

# CBCT as an Emerging Gold Standard for Presurgical Planning in Implant Restorations

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## ABSTRACT

Diagnostic radiology has undergone profound changes in the last three decades. New technologies have emerged and are being readily accepted into dentistry. Rapid developments in diagnostic devices and software applications have allowed new methods for dentomaxillofacial diagnosis and treatment planning as well as prosthetic and surgical treatment. Cone beam computed tomography (CBCT) is one of the most important developments in dental radiology over the years. Contemporary implant dentistry is a primarily prosthetically driven treatment. Implant restorations as a treatment modality is on rise in day to day practice. The implant position is defined during the diagnostic phase, and the radiographic guide indicates accurately the area of concern on the CBCT. CBCT can be used as an alternative imaging modality to conventional medical spiral tomography, spiral multislice computed tomography for preoperative radiograph assessment of potential dental implant sites. CBCT is capable of providing submillimeter resolution in image of high diagnostic quality, reliable bone width, bone height and bone density measurements comparable to CT and less radiation exposure the CT. CBCT is promising alternative to conventional CT for successful presurgical planning in implant restorations.

**Keywords:** Cone beam computed tomography, Computerized tomography, Dental implants.

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## INTRODUCTION

Presurgical dental implant planning requires specific and accurate data to assess the implant site so that dental implants can be placed where they have the greatest chance of success. The implant must not only occupy the edentulous site, but also must satisfy esthetic, restorative and prosthetic criteria, while respecting the surrounding anatomical structures.<sup>1</sup> Anatomic considerations, such as determination of bone height and width, determination of bone density and quality, identifying and localizing internal anatomy, determining jaw boundaries, and detecting pathologies are the principal determinants in selecting an optimal implant site.<sup>1</sup>

Although three-dimensional (3D) imaging technologies in dentistry have been available since the early 1990s, clinician now have much greater access to improved

diagnostic procedures for detailed presurgical evaluation of the bone substrate prior to implant insertion. In the past, only two-dimensional image like panoramic X-rays were used for this purpose, but the magnification and distortion of the image do not allow accurate presurgical examination.<sup>2</sup> Furthermore, no information can be obtained concerning the buccal-lingual anatomy or width of the alveolar crest from two-dimensional radiography. For the successful implant treatment, it is important for the clinician to identify anatomical structures plus bone height, bone width and angulations of the residual alveolar ridge. Clinical examination and panoramic X-rays offer useful information for initial evaluation but in many cases, 3D imaging will provide more accurate planning.<sup>3</sup>

In 3D radiography, the medical CT has become essential diagnostic tool and considered the gold standard in implant dentistry, for it allows three-dimensional views of the region on interest and relevant jaw anatomy such as the maxillary sinus and mandible nerve.<sup>4</sup> Medical CT provides several advantages that allow it to overcome the limitations of traditional two-dimensional imaging modalities, including uniform magnification, multiplanar views, and simultaneous study of multiple implant site.<sup>5</sup> However, in spite of the advantages that medical CT provides, there are some disadvantages. One limitation of conventional medical CT is a relatively large radiation dose,<sup>6</sup> radiation source rotate around the patient head several times to acquire the image which can range between 4 and 64 revolutions of slices.<sup>4</sup> Since a small gap will exist between each parallel slice, after mathematical reconstruction of multiple slices, a built in imaging error will exist.<sup>4</sup> Furthermore, conventional medical CT also has the disadvantage of being costly, the inferior alveolar nerve canal is not always shown well, and it suffers from beam hardening artifact or scatter due to adjacent metal structures like restorations.<sup>6</sup>

More recently in 2001, CBCT systems was developed providing another three-dimensional alternative to conventional medical CT with several advantages like in CBCT volumes of data are captured with a single 360° rotation about the patient head; this is possible since the X-ray volumes used in CBCT gaplessly contact each other. CBCT has proven to capture structures with high contrast, have excellent image acquisition of such structures as the inferior alveolar nerve canal and has proven more reliable than medical CT.<sup>7</sup> In addition, CBCT provides the

advantages of short scanning times (10-70 seconds) and radiation dosages reportedly up to 15 times lower than those of conventional CT scans. CBCT allows precise evaluation of the bone anatomy and accurate assessments to critical anatomic landmarks.<sup>8-10</sup> Furthermore, pathology such as tumors, cysts, infections, inflammatory lesions and some fractures can be visualized.

Over the past couple of decades, the literature has referred to the concept of prosthetically driven Implantology.<sup>11,12</sup> With this concept, the implant position is planned during the diagnostic phase according to the desired prosthetic restorations.<sup>13</sup> A radiographic guide (template) is fabricated to indicate precisely the area of restoration on the 3D scan, usually CBCT imaging.

The template is made of acrylic resin as a duplicate from the diagnostic wax-up of the shape of the planned final restoration which is essential for predicting esthetics and functional result. Many types of radiographic guides are presents for single or multiple implants.<sup>14-17</sup> Radiographic materials such as gutta-purcha, metal balls, barium sulfate, etc. are incorporated in the template to indicate the relationship of the final prosthesis to the bone substrate.<sup>18</sup> When a barium sulfate is processed in the acrylic resin template, the outline of the planned restoration is imaged in relation to the bone on the CBCT.<sup>19</sup>

From the CBCT, performed with an accurate radiographic guide, the following information may be obtained:<sup>13</sup>

1. Density, height and width of the residual alveolar ridge.
2. Anatomical structures related to the surgical guide.
3. Eventual need for horizontal or vertical augmentation.

The information obtained by the CBCT can guide the clinician to the selection of an appropriate implant, regarding length, diameter and inclination. The relation of the planned restoration to the residual ridge can be recognized.

## CASE REPORT

A 55-year-old female reported to the Department of Prosthodontics, Krishnadevaraya College of Dental Sciences, Bengaluru, Karnataka, India with a chief complaint of missing all teeth in the oral cavity and willing for fixed prosthesis. Detailed case history was recorded and no significant medical concerns were observed. Orthopantogram was taken as initial examination (Fig. 1) but the panoramic radiograph of the patient was not showing the clear picture of anatomical structures like mandibular canal, quality of the bone present, accurate measurement of bone height and bone width.

So, as a part of treatment planning, we fabricated a complete denture and delivered to the patient. Then,

radiographic template was made for the mandible by duplicating the mandibular denture. The radiographic template was made using translucent auto polymerizing acrylic resin and radiopaque material barium sulfate. Following the polymerization of the resin, the template was trimmed and tried on the patient to verify effortless insertion and proper fit (Fig. 2).

The patient was referred for CBCT scan along with the radiographic template. On this CBCT image, the placement of implants was planned along with the site, position and the number of implants based on the radiographic template. Further some of the findings like a bone defect on the left side of mandible in the anterior region could be identified which would have not been possible on the orthopantogram (Fig. 3). The template was successfully placed and restored predictably as planned (Figs 4 and 5).

## DISCUSSION

There is little doubt that cone beam technology will become an important tool in dental and maxillofacial imaging over the next decades. Clinical application of CBCT is rapidly being applied to dental practice. CBCT imaging for presurgical evaluation of the bone prior to implant placement is frequently used as it allows precise measurements of the alveolar crest.<sup>20</sup>

Proper patient positioning is desirable to insure accurate CBCT with minimum distortion<sup>21,22</sup> and optimal image quality. The angel created from the inferior border of the mandible to the level of scanning (orientation line) is usually called 'gantry angle'.<sup>23</sup>

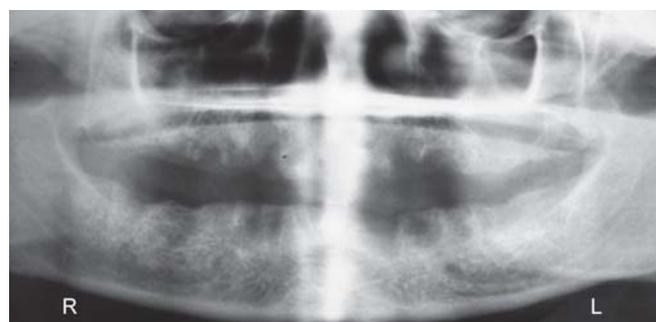


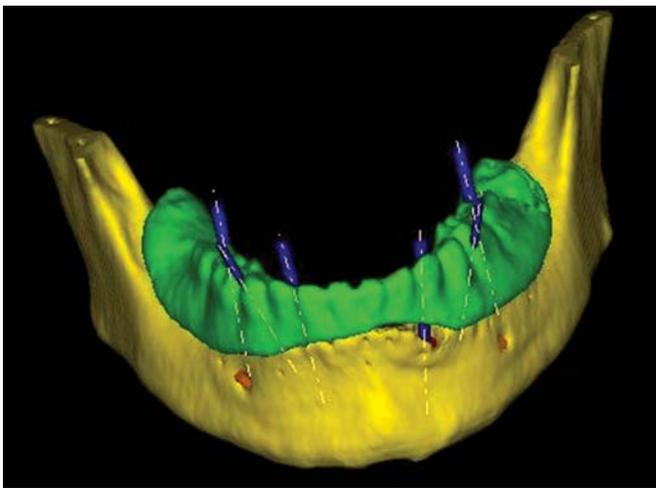
Fig. 1: Orthopantogram



Fig. 2: Radiographic template for mandible

Choi et al<sup>23</sup> investigated the influence of the gantry angle on a dry human mandible using a resin block model at 0, 15 and 30°. Increasing the angle resulted in obvious distortion on the reformatted cross-sectional images.

Kim et al<sup>24</sup> in a study of dry human skulls investigated the influence of the mandible angulations to the accuracy of depicted dimensions on cross-sectional images of CT scan. In the result of this study, no significant error was found in the area of mandibular premolars, but more intense deviation in the molar area. The author suggested the use of occlusal plane as indicated from an accurate radiographic guide as orientation line.



**Fig. 3:** Bone defect in mandibular left anterior region and showing the inclination of implants



**Fig. 4:** Orthopantomogram showing placement of implants



**Fig. 5:** Fixed hybrid prosthesis in relation to mandible

Surgical guide (template) fabricated using CBCT is also very helpful to indicate precisely the area of implant placement and restoration on the 3D scan. The bone drilling for implant placement is most frequently performed perpendicular to the peak of the alveolar crest, along the axis of the tooth in the planned restoration. Variation in the declination from the planned axis may lead to improper implant placement. The distance from adjacent teeth and the mental foramen may also be affected. For these reasons, it is essential to use an accurate radiographic template for the accurate placement of the implant at the predetermined position.

CBCT is more practical and perhaps even better alternative to CT in the preoperative radiographic assessment of potential dental implant site. When comparing the accuracy of diagnostic measurements between CBCT and CT which is absolutely crucial to ensuring the accurate site from the practitioners perspective—a comparison between the two suggest that CBCT is just as accurate if not more accurate than CT.

Kobayashi et al<sup>5</sup> concluded that not only can distance be measured accurately using CBCT, but also that CBCT can measure distance more accurately than CT.

Aranyarachkul et al<sup>25</sup> concluded that CBCT was a suitable alternative to CT for measurement of bone density. Loubele<sup>26</sup> demonstrated that both CBCT and CT provided reliable jaw width measurements compared to the digital caliper. Thus, it can be concluded that both CBCT and CT were as accurate as a digital caliper in measuring the bone width.

Loubele et al<sup>26</sup> demonstrated that there are subjective image differences between the two imaging modalities. CBCT offer higher resolution in any directions. Contrastingly, only the axial section images from CT were well resolved while the multiplanar reconstructions of image from CT were at low resolution. Further CBCT provides submillimeter resolution as small as 0.2 mm while traditional medical CT provides 0.5 to 1 mm of resolution.

Overall, the higher resolution in all dimensions and ability to image the finer details of small bony structures may make CBCT more desirable imaging modality than CT for implant site assessment.

Certain advantages from the patients perspectives may also make CBCT better alternative to CT. According to Mah et al<sup>27</sup> suggested that CBCT result in significantly less effective radiation exposure, between 3 and 18 times lower than various conventional medical CT. As for cost of ordering an image for dental implant assessment, CBCT is less expensive than that of CT.

Additional considerations may make CBCT an accessible and affordable option for use in a dentistry like

CBCT costs approximately one fourth to one fifth the cost of CT<sup>28</sup> to the practitioner.

CBCT is much smaller in size and has a higher scan speed than CT.<sup>28</sup> CBCT is comparable in size to a conventional panoramic machine.<sup>29</sup> Moreover, CBCT can also be utilized for other dental procedures that also require craniofacial imaging making its use practical for a wide variety of dental disciplines.<sup>30</sup> Such examples may include orthodontic treatment planning, assessing TMJ dysfunction and imaging wisdom tooth impaction.<sup>30</sup>

The CBCT provides improved imaging and offers valuable information for the preimplant treatment planning.<sup>31</sup> The interpretation of the CBCT images, with its possibilities and limitations, is very important for presurgical implant evaluation.

## CONCLUSION

Overall, the CBCT may be a better alternative for preoperative radiographic assessment of potential implant sites appears promising. CBCT provides diagnostic information as accurately or better as CT while, importantly, minimizing both radiation exposure and financial costs to the patients. The radiographic template made with the help of CBCT offers valuable information not only about the correct occlusal plane but also about the location and inclination of the implant and restoration. Proper reconstructions of the CBCT results in more accurate cross-sectional images and may contribute significantly to better presurgical and reconstruction planning.

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