'CBCT – A Positive Amelioration In Periodontics'

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Abstract: With the advent in the technology, accurate examination techniques, especially for delicate structures in the oral and maxillofacial regions are required over conventional x-rays, which are mere 2D (2-dimensional) representations of the 3D (3-dimensional) oral structures. Hence, a radiographic tool with a 3D presentation like that of CBCT (Cone beam computed tomography) technology is preferred in pre- and post-treatment assessment of periodontal defects & implant placements.CBCT technology has been used for almost 2 decades, but was previously more expensive to be used in routine dental practice. Recent developments in this field have made its use more practical in routine dentistry.This literature review, emphasizes the invent, development, working, uses, benefits & limitations of dentascan when used in Periodontics.[Shah M et al NJIRM 2013; 4(3) : 144-148]

Key Words: Dentascan, Cone beam computed tomograpgy, CBCT, alveolar bone assessment.

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Introduction: Bone levels can be assessed using radiographs, or by sounding under local analgesia or by direct visualisation during surgery.The most accurate method of assessing alveolar bone level is to elevate the flap and measure the bone level directly & hence is considered to be the Gold standard[1]. However, this method & other clinical methods like transgingival probing[2,3,4,5] cause discomfort to the patient and can damage the tissues. It is also difficult to employ such an invasive procedure for periodontal diagnosis. Therefore, many studies have been conducted to find an alternative method that can be used to assess the bone level both clinically & radiographically with accuracy and reliability.

Need for a newer radiographic technique to assess alveolar bone level: In routine dental practice, IOPAs (Intra-oral periapical radiographs) & Panoramic radiographs (OPG) are the most established imaging techniques[6,7]. However, Benn suggested that the current measurement techniques are insufficiently sensitive to measure 1 mm of bone loss until at least 1.9 mm of bone resorption has occurred[8]. Besides the detection ability problem, Eickholz and Hausmann showed that radiographic assessment using periapical radiographs tends to underestimate the amount of bone loss by 1.41 ± 2.58 mm[8]. They also often tend to obscure defects, dehiscences, etc., especially when placed behind the structures like roots, on the lingual/palatal plates.[9]

These short comings of all the 2D representations of the 3D alveolar bone, tooth and soft tissue, have been overcome with Dentascan[8,10,11] which provides 3D images that facilitate the transition of dental imaging from initial diagnosis to image guidance throughout the treatment phase.

A Dentascan examination is a specialized type of computed tomography study (CT or "CAT" scan), which is performed on a conventional CT scanner used to obtain true cross-sections of the mandible and maxilla from the easily obtained CT scans of the patients. It is used through advanced computer programs to analyze an X-ray, by providing detailed 2D and 3D images and enable diagnosis and plan the details of the surgery with accuracy, well before the operation.

The dentascan (CBCT) formats standard axial CT scans into 3 planes: axial (fig.1), (coronal) panoramic (fig. 2), and oblique sagittal (or cross-sectional) (fig. 3), which facilitatesclose inspection of buccal and lingual cortices, as well as clear visualization of internal structures, such as theincisive and inferior alveolar canals and in theory should improve specificity and sensitivity over standard CT imaging[12,13].

Evolution of Computed tomography: The first CT scanner was developed in 1967 by Sir Godfrey N. Hounsfield, an engineer at EMI. Since then, CT technology rapidly underwent five developmental generations. CBCT scanners, being the latest amongst these generations, utilize a two-dimensional detector, which allows for a single

Fig. 1 : Axial view with sectioning slices – 10 slices per tooth

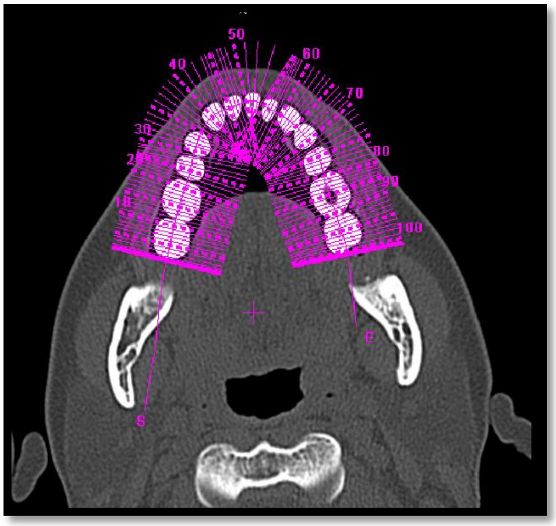


Fig. 2 : Coronal (OPG) view – emphasizing on posterior teeth & their supporting structures.

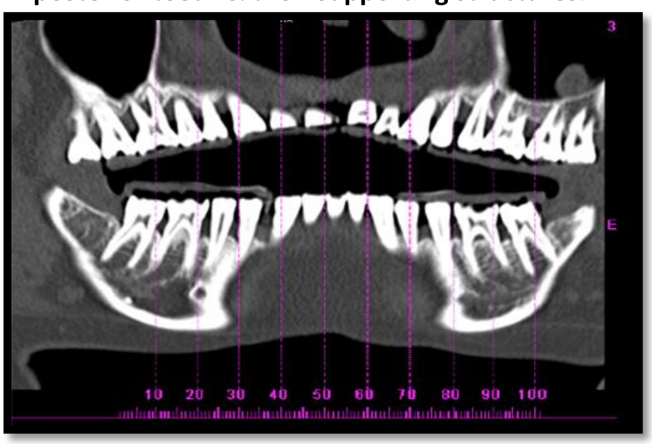
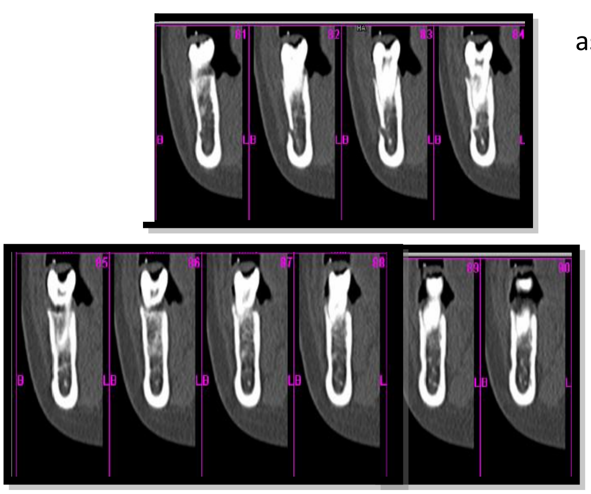


Fig. 3 : Saggital view – 10 slices per tooth



as

rotation of the gantry to generate a scan of the entire region of interest, compared with conventional CT scanners whose multiple "slices" must be stacked to obtain a complete image. In comparison with conventional fan-beam or spiral-scan geometries, cone-beam geometry has higher efficiency in X-ray use, inherent quickness in volumetric data acquisition, and potential for reducing the cost of CT.

Working of a CBCT: Image data are recorded in a single 360 degrees or 180 degrees gantry rotation, producing 100s of 2D images of a defined anatomical volume rather than the slice-by-slice imaging found in conventional CT. The images are then reconstructed in a visualizable 3D data set using a variation of the algorithm developed by Feldkamp et al in 1994.Options for images/slice thickness vary from machine to machine[8]. Because cone beam reconstruction algorithms make it possible to reconstruct an entire volumetric region, this region can be reformatted to show anatomical detail in any imaginable plane free from the usual problems of magnification and distortion. CBCT has excellent high-contrast resolution as a result of the small size and geometry of its isotropic voxels.

Producing the image: CBCT machines can scan patients in either of the following three possible positions: sitting, standing, or supine. The four components of CBCT image production are as follows: Acquisition configuration, Detecting the image, Reconstructing the image & Image display.

Uses: To visualize interproximal defects, buccal and lingual defects, furcation defects[14], diagnosing dehiscence and fenestration defects [9], diagnostic and treatment-outcome evaluations of periodontitis[9], to evaluate postsurgical results of regenerative periodontal therapy.[14]Other uses are: As a new volumetric imaging method– for measuring alveolar bone density, especially to assess healing after grafting.[9]

Qualitative & quantitative measurements of bone - to obtain detailed morphologic descriptions of bone, which are as accurate as direct measurement with a periodontal probe.[14]

PDL space assessment[9]: Simple & non-invasive technique of soft tissue CBCT - for the measurement of gingival tissue and the dimensions of the dentogingival unit, width of the facial and palatal/lingual alveolar bone & gingival tissue.[9] (fig. 4)

Fig. 4 : Soft tissue assessment (gingival margin – alveolar crest, gingival margin – CEJ, CEJ – alveolar crest)

Fig. 5 : 3D - Reconstruction

For diagnostic imaging for the implant patient[9], for multiple implant placements, for studying post implant therapy osseointegration over a period of time.

Software and technology development trends suggest that in the near future, CBCT scans will be used to develop a patient-specific 3D model that will be used for implant diagnosis, treatment planning, treatment simulation, implant placement (surgery), and tooth replacement (restoration of implant).

Benefits: It has a rapid scan time as compared with panoramic radiography & conventional CT scans.
It gives complete 3D reconstruction and display from any angle.Its cone beam collimation, enables limitation of X-radiation to the area of interest.

Image accuracy produces images with submillimeter isotropic voxel resolution ranging from 0.4 mm to as low as 0.076 mm.

Reduced patient radiation dose (29-477 µSv) as compared to conventional CT (approx. 2000 µSv). Patient radiation dose is 5 times lower & exposure time is approximately 1/7th (18 sec) the amount compared with the conventional medical CT.

Reconstruction - CBCT units reconstruct the projection data to provide interrelational images in three orthogonal planes (axial, sagittal, and coronal). (fig.5)Multiplanar reformation is possible by sectioning volumetric datasets nonorthogonally. Multiplanar image can be "thickened" by increasing the number of adjacent voxels included in the display, referred to as *ray sum.*
3D volume rendering is possible by direct or indirect technique.The three positioning beams make patient positioning easy. Scout images enable even more accurate positioning.Reduced image artifacts.

Cheaper as compared to conventional CT scan.

Limitations: *Radiation risk* - Although diagnostic X-rays provide great benefits, fact that their use involves some small risk of developing cancer is generally accepted[13]& may also cause genetic effects in children of irradiated individuals.

Studies have reported the CBCT dose (0.04-0.05 mSv) to be 3-10 times higher than the dose for a panoramic radiograph (0.003-0.011mSv) [Ludlow JB et al,2003; Scarfe et al 2006]. However, Scarfe et al (2006) also concluded that CBCT radiation dose (0.04-0.05mSv) is 15 times lower than conventional CT scanners (2000 mSV). Also, fatal cancer risk is at 20,000 mSV, which is much more than radiation produced due to CT scan. Their radiation dose depends on the chosen FOV (field of view), tube current (mAs), tube voltage (kVp) & exposure time.

Radiation damage is mostly only a consideration with rapidly dividing tissues such as reproductive organs, bone marrow, etc. The tissues exposed to dental x-rays (teeth, jaw, cheeks) are not as susceptible to radiation damage. Therefore, the risk of harmful effects from dental X-rays is negligible, & can reasonably be avoided by following ALARA (as low as reasonably achievable) principle

Clarity - Current CBCT technology has limitations related to the "cone-beam" projection geometry, detector sensitivity, and contrast resolution that produces images that lack the clarity and usefulness of conventional CT images. The clarity of CBCT images is affected by artifacts, noise, and poor soft tissue contrast.

Interpratation - Office-based CBCT imaging is usually performed and interpreted by non-radiologists, often without the accreditation, training, or licensure afforded by the radiology community. So, to address this issue, emphasizing the role of the practitioner in obtaining and interpreting CBCT images is necessary.

Costly - as compared to conventional 2D radiographic techniques.

Evidence based use of CBCT: Barriviera M, Duarte WR, Janua´rio AL, et al, 2009 [15] - A new method to assess and measure palatal masticatory mucosa by cone-beam computerized tomography They concluded that, with this new non-invasive method, it is consistently possible to obtain high-quality images of the palatal masticatory mucosa. Measurements of this mucosa could be obtained at different locations on the palate.

Hae-Rym Yoon, Hee-Jin Kim, Kee-Deog Kim, Chang-Seo Park, 2002 [16] – Radiographic evaluations of the various lesions of maxillary sinus, inferior wall of sinus and surrounding structures using reformatted computed tomography.

Comparing the lesions of specimens with intraoral radiographies and DentaScan reformatted images, they concluded that the dental and periodontal pathoses and topographical structures were more clearly observed in the DentaScan group than CT scan & periapical radiographs. Wahed, Nagla A. Abdel; Hamdy, Reham M; Abdel Latif, Zeinab A, 2012 [17] - Measurements of jaw bones, for implant site assessment using cone-beam computed tomography: interobserver and intraobserver agreement.

They concluded that there is inter as well as intra group agreement in measuring the jaw bones for implant site assessment using cone-beam computed tomography.

A A Al-Ekrish and M Ekram, 2011[18] - A comparative study of the accuracy and reliability of multidetector computed tomography (MDCT) and cone beam computed tomography (CBCT) in the assessment of dental implant site dimensions.
They concluded that CBCT measurements were significantly more accurate than those of MDCT (multi detected computed tomography).

Conclusion:CBCT technology has been used for almost 2 decades but was previously more expensive to be used in routine dental practice. Recently, however, in-expensive x-ray tubes, decreased complexity, high quality flat pannel detector systems & powerful personal computers have made this technique more affordable &practical, in routine dental practice & a natural fit in periodontal imaging.

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