan, the resultant image set or raw data are subjected to a reconstruction process that results in the production of a digital volume called voxels of anatomical data that can be visualized with specialized software. Voxel dimensions are dependent on the pixel size on the area detector. Therefore CBCT units in general provide voxel resolutions that are isotropic – equal in all three dimensions.[7,8,9]

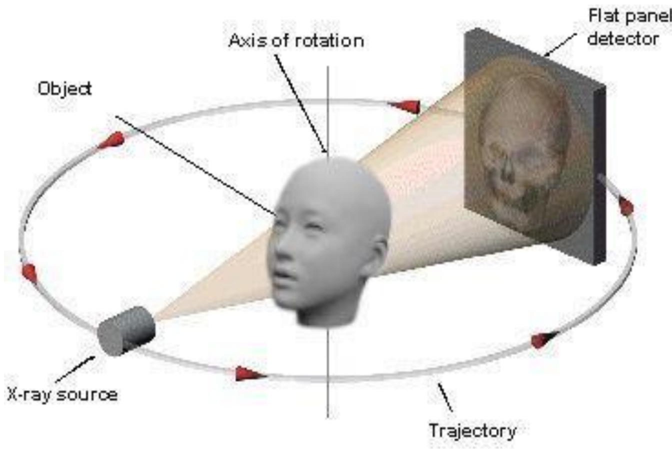


**Fig. 1 : Cone Beam Imaging Geometry**

**USES IN DENTISTRY:**

CBCT technology has had a substantial impact on maxillofacial imaging. It has been applied to diagnosis in all areas of dentistry and is now expanding into treatment applications. CBCT should not be considered a replacement for panoramic or conventional projection radiographic applications but rather as a complimentary modality for specific application.[8]

**IMPLANT SITE ASSESSMENT**

Conventional linear tomography and CT have traditionally been used in presurgical imaging, though the former has overlain ghosting artefacts and the latter has relatively high radiation exposure and cost.[10]

The use of CBCT image-based planning for oral implant treatment is now widespread. These methods are helpful in the preoperative evaluation of the surgical site. They also enhance the surgeon's knowledge of specific anatomic situation criteria can be an invaluable tool during preoperative planning for complicated endosseous dental implantation procedures.[11]

In most instances, a radiographic stent is made using standard impression models. This stent is worn at the time of CBCT exposure to provide a precise fiduciary reference. The CBCT data set is then sent to the outside laboratory and an implant placement stent is provided for use at surgery. This facilitates the precise placement of implants and speeds completion of the case. This procedure is enabling dentists to carry out implant procedures that were previously beyond their scope of practice.[12]

The use of the third dimension has improved the clinical success of implants and their associated prostheses, and led to more accurate and aesthetic outcomes. The images produced provide more precise evaluation of the alveolus.[5] In 2001, the American Association of Maxillofacial Radiologists recommended that a CBCT scan be obtained for the placement of dental implants.[13]

Authors introduced volumetric imaging for pre-surgical assessment of implant placement and compared this technique with other available imaging techniques. The large FOV and 3-D image set offered by CBCT created the opportunity for the clinician to adequately assess the implant site, look at the opposing occlusion, TMJs, and other factors that may be associated with the total success of implant-based rehabilitation of the patient's occlusion. It was shown that CBCT created the opportunity to extend the information yield beyond the conventional imaging methods and was an ideal modality for implant planning.[14]

A study evaluated the accuracy of the linear measurements obtained in CBCT images using a NewTom. Thirteen measurements were obtained in dry skulls (n = 8) between internal and external anatomical sites using a caliper and examined using NewTom 9000. The conclusion of this study was that, although the CBCT image underestimated the real distances between skull sites, differences were only significant for the skull base and therefore it was reliable for linear evaluation measurements of other structures more closely associated with dentomaxillofacial imaging.[15]

A study evaluated the usefulness of 3D images in implant treatment. 3D images were reconstructed from CT with a panoramic unit, compact CT images, and multislice helical CT images. The usefulness of each system was assessed for dental implant treatment. 3D images reconstructed from conventional tomograms with the panoramic unit were assessed as fair to unsure, compact CT 3D images were assessed as unsure to good, and multislice helical CT 3D images were assessed as good to excellent. It was concluded that compact CT 3D images and multislice helical CT 3D images were useful in dental implant treatment.[16]

Authors reported a case describing a systematic approach to the planning and surgical placement of a single implant-supported crown, utilizing CBCT-based dental imaging for implant planning and surgical guidance. It helped the clinician to safely and predictably transfer the optimal-implant trajectory and distances from the adjacent tooth and mandibular nerve to the patient's mouth. The simple steps resulted in the accurate transfer of critical radiographic information to the surgical site.[17]

A study was conducted to determine a conversion coefficient for Hounsfield Units (HU) to material density (g cm (-3)) obtained from cone-beam computed tomography (CBCT-NewTom QR-DVT 9000) data. The raw data were converted into DICOM format and analysed using Merge eFilm and AMIRA to determine the HU of different areas of the models. The study concluded that CBCT provides an effective option for determination of material density expressed as Hounsfield Units.[18]

Authors developed an image guided protocol for placement of a temporary anchorage device without surgically reflecting a mucoperiosteal flap using CBCT. CBCT three dimensional imaging guided placement of temporary anchorage devices for orthodontic anchorage. Benefits of this protocol showed atraumatic treatment, minimally invasive therapy, and flapless insertion with predictable success.[19]

In one study authors compared the accuracy of CBCT scanning (NewTom 3G) with intraoral periapical radiography (Dixi2, Planmeca CCD sensor and Insight film) for the detection of periapical bone defects. In conclusion, the results of the study showed that the NewTom 3G was better than intraoral periapical radiography when evaluating the presence of artificially created periapical bone defects. NewTom 3G may be useful in cases of immediate implants intended to replace teeth with suspicion for possible existing endodontic pathology, or in candidate implant sites neighbouring such teeth.[20]

A study reviewed two cases to illustrate how model-based CBCT treatment planning and 3-D multiplane treatment programs can assist with the pretreatment evaluation and decision-making process for the complex placement of implants. Utilization of CBCT clearly illustrated the true 3-D shape and size of all anatomical structures. By combining CBCT and 3-D treatment planning, implants were placed with ideal prosthetic results. They concluded that CBCT and 3-D treatment planning were emerging technologies that provided the clinician with the necessary information for routine and complex cases involving the placement of implants in the mandible or maxilla. Through the 3-D treatment planning the clinician was better able to understand the limitations that may be encountered in surgery before a flap was laid. These imaging and manufacturing capabilities do not exist with 2-D imaging and model-based treatment planning.[21]

A study conducted, analyzed the availability of bone in the interforaminal region and demonstrated the variation in diagnosis between panoramic x-ray and CBCT. Study concluded that panoramic images underestimated the vertical and horizontal measurements when compared with CBCT which was an advantageous system for interforaminal implant treatment planning, especially since the reported radiation dose was minimal and geometric accuracy was very high.[22]

A study evaluated the accuracy of linear measurements obtained with dental CBCT and Multi slice computed tomography (MSCT) by altering radiation doses using pre-operative planning of the placement of oral implants as a model. A human cadaver mandible was examined in two edentulous areas and one dentate area using CBCT and MSCT. They concluded that CBCT was a reliable tool for implant-planning measurements when compared with MSCT. A considerable radiation dose reduction could be achieved with low-dose MSCT examinations without a major loss of measurement accuracy.[23]

One study evaluated the accuracy of the first integrated system for CBCT imaging, dental implant planning and surgical template-aided implant placement. Although hardly comparable due to different study designs and measurement strategies, the investigated system's inherent accuracy corresponded to the most favourable results for computer aided surgery systems published till date. In combination with the Nobel Guide surgical set for fully guided insertion, the same accuracy level could be maintained for implant positioning.[24]

A study conducted to establish a basis for weighing the potential diagnostic and therapeutic benefits of three-dimensional cone-beam data sets in contrast to digital Orthopantomograph (OPG) and Computed tomography (CT) in implant dentistry. The results of the present study confirmed superior radiographic visualization for all important high-contrast structures in presurgical implant dentistry assessment for CBCT imaging in contrast to OPG and a CT-like degree of information for high-contrast structures in CBCT data sets. Clinically, however, the elevated radiation dosages transmitted by CB imaging should be taken into account.[25]

A study was conducted to assess the accuracy of measuring the cortical bone thickness adjacent to dental implants using two CBCT systems. It was concluded that i-CAT NG (voxel size 0.3) may not produce sufficient resolution of the thin cortical bone adjacent to dental implants and, therefore, the measurements may not be accurate; whereas, Accuitomo 3D60 FPD(voxel size 0.125) may produce better resolution and more accurate measurement of the thin bone.[26]

Since specificity for the NewTom 3G is not significantly different from the periapical techniques, and the facts that CBCT has a 3–7 times higher dose than film orthopantomograms traditionally used in implant treatment planning[27] and is a quite time consuming method, it would be wrong to suggest that all patients intended for implant treatment should be examined with CBCT. However, it may be suggested that when teeth with diffuse symptoms or asymptomatic teeth with suspicion for endodontic pathology (e.g. inadequate root canal treatment, history of recurrent problems of endodontic etiology etc.) are intended to be replaced with immediate implants, or in case such teeth are neighbours to candidate implant sites, the use of the CBCT may be beneficial.[28]

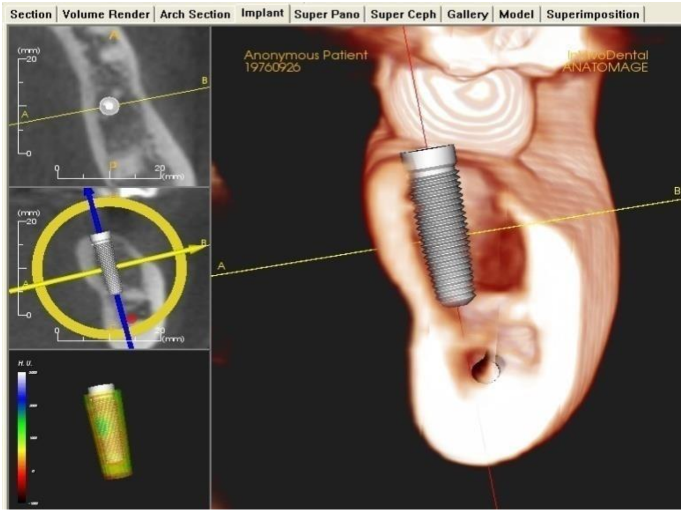


**Fig. 2.1 : Implant Site Assessment Using CBCT**

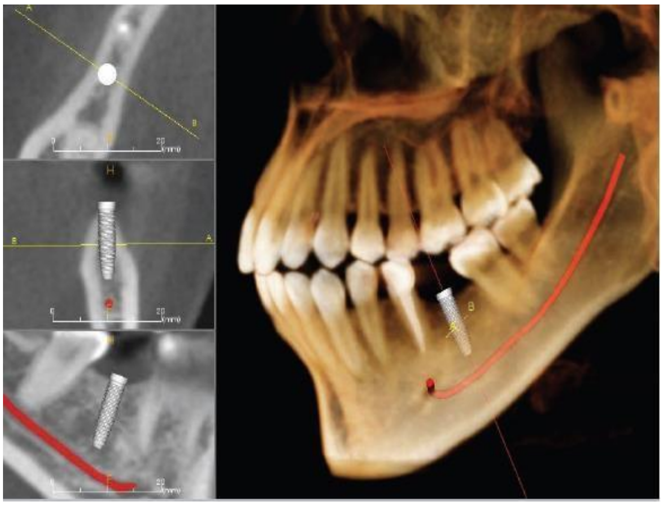

**Fig. 2.2 : Implant Site Assessment Using CBCT**

## CONCLUSION:

As CBCT scanning is finding more and more commercial applications in medicine, dentomaxillofacial radiology stands as the privileged field that has driven growth of this exciting technology into the commercial maturity.[29]

This is a blossoming field which provides an ongoing income potential for a dentist who combines CBCT image-guidance with treatment. Image-guidance is an exciting advance that is already having substantial impact on the practice of dentistry.[7]

The most dramatic of anticipated new developments will be the merging of 3-D digital photography with CBCT and diagnostic software to create real images of patients and to show actual facial changes that could result from implant placement, as well as reconstructive surgery. All of these developments and tools will ultimately improve patient dental care, the major goal of all of our profession.[30]

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