One beam computed tomography (CBCT) was first introduced in the United States in 2001. Since its inception, CBCT has been slowly gaining acceptance as the premier diagnostic tool of choice in just about every specialty in dentistry, both as a research and clinical tool. Its advantages over traditional 2D imaging in orthodontics have been well documented, and its use in clinical practice varies from no use at all, to routine use for every patient. A 2011 independent study showed 4/5 of all orthodontic residency graduate programs in the U.S. utilize CBCT for specific applications, and 1/5 of all such programs use CBCT as a routine radiograph on all patients. That number is likely increasing and represents a significant trend towards CBCT replacing panos and cephs in orthodontics due to lowering dosimetry levels and continued reductions in pricing.

3D diagnostics is a mental quantum leap for most orthodontists when faced with the prospect of transitioning from a 2D to 3D mindset. As a specialty, we’ve grown so accustomed to asking diagnostic questions derived from 2D information (i.e., cephs, pano, FMX), that our instinct now is to ask the same 2D questions from 3D information. We will never be satisfied with our answers if we continue such mental trickery because our anatomy is simply not 2D. For instance, cephalometrically speaking, is it really appropriate to ask about lower incisor angulation from a 3D data set? Which lower incisor are we talking about (i.e., the right or the left, the central, or the lateral)? Which mandibular plane (i.e., the right or the left; which humanly located anatomic landmarks define our plane)? First, it is well documented that cephalometrics is fraught with error. Second, we’ve grown accustomed to having a set of multiple diagnostic pieces that geometrically do not correlate well with each other (i.e., photographs versus 2D radiographs versus physical models) like different languages speaking to each other. CBCT offers a relatively low-risk solution to these diagnostic and geometric shortfalls.

There are now over 20 CBCT manufacturers, most offering different products. The competition has lowered prices and, more importantly, lowered dosimetry levels, a major concern and obstacle for most orthodontists considering embracing CBCT for their practices. With the introduction of newer generation machines such as the i-CAT® FLX (Imaging Sciences International), whose independent validation studies recently showed a ceph-sized scan (16 cm x 13 cm) to deliver less than half the radiation of a panorex®, it is now foreseeable that the orthodontic and possibly the pediatric community will shift toward CBCT as the routine imaging modality of choice in everyday practice. The tide seems to be turning. Will panos, cephs, and periapical radiographs in orthodontics soon be considered outdated, even irresponsible imaging?

Dynamic digital modeling (DDM) is a product of CBCT data, producing a single all-inclusive orthodontic 3D digital record. This DDM product is Anatomodel from Anatomage Corporation.
product of CBCT data producing a single all-inclusive orthodontic 3D digital record (Figures 1A and 1C). Because volumetric imaging captures information in the form of voxels, not pixels, this comprehensive digital data set can produce an array of useful diagnostic information in the form of accurate, interactive, segmented anatomy in 3 dimensions. The i-CAT FLX captures a ceph-sized 3D scan in 11-18 microsieverts (data on file with i-CAT). In comparison, a digital panorex is 15-25 microsieverts.* It’s all software modeling after that. The Anatomodel™ (Anatomage Corporation) is an all-inclusive orthodontic record file made from DICOM, producing impressionless digital orthodontic models with segmented roots, jaws, condyles, bone, and crowns (Figures 1A, 1C, and 2). Additionally, a 3D photograph is easily produced and perfectly wrapped over the soft tissue facial mapping, resulting in perfect correlations of soft and hard tissue. Much more than just a pretty picture, once these individualized pieces of anatomy have been digitally and independently segmented with Tx STUDIO™ (Imaging Sciences International) or InvivoDental™ (Anatomage Corporation) software, it is easy to perform virtual 4D treatment planning involving tooth movements (Figure 2), OMFS movements, soft tissue predictions (Figure 3), computerized planning for TAD placement (Figure 4), eruption management of the mixed dentition (Figure 5), and airway management in all patients. Airway segmentation and measuring tools allow for orthodontists to treatment plan around the airways and screen for patients at risk for obstructive sleep apnea.

Figure 2: Dynamic modeling through segmentation allows for interactive virtual treatment planning. Here teeth can be colored, labeled, and even moved using proprietary software from i-CAT and Anatomage Corporation

Figure 3: Software allows for computerized surgical treatment planning of orthognathic cases and soft tissue predictions using 3D data acquired from low-dose CBCT scans

Figure 4: Temporary anchorage devices (TADs) can be strategically mapped in 3D for ideal placement and best surgical planning and communication with patients and specialists

Figure 5: Eruption management in the mixed dentition using 3D imaging is one of the most exciting applications of new technology in light of the new low-dose i-CAT FLX

Figure 6A: Airway segmentation and measuring tools allow orthodontists to treatment plan around the airways and screen for patients at risk for obstructive sleep apnea

Figure 6B: Multiplanar reconstruction views (MPR) of CBCT data allow orthodontists to better evaluate the paranasal sinuses and nasal cavity as it potentially affects the oral cavity

Figure 6A: Airway segmentation and measuring tools allow orthodontists to treatment plan around the airways and screen for patients at risk for obstructive sleep apnea
obstructive sleep apnea. It is foreseeable that airway-centered treatment planning will become standard in orthodontics with the arrival of low-dose imaging using CBCT technology (Figures 6A and 6B).

As a patient education tool and practice management tool, 3D CBCT is extremely useful. The visual nature of CBCT, enhanced with dynamic modeling, makes the information being presented to patients easier to understand—in particular the complexities of treatment that often go missed or misunderstood. It helps present treatment expectations, CBCT in the form of dynamic models helps present treatment expectations and treatment limitations. Some legal experts argue that, from a medical-legal perspective, one is better off with a CBCT than without one. Not only does the file serve as an accurate treatment record, but can also help reduce treatment liability and risk of litigation because to see is to know; to not see is to guess.

The future has arrived. Last year, i-CAT released the i-CAT FLX, yet another improvement in their generation of machines making cone beam CT technology better and safer. Using the QuickScan+ setting, the i-CAT FLX can produce a ceph-sized (16 cm x 13 cm) extended field of view volumetric scan at a dosimetry level as low as half of a panorex. These levels were recently confirmed though an independent academic institution-based study by Dr. John Ludlow at the University of North Carolina that measured the dosimetry levels of the new i-CAT FLX machine. These findings, recently published in the American Journal of Orthodontics and Dentofacial Orthopedics (AJODO), reports that the i-CAT FLX can produce a 16 cm x 13 cm extended field of view image using the QuickScan+ mode at a relatively low level of 11–18 microsvs according to lab-controlled phantom studies. To give you an idea of how low this is, a digital panorex is about 25 microsvs in similar studies. The implications of this in orthodontics and even pediatric dentistry are enormous. There are still CBCT machines out there that deliver over 500 microsvs, so clearly, CBCT dose varies substantially depending on what machine and what parameters are used. What’s more, is that dynamic modeling and anatomical segmentation of airways and other structures can just as easily be performed with this new low-dose scan. Figures 7 and 8 are examples of what is readily possible today using a combination of the i-CAT FLX QuickScan+ settings and the Anatomodel dynamic modeling at 11 microsvs. Will this set a new standard as an orthodontic diagnostic record? Has the radiation-overexposure argument now been suddenly flipped on its back?

One thing is for sure: With extremely low radiation doses, CBCT scanners, such as the i-CAT FLX and its QuickScan+ setting now on the market, mark not only the end of the CBCT-in-orthodontics controversy, but likely the future death of panos, cephs, and plaster (Figure 1B).

REFERENCE