Three-Dimensional Diagnosis & Treatment Planning: The Use of 3D Facial Imaging and 3D Conebeam CT in Orthodontics & Dentistry – Part II

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Conebeam Computed Tomography (CBCT)

Conebeam CT is a new form of computed tomography which uses different source detectors and a different type of acquisition than traditional Fan-beam medical CT. Conventional "fan-beam" CT images the patient as a series of axial cuts, like a fan, and are captured as individual slices, which can be stacked into a 3D volume or viewed in cross sections. The voxel size is dependent on the scan thickness, which is usually between 1 – 5 mm. This produces anistropic voxels, which means the width and thickness are equal, but the height measurement (axial slice thickness) may vary between 1– 5 mm. Anistropic voxels are like a rectangular box, equal on 2 sides and the third side varies in thickness (i.e. 0.1 x 0.1 x (varies between) 1.0 – 5.0 mm). The radiation dosage of conventional CT is much higher than Conebeam tomography (see above table of radiation dose). Conebeam volumetric tomography uses one rotational sweep of 360 degrees. The scan times vary between 10 to 75 seconds, depending on the field of view and the CBCT unit used. The radiation dose for a complete volume of the maxillofacial area is usually less than a periapical survey (see chart from James Mah). One of the biggest advantages of Conebeam CT, is that the doctor can get much more accurate information from one Conebeam scan than the multiple 2D views, we traditionally use, with much less radiation. The voxel size of CBCT is between 0.1 – 0.4 mm in all 3 planes of space (the X,Y, & Z planes) and produces isotropic voxel size which are equal in width, thickness and height. Isotropic voxels are like a square box with all sides having the same dimension (i.e 0.1 x 0.1 x 0.1 mm). The image data output can be sliced into various planes (axial, coronal, sagittal) or viewed as a 3D volume (Figure #4 A & B). Accurate 1:1 measurements can be made along any slice plane and on any part of the anatomy

Conebeam CT can allow for different views to be created from one scan. All of the views are accurate and not subjected to geometric projection errors that are inherent in traditional 2D images. Sophisticated computer algorithms correct for the geometric distortions that are inherent in 2D imaging. A reconstructed panoramic view can be created. This type of panoramic view is different from what traditional film-based or digital panoramic units create, as there is no superimposition of anatomic structures, the panoramic slices can be as thick or as thin as you wish and the teeth and TMJs are an accurate panoramic view as the doctor defines the path of the panoramic cut through the mandible and maxilla. (Figure 5) With the thinner slices, one can evaluate the relationship of the lingual nerve for evaluation of extraction, implants, etc. Evaluation of implant receptor sites based on the understanding of available bone, the density of the bone (which can be determined by measuring the Hounsfield units), avoidance of important anatomical structures, restorative and esthetic requirements are all important areas to evaluate prior to therapy. Cross sections of the anterior teeth can allow the doctor to evaluate the alveolar bone width and heights, and plan the orthodontic torquing needs of the specific patient. (Figure 6A & B) Posterior cross sections can allow for bucco-lingual skeletal and dental evaluations of individual pairs of teeth. From the panoramic view cross sections can be made for evaluation of implant placement, implant anchorage placement for orthodontics, etc. Position of impacted cuspids can be accurately assessed and treatment planned for proper attachment placement and directions of movement. (Figure 7A & B). Walker, Enciso & Mah, using 3D conebeam localization, found that incisor root resorption adjacent to the impacted canines were present in 66.7% of the lateral incisors and 11.1% of the central incisors, prior to any treatment. (Ref #8)

Studies using Conebeam CT find significant changes in the TMJ are found in 15-20% of the cases prior to any treatment. (Personal communication, Dr. Joe Caruso, Orthodontic Chairman, Lomalinda University). Figures 8a & b show constricted airway - pre-tonsil and adenoidectomy. Figures 8C & D show post surgery of airway, now normal size. Airway problems in young children affect their craniofacial growth and development (REF #7). Sinus and airway analysis can also be easily evaluated from the same Conebeam scan.. Studies using Conebem CT have shown that 25% of patients have significant airway findings, including obstruction, lack of airway patency, sinus inflammation, polyps, nasal deviation, etc. (Ref# 5)

Abnormal eruption pattern of the maxillary right 2nd bicuspid is not evident in the panoramic view in Figure 9A. Figure 9B shows the coronal cross section view of the lingually developing maxillary right 2nd bicuspid. Other developmental abnormalities such as transposed roots of maxillary cuspids and 1st bicuspids (Figure 10A), supernumary teeth in mandibular anterior area (Figure 10b), and TMJ degenerative joint disease (Figure 11) can be seen from any view.

The use of 3D imaging, along with evaluation of the 4th dimension of time, will improve diagnostics and treatment by increasing the understanding of the patient's true anatomical form °V the anatomic truth.

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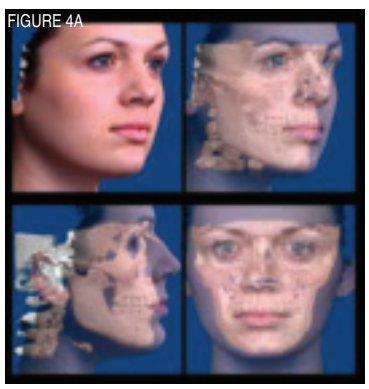


FIGURE 4A

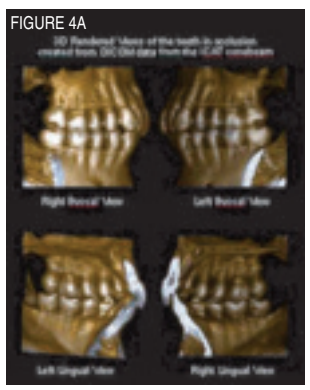
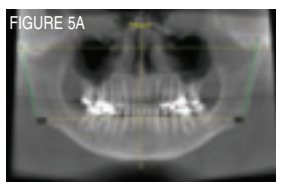


FIGURE 4A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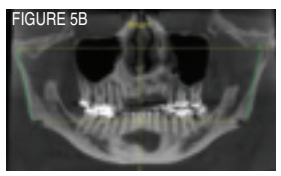


FIGURE 5B


FIGURE 6

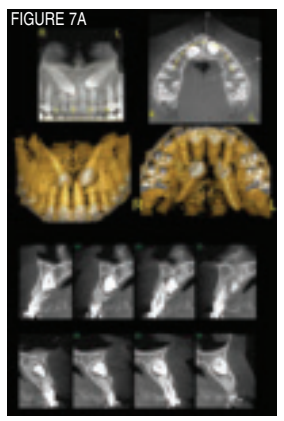


FIGURE 7A

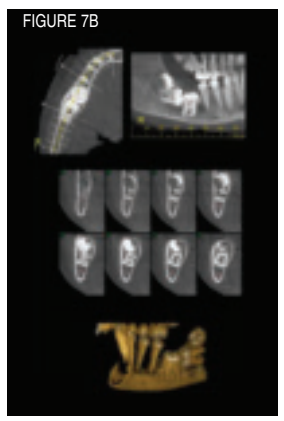


FIGURE 7B


FIGURE 8A

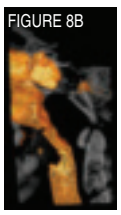


FIGURE 8B


FIGURE 8C

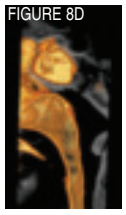
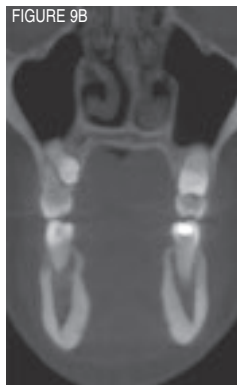


FIGURE 8D


FIGURE 9A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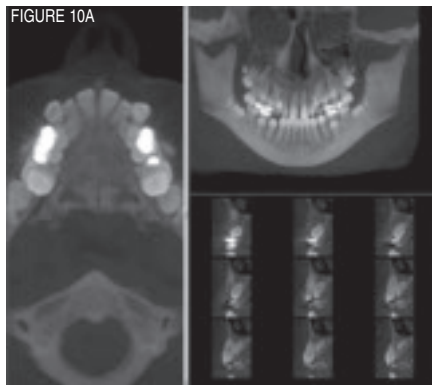
FIGURE 10A


FIGURE 10B

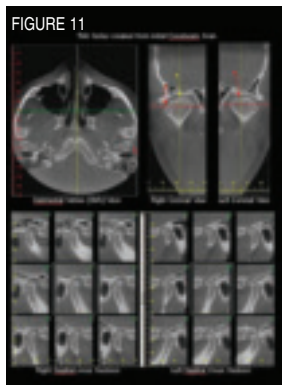
FIGURE 11