IMAGING PEARLS

When to Recruit the Third Dimension and How to Maximize Your Yield from Radiographic Studies

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Both two- and three-dimensional imaging have great utility in dental diagnostics, each with their advantages and limitations. Radiology has the ability to not only answer questions about disease or abnormalities but also to provide anatomic information that is essential to proper diagnosis, treatment planning, and treatment delivery. Cone beam CT (CBCT) imaging has transformed the landscape of the entire dental industry, adding tremendous diagnostic value and broadening the scope of care that dentists can comfortably render to their patients. However, CBCT imaging does carry its limitations and certain dental diagnostic applications remain superior with 2D imaging.

Many of the advancements in imaging systems over recent years have been geared toward two main goals — improving image quality and reducing radiation burden, across both 2D and 3D systems alike. Improvements in 3D platforms have reduced the associated risks between 2D and 3D imaging that make CBCT an attractive modality to use across a wider range of dentoskeletal diagnostic tasks, especially given the enormous increase in the amount of information obtained. But, as the adage goes, with great power comes great responsibility — including ordering the right exams and interpreting them comprehensively.

While no X-ray exposure can be considered free of risk, most dental diagnostic examinations, from small intraoral X-rays to large CBCT volumes, in and of themselves carry very low risk of harm to patients. The decision to prescribe any radiographic examination for a patient depends on the probability of the information being useful for a particular diagnostic question that otherwise cannot be determined using a thorough workup including clinical examination, a patient's history, and review of prior radiographic examinations. These decisions must also be tailored to the needs of the individual patient, including their sensitivity to X-rays, with the goal of maximizing diagnostic utility while keeping radiation doses as low as diagnostically adequate. Large, exhaustively detailed volumes can be (and have been) written about this discipline (selection criteria for dental radiographic examinations), but for sake of brevity, this article will summarize the pros and cons of various 2D and 3D examinations as well as the steps any dentist can take to maximize the information gathered during these exams.

GENERAL ADVANTAGES OF 2D IMAGING

- Low radiation dose
- High-resolution images
- Improved diagnostic value for caries detection
- Fewer artifacts
- Quick acquisition, post-processing, and viewing (digital)
- Cost-effectiveness

GENERAL DISADVANTAGES OF 2D IMAGING

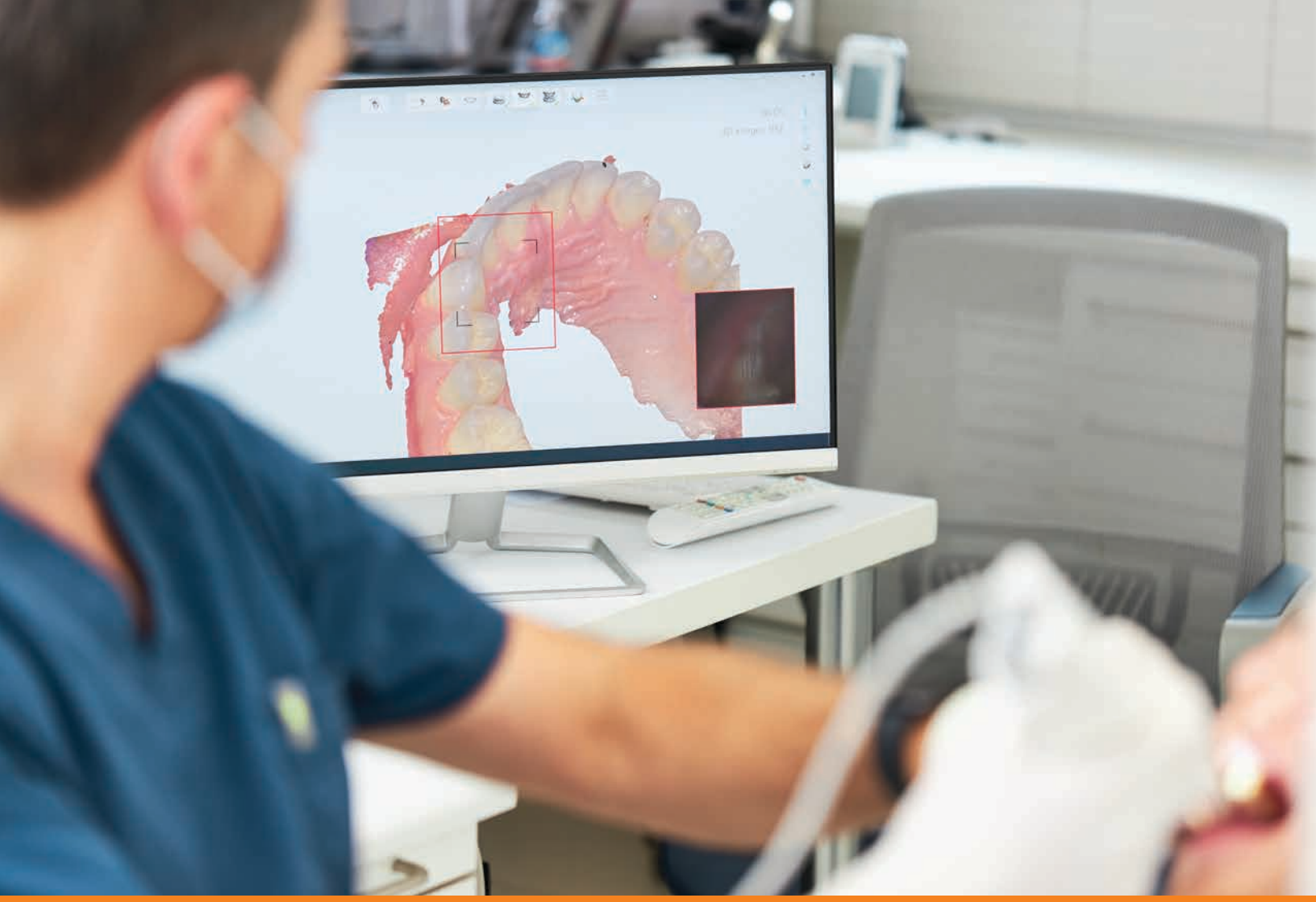
- Reduced ability to discern details in the dimension through which the subject is imaged
- Geometric distortions
- Technique sensitivity
- Infection control concerns (intraoral radiographs)
- Higher occurrence of superimpositions (all types but more so in extraoral images)

GENERAL ADVANTAGES OF 3D IMAGING

- Increased diagnostic yield in all dimensions (the most profound benefit)
- Lack of geometric distortion
- Localization of structures or disease extent
- Capacity to analyze asymmetries
- Ability to render various views, orientations, slices, sections, etc. (manipulation of the volume to improve perspective and diagnostic confidence)
- Implementation of software tools (nerve tracing, 3D volume renderings, etc.) to highlight various structures (airway, TMJ, etc.)
- Better opportunity for occult disease detection

GENERAL DISADVANTAGES OF 3D IMAGING

- Radiation burden
- Spatial resolution (can be excellent but still inferior to intraoral radiography most of the time)
- Wide range of artifacts that preclude detailed assessment of fine structures (motion, noise/graininess, streaking, beam hardening, calibration etc.)
- Longer post-processing time required
- Greater burden of interpretation of all structures and liability potential
- Cost and availability »



The following is a short list of diagnostic tasks for which 3D imaging is categorically superior to that of 2D (not implying that 3D must be used but when used is superior to 2D):

- Dentoalveolar
  - Localization and extent of periapical/periradicular disease
  - Third molar relationships to the mandibular canal
  - Other endodontic applications such as complex root canal anatomy, detection of vertical root fractures, extent of resorptive defects, mandibular canal involvement for lower second molars, etc
  - Periodontal applications such as detection of buccal/lingual periodontal bone loss, localization of trabecular anomalies, dehiscences, etc
  - Orthodontic applications such as localization of eruption anomalies, impacted teeth, associated resorptions or eruption obstructions, supernumerary teeth, etc
  - Implant-related diagnosis and planning
  - Dental trauma assessment where periapical images provide inadequate information
  - Hard-tissue pathology assessment (other advanced imaging modalities such as medical CT and MRI should be chosen over CBCT for disease evaluations that are likely to require evaluation to the extent of disease spread into adjacent soft tissues)
- Macroskeletal
  - Morphological assessment of craniofacial anatomy in three dimensions
  - Diagnosis of skeletal asymmetries
  - Diagnosis of craniofacial anomalies such as cleft lip and palate

- Sinonasal and airway applications (all)
- TMJ hard tissue diagnosis
- Surface imaging integration, model superimposition, virtual surgical planning, and other digital workflow solutions

2D imaging remains the gold standard for caries detection, routine imaging of general periodontal bone support, and routine dental and orthodontic diagnostic tasks for the pediatric population provided that clinical examination does not immediately establish a clear indication to image in three dimensions for one of the above tasks. And, 2D imaging is often a good tool for images that need to be taken in frequent series, such as progress orthodontic panoramic images, implant post-op periapical images, and intraoperative checks, etc.—of course at the discretion of the clinician.

Most dentists wonder which type of CT machine to purchase if they are thinking of integrating 3D imaging within their practice or which local dentist or imaging provider to send their patients for a scan. The most important factor in this decision should be related to the field of view required for the diagnostic applications that will be used most often. For example, an endodontist will want to select a unit with the best resolution and smallest fields of view. A dentist who will extract the occasional third molar, place the occasional implant, or do the occasional complex root canal will select similarly. More complex cases with full-mouth implant rehabilitations or sinus lifts will likely require some upward flexibility in the field of view. An oral surgeon, TMJ specialist, or sleep therapy provider will want to capture an upper medium to large field of view depending on their scope of practice. An orthodontist who would like to evaluate pediatric patients for more complex airway or structural diagnosis might seek a CT unit that allows for a faster scan with parameters geared to intentionally reducing the total radiation burden to even less than that of the sum of a traditional panoramic and cephalometric series. Many units commercially available offer a range of collimations, from an arch or a quadrant to a full-head view, and this may be the best solution for a versatile provider.

Every dentist should define a workflow appropriate for their practice and patient imaging needs that includes the following considerations:

- Perform a clinical examination and review the patient's history prior to radiographic prescription to better pinpoint the imaging that will most benefit the patient, as opposed to instituting a blanket imaging protocol that "every patient automatically gets."
- Know your patient (age, size, radiation history, etc.).
- Review a patient's chart to check for similar prior examinations, within which may lie answers to current clinical questions, if recent, or guide future imaging protocols in the presence of a finding that needs monitoring, referral, or follow-up (this is an oft-understated aspect of imaging selection).
- Adequately train staff on how to select the proper acquisition parameters and field of view for the examinations ordered.
- Employ a system for reviewing all conventional radiographs or scrolling through any CBCT volume in its entirety, and if it cannot be done during the patient's appointment, set aside time later to do so.
- Determine how to manage the requirement to interpret the entirety of all radiographic exams to cover the full range of anatomy captured (self-acquired or outsourced).

The specific information you need for your patient and why you need it should be determined prior to all CBCT scans taken. It is important to gain the expertise, at minimum, to understand the content of the volume of a CBCT image within the region of interest. Further, it is essential to either have or seek the expertise to interpret all structures outside the region of interest, as most CBCT scans contain an abundance.

Dr. Newaz received his DDS degree from the University of Michigan School of Dentistry and continued on to complete residencies in both Oral & Maxillofacial Radiology and Orthodontics from the University of Florida and NYU-Langone Hospitals, respectively. He has been a member of the BeamReaders team since 2016 and is currently engaged in airway-focused practice of both specialties, based out of Florida and New York City.

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