

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

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The goal of diagnosis & treatment planning in dentistry is to decide a course of treatment based on the evaluation of the initial condition of the patient's anatomy from various types of imaging sources. These imaging sources (X-rays, photos, etc.) have traditionally been from two-dimensional film-based systems and more recently from 2D digital imaging systems. Imaging in dentistry is used for developing various treatment plans, monitoring treatment response, and for evaluation of treatment outcomes. In orthodontics, imaging of the patient's anatomy has traditionally been evaluated from two-dimensional (2D) imaging sources such as: 2D cephalometric X-rays (lateral, frontal, etc.), panoramic & other X-rays, 2D facial & intra-oral photographs, etc. These 2D images and the resultant 2D tracings have then been compared to "standards" or "norms" created from data which differ by age, sex, race, etc. The limitations of 2D cephalometric projections have been known since its inception (REF #2). Geometric errors of projection not only affect X-ray projections but also affect measurements made on 2D photographs and 2D video imaging.

Evaluating the "Anatomic Truth" of our patient's anatomy in 3D has traditionally been limited to evaluating the patient "live" in the chair and by the evaluations of dental study models (either plaster or 3D digital representations). New 3D technologies (3D facial scanning & 3D Conebeam CT) are just beginning to be introduced into the dental & orthodontic community in order to evaluate the three-dimensional anatomic relationships of the patient's true anatomy. The 4th dimension, which is time, consists of evaluating the three-dimensional relationships as they change over time. This

could be in "real time" such as function, para-function, chewing, smiling, etc. or "over a period of time" which could be days, weeks, months or years, such as: aging, degenerative changes, traumatic changes, surgical changes, etc.

It is essential to evaluate, analyze, and use **accurate imaging data** that represents the "anatomic truth" of the patient's anatomy. The American Dental Association (ADA) defines **evidence-based practice** as an approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical expertise and the patient's treatment needs and preferences (REF #3). Three-dimensional imaging and its use "over time" (the 4th dimension) provides the true anatomical data necessary to expand clinical practices and researchers into evidence-based dentistry. Dental Informatics and Orthodontic Informatics is that area of dentistry that deals with the optimal creation, integration, and use of biomedical information, as it relates to dentistry and orthodontics, which includes accurate imaging of our patients. The American Dental Association is the national and international leader in the development of standards, technical reports, and guidelines for materials, information and technology impacting the practice of dentistry and the safety and health of the public (Ref #6). In order to understand the importance of these standards and guidelines in dentistry and orthodontics, a few terms should be defined:

- **Information Technology** is a term that encompasses all forms of technology used to create, store, exchange and use information in its various forms (business data, voice conversations, still images, motion pictures, multimedia presentations and other forms, including those not yet conceived). It is a convenient term for including both telephony and computer technology in the same word. It is the technology that is driving what has often been called "the information revolution."

- **Medical Informatics** is a term that is defined as "the well established scientific field of medicine that deals with biomedical information, data, and knowledge – their storage, retrieval, and optimal use for problem-solving and decision making." (Ref # 4)

- **Dental Informatics** is a subdivision of Medical informatics, and deals with information in the field of dentistry.

- **Orthodontic Informatics** was first described in an article in AJODO Sept 2002, by Drs. Harrell, Hatcher, & Bolt (ref #1) as, a subdivision of dental informatics and deals with the storage, retrieval, sharing, and optimal use of orthodontic, orthognathic, and dentofacial orthopedic information of the craniofacial region for decision making (diagnosis) and problem solving (treatment planning).

- **Imaging Informatics** is also a subdivision of health informatics, which plays a significant role in orthodontics and dentistry because, as clinicians and researchers, we use imaging every day in our practices. Shortliffe (ref # 4) describes the role of imag-



ing in health care (imaging informatics) as "a central part of the assessment of response to treatment and estimation prognosis. In addition, imaging plays important roles in medical communication and education as well as research."

In June 2005, Dr Bill Harrell, orthodontist Alexander City, AL became the first orthodontist in private practice in the USA to begin using 3D facial capture (3dMD, Atlanta, GA) and the first practitioner in Alabama to use Conebeam Volumetric Tomography (Imaging Sciences, iCAT, Hatfield, PA). 3D face scans (3dMD) uses no radiation and produces an accurate 3D model of the patient's facial contours (RMS < 0.5mm) with phototexture in 1.5 milliseconds capture time.

Conebeam CT (CBCT), also known as Conebeam Volumetric Tomography (CBVT), produces accurate 3D image data of the craniofacial region, with very low radiation dose (see dose chart).

Together these two 3D imaging modalities can be combined to create a "virtual 3D patient" (Figure #1) which the orthodontist and referring dentist can then evaluate in an anatomically true fashion. These 3D models are interactive and can be rotated to any view for more complete diagnosis and treatment planning.

## 3D facial scanning

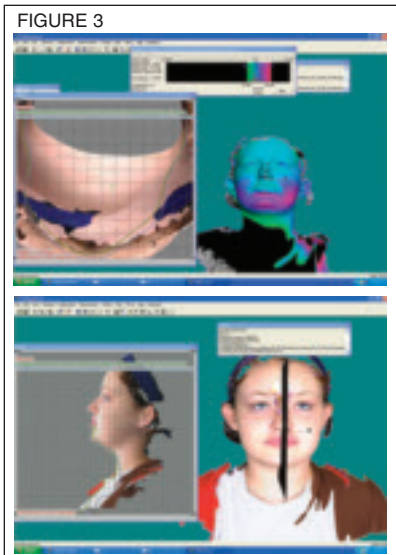
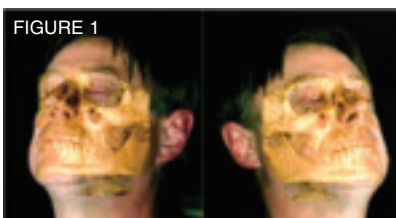
Multiple views can be created from one 3D scan. (Figure #2). Facial asymmetry analysis can easily be done by evaluating the differences between the right and left sides. Co-registration of pre and post surgical treat-

ment plans can allow the doctor to visually and quantitatively evaluate changes in Three-Dimensions). Quantitative differences between orthodontic extraction and surgical advancement can be assessed (Figure #3A & B).

Part II of this article will be featured in the Spring 2007 issue of ALDA News. Dr. Harrell is presently serving on the American Dental Association's (ADA) Standards Committee on Dental Informatics. Further information can be found in an article written by Dr. Harrell (REF# 1). Dr. Harrell can be emailed at drharrell@aol.com.

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**"Background" Exposure**  
X-rays are naturally occurring! People are exposed to radiation from natural sources all the time. The average person in the U.S. receives an effective dose of about 3000 µSv per year (~8 µSv per day) from natural sources such as cosmic radiation from outer space and sources in the soil. The largest source of background radiation comes from radon gas in our homes which is about 2000 µSv per year. Radon exposure varies from one location in the country to another. Altitude also plays an important role as people living at elevation such as in the plateaus of Colorado or New Mexico receive about 1500 µSv more per year than those living at sea level. The dose from cosmic X-rays during a coast to coast flight in the U.S. is about 30 µSv.

**Relative Radiation Exposure**  
To explain exposure in simple relative terms, the following table compares common dental procedures with comparable natural background exposures and select medical examinations. Note that dental X-ray images are equivalent to less than one day to a couple weeks of natural background radiation.

Examination	Effective Radiation Dose (µSv)	Equivalent Natural Background Radiation for
Panoramic	3-11	Half to One day
Cephalogram	3-7	Half to One day
Occlusal Film	5	Half day
Biting	1-4	Half day
Full mouth series	30-170	4-21 days
DHII series	20-50	1-4 days
Ortho X-ray	40-135	4-17 days
<b>Medical Examinations</b>		
Chest X-ray	100	10-12 days
Mammogram	300	30 days
Medical CT	3000	3000 days

Credit: from James Mah, DDS, MSc., X-ray Imaging and Oral Healthcare, 2006