Cone Beam Computed Tomography: For Diagnosis and *Now Customized Therapeutic Treatment*!!!

Introduction:

Without a doubt, over the past decade, 2D digital radiography of the craniofacial region has been established as the standard of diagnostic care in our profession of orthodontics. It is my opinion that our profession is now making another transition with cone beam computed tomography (CBCT) establishing itself as the new standard of care in both 2D and now also 3D digital radiographic imaging. CBCT was first introduced to the dental profession in the United States in April of 2001 with the New Tom machine. Today, there are several different CBCT machines that are now commercially available: i-CAT, New Tom, Iluma, EWOO, Sirona, Plan Mecca, and Kodak to name a few. Until recently, CBCT has been utilized for the sole purpose of diagnosis and treatment planning in clinical orthodontics. Approximately 2 years ago, another significant application was developed for CBCT as it became integrated into clinical orthodontics with the merging of the two technologies of i-CAT and SureSmile. This merged application of i-CAT and SureSmile, has given to us the orthodontist, the ability to create from a CBCT scan customized robotically bent SureSmile wires that can now be utilized for actual therapeutic treatment of our patients. The ramifications of this are incredibly significant as we can now treat our patients in the 3D world. In this article, I will provide a general overview of the benefits of CBCT for both diagnostic and therapeutic treatment in orthodontics.

The use of CBCT in clinical orthodontics has been limited until recently due to two main factors: 1) cost and 2) radiation exposure to the patient. *Both these factors have become less of an issue as the cost of a CBCT machine has decreased approximately fifty percent since 2001. Radiation exposure to the patient has also decreased to a range from 30 – 160 microsieverts(µSv).* In comparison, this radiation exposure range is the equivalent of 3 digital panorexes to a full mouth digital series. Radiation exposure can be controlled and is dependent upon two main factors: 1) field of view (FOV) that can be collimated from 20 cm to 6 cm and 2) resolution or voxel size ranging from 0.1mm – 0.4 mm. The smaller the FOV and the lower the voxel resolution (i.e. – 6 cm at 0.4 mm) leads to lower radiation exposure.

As we all know, problems that have been associated with 2D radiography are superimposition, elongation, and distortion. With the advent of CBCT, this has now given our profession both superior 2D and 3D imaging capabilities. We are now able to isolate precise 2D slices in the axial, coronal, and sagittal planes without the problems associated with traditional 2D digital radiography. The advantages of this for diagnosis and treatment planning are immense as can be illustrated in the following case.

I was brought in by an attorney as an expert witness to review orthodontic treatment for a 15 year and 6 months old male patient **(See Figure 1).** This young man had suffered an ATV accident at the age of 10 years and 8 months and had been plated for an open mandible fracture in the right inferior border of the mandible. In January of 2008, at the age of 14 yrs and 10 months, orthodontic treatment was initiated by another clinician. It had been recommended by this clinician after several months of orthodontic treatment that the LR5 was ankylosed and should be extracted. When provided with a copy of a conventional non-digital panorex **(See Figure 2),** my suspicion was that the screws on the mesial and distal of his LR5 possibly could be preventing the eruption of this tooth. As a result, I suggested that we get a CBCT scan with our i-CAT for further evaluation of his situation. Utilizing Dolphin 3D Imaging to

view an axial slice of the root of his LR5, it is clearly evident that the distal screw is embedded in the root of his LR5 and that the mesial screw is adjacent to the mesial root surface of his LR5 **(See Figure 3).** Further analysis of the position of the screw with sagittal slices also led to concern for potential paresthesia during the removal of the plates and screws due to the proximity of the tip of the screw in relation to the inferior alveolar nerve **(See Figure 4).** I was asked to take over his orthodontic treatment by his parents and all this was explained to his parents prior to plate and screw removal by the oral surgeon. My treatment plan also included surgical uncovering of his LR5 with sub-luxation of his LR5 and LR4 and placement of a TAD between his UR4 and UR5 for indirect anchorage to prevent canting of his maxilla as we attempted to extrude his LR5 and LR4 with vertical elastics. In only 4.75 months of treatment, it is clearly evident that there have been significant positive changes with the positions of his LR6-LR3 **(See Figue 5).** There was minor paresthesia that did develop as a result of the plate and screw removal although this has continued to improve over the past 6 months.

CBCT also gives us the capability to easily transition between the 2D and 3D world. As a result, pathologies are now clearly evident when compared to traditional 2D radiography. This is clearly evident with the following patient. This 2D digital panorex taken in July of 2005 **(Figure 6)** does not display the traumatic bone cyst that is clearly evident on the 3D i-CAT panorex taken in January of 2007 **(Figure 7).** The reason for this is because with traditional 2D radiography there is superimposition of the dentition with bone, the tongue, airway space, and vertebrae along with elongation which leads to distortion. However, with the i-CAT panorex, we are able to create a focal trough that allows us to see only the specific regions of interest **(See Figure 8).** We can also very easily view the lesion utilizing Dolphin 3D imaging with a combined 2D and 3D approach **(See Figure 9).**

3D images derived from CBCT scans also give us the capability to view our patients from multiple planes and as a result we are able to precisely determine crown and root morphology and orientation of unerupted teeth within bone. We are also able to better evaluate the potential for root resorption of the adjacent teeth while actively extruding these teeth. Both of these points are clearly illustrated with the following patient **(See Figures 10a and 10b).** Because we know precisely the crown orientation of the LR3 and that the adjacent root morphology is intact, the oral surgeon was able to bond a button with gold chain in a position so that I could direct the proper vector of force to a temporary anchorage device that I placed between the roots of his LR4 and LR5. After 16 months of treatment the crown of the LR3 has just penetrated through the mucosal tissue and we will be able to bond a bracket on the tooth in the very near future **(See Figures 11a, 11b, and 11c).**

The superior benefits of 2D and 3D imaging with CBCT for the diagnosis and management of transposed and impacted teeth are clearly evident with the following case. It is clearly evident that the UL3 and UL4 are transposed on his i-CAT panorex **(See Figure 12).** In combination with a 3D slice from the axial view, we are able to precisely determine the exact positions of these two teeth as well as that of the impacted UR3 **(See Figure 13).** As a result, on the day of the initial bonding of his maxillary arch, a soft tissue laser was utilized to uncover his UR3, UL3, and UL4 with placement of an open coil spring between his UL3 and UL5 for anchorage of his UL5 to retract his UL4 and to protract his UL3 **(See Figure 14).** As a result, we are able to make definitive treatment decisions that lead to a higher quality of care and more efficient care for our patients **(See Figure 15).**

Although the significant advantages of CBCT for diagnosis and treatment planning cannot be questioned, until a little over 2 years ago, CBCT did not offer any means to actively treat our patients. In September of 2006, our practice in Green Bay, WI initiated a beta-testing project with Orametrix (the producers of SureSmile) and Imaging Sciences International (the producers of i-CAT) to evaluate the possibility of integrating i-CAT's 3D scans to create SureSmile's 3D virtual treatment models instead of using

SureSmile's intraoral scanner. SureSmile incorporates very powerful software applications to give the orthodontist the ability to create 3D virtual treatment simulations resulting in the fabrication of customized, robotically bent SureSmile wires. Because of the positive results that we saw with the quality and development of this project, in January of 2007, we began utilizing i-CATs 3D scans for the actual fabrication of our patient's SureSmile virtual treatment models and wires. *This was the first time ever in the history of orthodontics that 3D diagnostics was merged together with a customized therapeutic application for clinical orthodontic treatment!!!*

There are several benefits for the patient with utilizing an i-CAT scan instead of SureSmile's intraoral scanner. First and foremost is patient comfort. The time necessary to take a SureSmile scan is 20 seconds with the i-CAT Classic and is 26.9 seconds with the Next Generation i-CAT. This is in comparsion to an average of 20-30 minutes for an intraoral SureSmile scan. The clinical time savings utilizing