The orthodontic viewpoint of 3D imaging

by Alan A. Winter, DDS and Terry J. Sobler, DDS

It is endemic to being a dentist that we approach every patient who seeks our care by first taking an oral history. We perform a clinical examination and utilize a host of other data that includes dental X-rays, photographs, medical information, study models and other guides to help us form a diagnosis that results in a treatment plan with expected outcomes. And while dental school trains us in data-gathering procedures that are tried and true, some new technologies of the digital world can no longer be ignored or viewed as fads when they transcend anecdotal experiences to be worthy of being embraced.

When does the tipping point occur when high-tech becomes low-tech? When a futuristic concept laced with glitz and fanfare transcends and overcomes everyday comfort levels to the point that they need to become part of one's regular armamentarium? Some dentists become early adopters of these new technologies, while others sit on the sidelines and resist stretching beyond their comfort levels to adopt them. Those willing to learn new clinical techniques, tackle new software applications and alter their daily routines do so because, in their desire to provide the best patient outcomes, they feel compelled to reach for a higher level of performance. In some instances, they may do so because it may give them a competitive edge in the marketplace. For others, it is simply the level of excellence they strive to deliver to their patients.

Fig 2: Impacted third molar can be viewed in 3D software that permits superimposition of the patient's facial image. This software (In Vivo by Anatomage as seen above) can be rotated, cut in cross-section, and viewed from multiple perspectives.

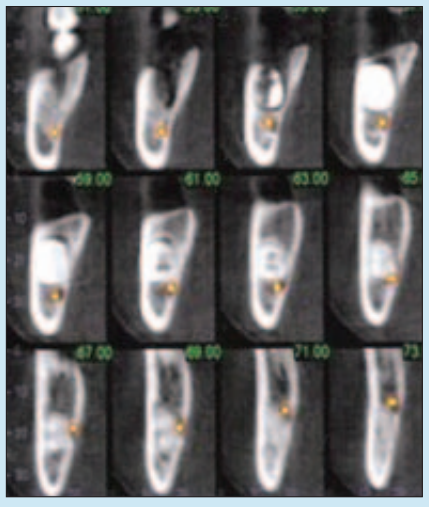

Fig. 2A identifies (in a different patient) the nerve in millimeter cross-sections from anterior (upper left image) to posterior (lower right image).

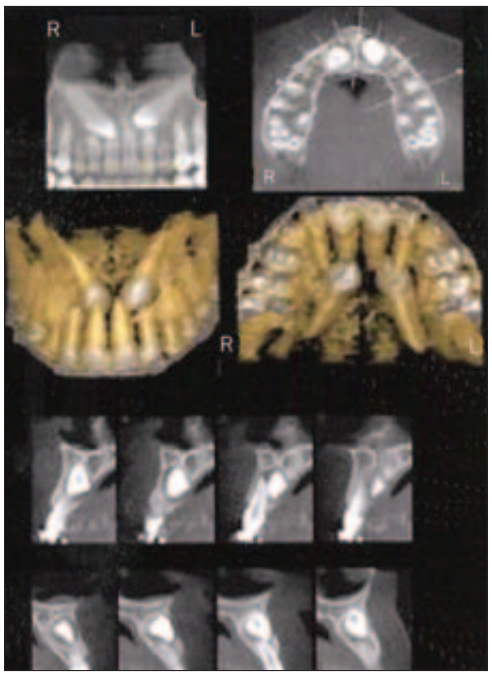

Fig. 1: 3D imaging enables the clinician to identify that the impacted #6 is palatal to the right central incisor while tooth #11 is labial to the left central incisor. (Photo courtesy Dr. David Hatcher)

Take X-rays, for example. Ever since Roentgen discovered X-rays in 1895, dentists have relied on 2D dental X-rays to give them more information in diagnosing and treating patients. In 1950, machines that revolved around the head to give a "panoramic" view of the teeth and hard structures of the head were introduced. Conventional dental and panoramic machines, however, had distortions that were (and still are) not clinically acceptable. For example, panoramic images are distorted by as much as 7.5 mm or 27 percent; dental X-rays can be distorted by 1.9-5.5 mm (Sonick, JOMI, 1994, pgs 455-460). These potential radiographic inaccuracies increase the risk for permanent (inferior alveolar) nerve damage or perforation of the maxillary sinus.

In 1972, Geoffrey Hounsfield invented the CT scanner. Software to adapt the CT scanner for dental use was introduced in the late 1980s. Other than the introduction of third-party software for implant treatment planning (by Materialise, Glen Burnie, Md.), little changed until dental cone beam volumetric (CBVT) scanners were introduced in the late 1990s first by QR Verona in Italy, and then next Imaging Sciences,

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Fig. 3: Cross-section (trans-axial view) displays the relationship of the buccal aspect of the molar relative to the thickness of the buccal housing and cortical bone.

Fig. 4: In Vivo software by Anatomage, (courtesy Dr. David Hatcher) enables segmentation to peel away the hard structures and give accurate relationships of teeth:teeth and roots:roots.

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Inc. in Hatfield, Pa. Presently, there are more than a dozen manufacturers in this marketplace. These dental scanners are more accurate than medical scanners, utilize less radiation, and capture images of both the maxilla and mandible at the same time.

Implant dentistry initially embraced medical CT scanners, and now dental CBVT scanners as a technology that enhanced patient's pre-surgical implant planning. But what started for many dentists in the implant world, in the craniofacial world, in the removal of impacted third molars, as a personal standard of excellence has now transcended to become a standard of care.

But is the same true for orthodontics? Is 3D planning software a fad or a necessity to treat patients with malocclusions? With more and more CBVT scanners being installed across the US every day, should orthodontists strive to use this technology, or can they afford to sit back and wait until it becomes more accepted in their community?

Traditionally, orthodontists have utilized two-dimensional, film-based systems for X-rays (and photos) to help make their diagnosis and create their treatment plan. Only recently, with the introduction of 3D CBVT scanners, have these images offered unparalleled views in the analysis of a number of everyday clinical entities that confront orthodontists.

Impactions

The unlimited number of views generated by 3D imaging software gives new dimensions for many aspects of orthodontic treatment planning. None is more readily apparent than the way 3D imaging changes the means in which impacted teeth can be viewed, both by orthodontists and oral surgeons. Imagine taking an image in 5-20 seconds (regardless of the cone beam scanner manufacturer) and being able to view the exact position of impacted teeth.

Fig. 1 highlights a patient with both maxillary canines impacted. While a traditional 2D image readily identifies these impactions (as seen in the top left panel), the right canine is palatal to the apex of the right central incisor while the left canine is labial to the left central incisor. These positions are accurately determined, along with the vertical relationship to all adjacent structures, by viewing the cross-sectional views (which are also referred to as transaxial or sagittal views). The degree of overlapping, teeth/roots touching, or areas of root resorption of adjacent teeth can be visualized in a way no current 2D media can demonstrate. In practical terms, treatment plans can now be determined with a higher degree of accuracy than ever before. It becomes simpler to plan which way the canine should be moved for the quickest eruption into the oral environment or, in some cases, the manner in which an impacted tooth should best be removed.

For third molar impactions, their proximity to the inferior nerve is clearly established with CBVT. This becomes an invaluable aid in the determination of whether the impacted tooth should be removed and how best to remove it *(Figs. 2 and 2A)*.

Palatal expansion versus tipping teeth

3D imaging permits the frontal cephalogram to be seen with clarity not previously achievable. J point in the frontal analysis is no longer guesswork *(Fig. 3)*. We can now visualize the axial relationship of all teeth from the buccal to palatal. The transaxial (cross-sectional) views may be constructed in 1mm thicknesses, and each tooth can be studied relative to the root position within the alveolar housing, whether there is medullary bone juxtaposed between the root and the buccal plate, or how thick the cortical bone is. This information aids in the decision as to whether palatal expansion or just tipping is necessary to correct crossbites in the posterior dentition.

This will limit the risk of moving teeth to the extent that it will create dehiscences or fenestrations. Conversely, 3D imaging identifies thin buccal/labial bone from the outset so that treatment can be modified to take this into account. What was once conjecture in radiographic and clinical diagnosis is now factual.

Tooth:tooth and root:root relationships

All teeth can now be viewed in every direction with accuracy as a result of 3D imaging; the absolute position of tooth-to-tooth and root-to-root is no longer an issue *(Figs. 4 and 5)*.

Fig. 5: In Vivo software (Vultus software by 3dMD, Atlanta, Ga., has this ability) can superimpose the patient's digital image on a 3D CT scan to view the hard and soft tissue relationships in a life-like view. These images can be rotated, cut in cross-section and viewed from any direction or angle. (Photo courtesy Dr. David Hatcher)

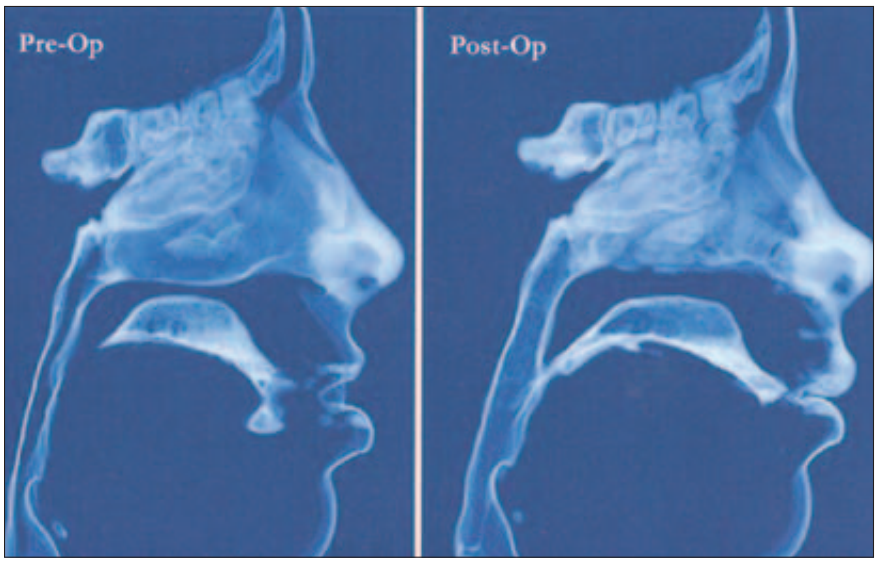

Fig. 6 demonstrates the versatility of 3D imaging by identifying all air spaces in a patient pre- and post-treatment. These images can be seen in cross-sectional and rotated to study any view. (Photo courtesy Dr. David Hatcher)

Everyday therapeutic questions are more easily answered with the aid of 3D images. For example, should mandibular incisors be retracted? Now, *(Figs. 4 and 5)* because we can clearly see the relationship of roots:to:roots and roots:to:bone, we are able to make better decisions.

Airway space

With our aging population, sleep apnea is becoming a more common problem. Increasingly, dentists may be called upon to treat this entity. 3D imaging permits visualization of the airway and the lymphoid tissue both to help diagnosis and evaluate therapeutic results with great clarity. Segmenting the airway provides empirical proof of clinical improvement and provides a direct mechanism for researchers to study this increasing problem *(Fig. 6)*.

TMJ anatomy

Traditional views of the TMJ complex (lateral films) have been used for decades to help determine the TMJ anatomy. While fractures and a variety of pathologies can be noted on lateral films, 3D imaging enhances and makes these views clearer than ever by reconstructing them in 1mm sections not only laterally (cross-sections) but from unique anterior views (coronal sections). These clear and precise views may *(Fig. 7)* alter treatment plans and help diagnose pathology to the head of the condyle or to the joint. Clear images can be obtained depicting the role of condylar size that may cause malocclusions that affects treatment success.

Additional 3D benefits for the orthodontist

- Arch length analysis can be performed from the 3D scan since there is no distortion.
- Eruption patterns become more evident as the patient's scan is studied in three dimensions.
- Decisions to extract primary teeth to aid in eruption of potentially ectopically erupting permanent teeth are more accurately made.
- Accurate stereolithic models can already be fabricated from 3D scans.
- In the not-so-distant future, 3D scans will be uploaded to third-party services who will fabricate virtual models of the dentition from which indirect bonding trays will be created without taking impressions.
- The gold standard for 3D scanner manufacturers is to create accurate models for Invisalign from the scans without the need for impressions. This will be a precursor to the day when dentists no longer need to take impressions to fabricate any sort of dental restoration.

With 3D imaging, we can now visualize accurate root relationships. We have the ability to reconstruct the skeleton in 3D giving new insights into assessment of asymmetries, craniofacial anomalies, and how best to treat these patients. Consider that the present world of orthodontic radiographic imaging – cephalometic views, TMJ imaging, submental vertex images and panoramic reconstructions – can be captured in one, brief CBVT exposure.

Today, CBVT is a novelty that most orthodontists find interesting but not necessary for them to successfully treat their patients. But as more and more orthodontists leap into the world of 3D imaging, when will that tipping point occur when a fad becomes standard of care? OT

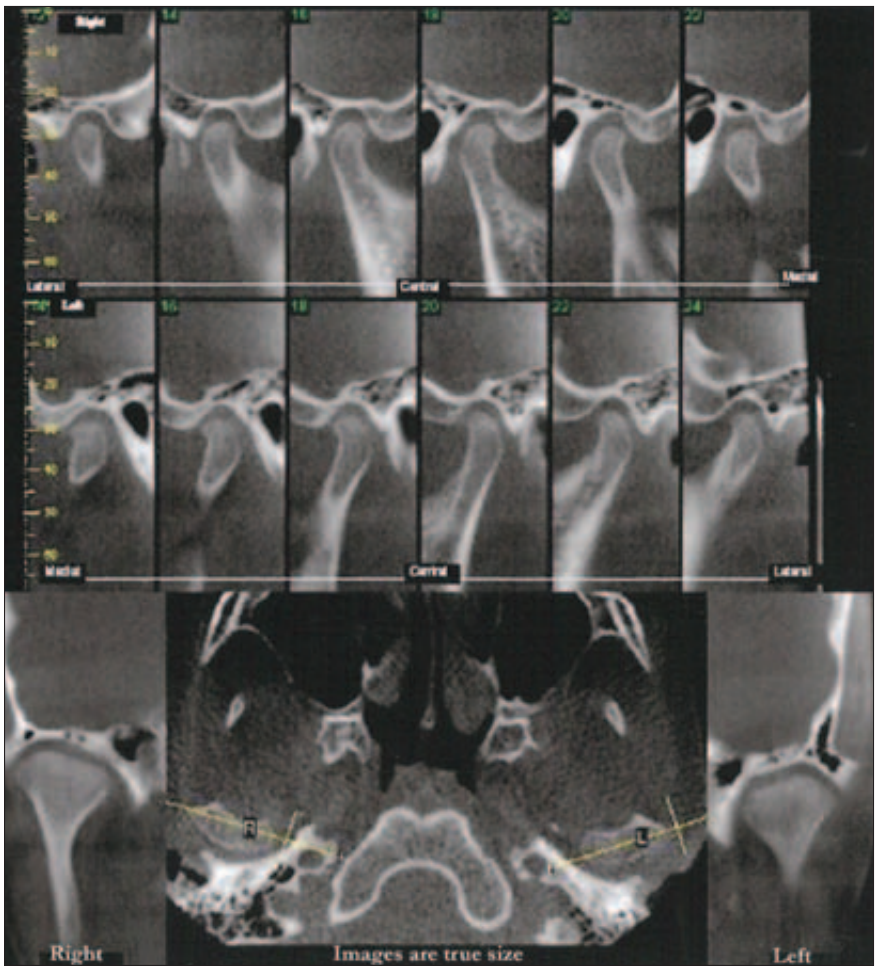

Fig. 7: Composite TMJ films demonstrating (top) right condyle from lateral (sagittal) view, and (middle) left condyle with same views. The (bottom) anterior or coronal views demonstrate the condyle in the fossa. (Photo courtesy Dr. David Hatcher)

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