Orthodontic applications of 3D imaging

By Lisa Randazzo

Not too long ago, 3D imaging was a pipe dream reserved for academic institutions and medical centers with deep pockets and sophisticated research goals. In the more recent past, dental specialists such as orthodontists and oral maxillofacial surgeons have been enjoying the abundance of accurate data delivered by volumetric datasets. Today, the rapid pace of development and reasonable pricing surrounding 3D imaging technology has made it accessible—and increasingly relevant—to dental professionals of all disciplines, including the GP.

For many practitioners, the single, 20-second scan captured by a cone beam computed tomography (CBCT) device has replaced the full set of traditional dental imaging that was routine at the initial exam: Emitting a lesser radiation dose than spiral CT, a CBCT scan is comparable to a dental periapical full-mouth series.[1] In addition, secondary reconstructions of any desired anatomical view or isolated structure can be easily generated from this single scan.[2] "I no longer use two-dimensional images," says Dr. Ilya Lipkin, an orthodontist in Emerson, New Jersey, who has a CBCT unit onsite and says 3D records are standard protocol in his practice. "The 3D image is the only x-ray that I take. From it I produce all of the images I need—from ceph to airway to TMJ. All those get analyzed and put into my diagnostic workup." Dr. Lipkin says he enjoys the volume of information matched with the high level of accuracy that three dimensional data delivers. "I can see everything in 3D," he says. "That improves my diagnostic ability incredibly. The right diagnosis = right treatment = better practitioner." [1 & 2]

Spacial Reality

Volumetric data not only offers more, accurate information than traditional 2D records, but the 1-to-1 image-to-reality ratio produced by a 3D scan[3] allows the practitioner to examine and evaluate conditions without the burden, or margin of error, associated with accommodating for magnification and distortion. Witnessing anatomy in true spacial perspective removes the guesswork inherent in the analysis of conventional radiography.

Digital rulers imbedded in 3D rendering software allow for the exact measurement of anatomy. “3D imaging provides the precise locations of TM joint pathologies such as bone cysts, different stages of erosion, joint compression, DJD and secondary arthritis,” says Kenneth Lau, DDS and TMJ specialist in Pendleton, Indiana. “It can show the physical relationship of anatomical parts and provides the actual measurement of their relationship. For example, I can measure the width of each tooth to help with the arch length calculation for orthodontic purposes.” In addition to measuring distances, cephalometric landmarks can be accurately identified on hard and soft tissue—in three-dimensions.

The added dimension of volumetric data opens a window that remains closed in traditional 2D imaging: 3D also allows the clinician to view and identify previously hidden conditions. This includes performing serial tracking of expanding or contracting lesions, and accurately anticipating the progress of infectious lesions. The volumetric models also serve as reliable references in the surgical planning of oral maxillofacial reconstruction after surgery or trauma.[4]

Calculating the 3D volume of the oropharyngeal airway and sinuses is another advantage offered by CBCT data. “If I see other related medical problems like those of the upper airway, I can refer the patient out with the actual imagery,” says Dr. Lau. “The ENT can use the images to help diagnose.” Software exists that is able to measure the airway volume, enabling the clinician to calculate the most restricted areas. [7]

Endless Views

A major advantage of 3D datasets over 2D is the ability to process the data using special software that by design has a very low learning curve, making it easy and practical for all staff to use. “My staff can take the scan and within five minutes build me an image file,” says Dr. Inna Gellerman, an orthodontist in Huntington, New York. “The 3D scan gives me all the information I need. Even if I don’t use the information right away, I have it all in the patient’s record for the future.” Once the data has been imported into the software, the user is able to isolate anatomy and segment the hard and soft tissue for closer

viewing. Different colors can be assigned to different anatomy for further visual clarity. [6] The ability to manipulate volumetric datasets has enabled practitioners to assess anatomy from previously impossible angles, such as viewing the occlusion from the back of the patient's head into the oral cavity.[5] These software programs are also able to locate cranial nerves and their relationships to roots and other structures, making the technology invaluable for the safe execution of impaction and implant procedures. [view nerve in 3D]

The ability to adjust translucency and colors of the image gives an opportunity to determine the specific relationship of soft tissue to skeletal structures. This has significant applications for orthodontic treatments such as planning tooth movement, extractions, and other therapies that might alter facial appearance.[6] [3 & 9]

Virtual Patient

Merging volumetric datasets from a CBCT scan with surface data produced by a high-definition facial camera (such as a Canfield System), creates a virtual patient that serves as a valuable model for the assessment of facial deformities, as well as for evaluating treatment progress and outcomes. In addition, the fact that three-dimensional models can be manipulated in any direction without compromising the integrity of the data eliminates the hassle and time involved in calling a patient back for further imaging.[7] [3D sample] Dr. Lipkin has a high-definition facial camera system on site at his practice because of the exponential diagnostic value it delivers. "Surface data is so much more accurate than 2D photos," he tells us. "You can look at the face at any angle, and pick up things that aren't readily visible at the clinical exam. You can measure asymmetries, midlines, etc. off the 3D surface without having the patient present. So, if my assistant took 3D photos I can analyze it later without having to spend too much time at the chair measuring the same things or measuring from a 2D photo." The 3D model that defines the virtual patient is also valuable for revealing surface irregularities due to ectopic teeth, bone dehiscences and other abnormalities.[8] [3d (dr lipkin w/ patient)]

Enhanced Communication

The visual benefits offered by three-dimensional data have a huge impact on patient comprehension, in addition to adding to their sense of confidence and security that their practitioner is comprehensively caring for their needs with the latest technology.[9] "Patients love it. When they see their skulls it is so easy for them to understand their conditions," says Dr. Gellerman. "It is difficult for patients to see and comprehend 2D images; if you show them a traditional x-ray and tell them they have an impacted cuspid, they really don't see it." The simple interface of 3D software allows the practitioner to quickly assess a patient's condition during the initial exam, as the patient sits in the chair. "The 3D software lets you calculate the situation within minutes and explain it to the patient," adds Gellerman. "It makes it easy for them to see the relationships between hard and soft tissue." [005]

The portability of three-dimensional file formats is also an added advantage; being able to copy and share over the Internet with no further effort than a mouse click is a value all its own. "Being able to email the images to parents is especially helpful because kids don't always go home and convey the information so well," says Gellerman. "And this is partly because it is difficult for them to explain their conditions."

Getting the View

Fortunately, any practitioner can benefit from CBCT without a huge financial commitment or the need to surrender valuable office space. Most oral and maxillofacial imaging labs will deliver 3D datasets with copies of OEM (original equipment manufacturer) software that allow the practitioner to analyze the images within the 3D environment. While these programs are typically limited in terms of saving and archiving capabilities, they do allow the recipient to build secondary reconstructions of desired anatomy; map the mandible for nerve identification; calculate measurements; rotate the image; segment tissue density; and view media sequences created by the generating party. "Cone beam imaging is new to a lot of practitioners, and the viewing software packages gives them the opportunity to interact with the DICOM data," says Jerry Peck, DRT, owner of C-Dental X-Ray and McCormack Dental Imaging labs in California. "It's a huge value to them that they can rotate the image; they can actually go in and

manipulate the volume to evaluate areas that matter to them, instead of getting just a slice. It gives the doctor the ability to evaluate his treatment plan much better because all the information is there—you could never give anyone that many prints." [5]

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Features and Capabilities of 3D Software

Importing, processing and viewing three-dimensional volumetric datasets is easy with the cutting edge 3D software packages on the market today. These programs are designed to import and process volumetric data from a variety of sources, including MRI, CT, cone beam CT and high definition facial camera systems. The datasets are then easily saved into a patient's file. Object orientation and tissue segmentation tools make it simple to get a close look at any craniofacial anatomy. Some other tools bundled in these software packages include:

- Nerve Marking. Locate and isolate the nerve canal on a panoramic projection, then clearly draw the visible nerve canals with a choice of width and color. View corresponding nerve positions on cross sections, and view the marked nerve canal within 3D rendering of the skull volume.
- TMJ View. Designed specifically for analyzing the temporomandibular joint, this function lets you choose an area of interest by setting the center point and axis direction. Set a desired slice thickness, width, number and direction such as coronal, sagittal or patent-pending circular. Cross sections can be viewed at the chosen axis.
- Airway Volume Analysis. Enables the clinician to visualize and measure airway and sinus volume to determine most constricted areas.
- Volume Superimposition. Allows the simultaneous loading and aligning of volumetric scans from two different time points to view changes in hard tissue, soft tissue or airway.
- Virtual Modeling. CBCT images can be modeled in the traditional form of digital study casts for viewing and morphing into desired tooth positions. Models from different treatment stages can be superimposed for precise progress analysis.

Most programs also offer the ability to design automated image layouts, and export easily to other applications including Word and PowerPoint.
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