

The Modern Role of Technology in Dental Diagnostics

Advantages Over 2D Radiography and Added Benefits Compared With CBCT

INTRODUCTION

Radiographic evaluation remains the cornerstone of dental diagnostics, guiding clinicians through restorative, surgical, endodontic, periodontal, and implant-related decisions. However, 2D radiographs compress 3D anatomy into a flat projection, often masking relevant structures while obscuring anatomy and pathology. This inherent limitation can create issues, particularly in complex cases or when evaluating early pathology.

While CBCT imaging provides volumetric detail and has transformed the diagnostic process, practical considerations limit its universal use. These include increased radiation exposure, equipment cost, and workflow interruptions related to moving the patient to a different room to capture a CBCT scan, which means clinicians must reserve CBCT for cases when full 3D visualization is essential.

Lumos 3DX (Valkyrie BioScience, Inc) enters the diagnostic arena as a technology that enhances the value of the radiographs clinicians already take chairside daily. The unit is portable and can be easily moved from operator to operator within the clinic, connecting to the internet via the clinic's Wi-Fi and LAN (Figure 1). Lumos 3DX is compact enough to fit in most operatories (Figure 2).

By reconstructing a 3D model from standard radiographic images captured in seconds, superimposition is removed, revealing anatomy concealed in the 2D radiographs. Thus, improving the practitioner's ability to assess pathology without subjecting the patient to additional radiation exposure. The system acquires 30 low-dose images in approximately 3 seconds, with a total radiation exposure comparable to D-speed film, yet nearly twice the resolution of high-end 2D systems and 3 to 5 times that of many CBCT units. This makes Lumos 3DX an accessible and clinically meaningful adjunct in nearly every discipline of dentistry.

Diagnostic Limitations of Traditional 2D Radiographs

Despite widespread use, 2D radiographs remain limited by distortion, magnification, and superimposition of anatomy. Overlapping structures may mask defects or mimic pathology, while angulation discrepancies can distort anatomical relationships.



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Early periapical lesions, buccal or lingual caries, minor root fractures, and subtle periodontal defects may be invisible on 2D imaging until pathology has advanced.

Additionally, traditional radiographs also obscure critical diagnostic detail. For example, a faint radiolucency that represents early caries may be visible in 2D, but the clinician cannot determine its precise facial, lingual, or interproximal position due to overlapping structures. Teeth often appear overlapped, preventing accurate evaluation of proximal surfaces. The dento-enamel junction may appear indistinct, reducing the clinician's ability to detect early demineralization or structural compromise. Root canal anatomy frequently lacks sufficient detail, making small accessory canals or calcifications difficult to diagnose and appreciate. Buccal or lingual caries can be entirely masked by overlying anatomy. Evaluating restorative margins becomes challenging when additional structures superimpose over the restoration. Importantly, the periodontal ligament space and fine trabecular bone patterns, which are early indicators of pathology, may become blurred or invisible in a 2D radiograph.

Those limitations add uncertainty to diagnosis, preventing pathology from being diagnosed until it has advanced significantly, complicating treatment planning. Even skilled clinicians occasionally encounter surprises during treatment that were undetectable with 2D imaging alone. A technology that enhances traditional radiographs and reduces ambiguity offers substantial clinical value.

Enhancing Imaging and Clinical Interpretation

Lumos 3DX improves diagnostic capability by synthesizing standard radiographs via tomosynthesis into a volumetric model that can be rotated and evaluated from multiple angles. This eliminates the distortions inherent in 2D radiographs, allowing hidden structures to be seen with significantly greater clarity. Tomosynthesis, the formal name for the type of 3D reconstruction performed by Lumos 3DX, has the same mathematical foundations as tomography, including CBCT.

Many of the diagnostic uncertainties of 2D imaging are directly



Figure 1. The portable Lumos 3DX unit (Valkyrie BioScience, Inc) and its centralized computer system that connect via Wi-Fi.



Figure 2. The Lumos 3DX unit being used in the operator.

corrected through Lumos 3DX visualization. The system reveals the exact location of a carious lesion by removing anatomical overlap, while distinguishing facial, lingual, and interproximal involvement with precision. Interproximal spaces appear sharply defined, making early decay easier to identify. The dento-enamel junction is rendered in higher clarity, enhancing the clinician's ability to detect early demineralization. Fine internal structures such as accessory canals, or pulp stones, which are often invisible in 2D, become clearly discernible in 3D slices. Lesions extending through enamel into dentin appear with unmistakable contrast. Additionally, restorative margins reveal their true adaptation without overlapping interference from adjacent anatomy. Subtle features such as the periodontal ligament space and early metabolic changes in bone become visible, allowing the clinician to identify pathology at an earlier stage.

Lumos 3DX technically acquires 30 projections in approximately 3 seconds, producing a highly detailed 3D reconstruction with an effective resolution of roughly 55 μm . This level of clarity surpasses that of many CBCT units and even outperforms high-end digital 2D sensors. Radiation dosage remains minimal, being only slightly higher than a single 2D exposure. Thus, making the system safe for routine and repeat imaging. The workflow importantly mirrors conventional periapical radiography, integrating seamlessly into the clinical

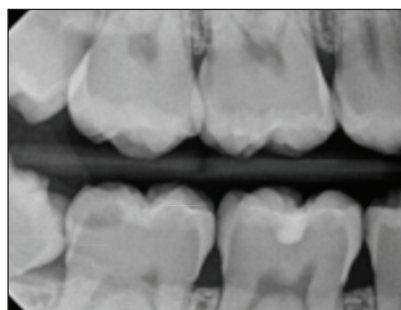


Figure 3. A 2D radiograph with no issues noted on the filling on the occlusal of the first molar. (Image courtesy of Dr. Sid Johnson.)



Figure 4. Various image slices utilizing Lumos 3DX demonstrating recurrent caries associated with the occlusal restoration on the maxillary first molar. (Image courtesy of Dr. Sid Johnson.)

Figure 5. Various image slices utilizing Lumos 3DX demonstrating a vertical root fracture in the distal root of the mandibular first molar not readily evident on a standard 2D radiograph. (Image courtesy of Dr. Brad Johnson.)

environment without requiring new equipment placement or a separate imaging room.

Visual output with Lumos 3DX drastically improves patient communication. The volumetric model allows patients to clearly understand what pathology has been identified and is present. Thus, with better patient understanding, which is the rationale for treatment, case acceptance is enhanced, and long-term compliance by the patient improves.

Benefits Compared With CBCT

CBCT remains the gold standard for cases requiring full volumetric assessment, such as complex implant plan-

ning, sinus evaluation, pathology mapping, and surgical navigation. However, its routine use is limited by radiation exposure, cost, and logistical barriers.

Lumos 3DX offers several advantages for localized diagnostic tasks:

Superior Resolution for Fine Detail

CBCT voxel sizes typically range from 150 to 300 μm , which limits visualization of small anatomical structures. Many early lesions, root fractures, and fine canal features remain undetectable at those voxel dimensions. Lumos 3DX can provide a voxel size down to 39 μm and has demonstrated approximately 55 μm of image res-

Significantly Lower Radiation Exposure. Radiation exposure from Lumos 3DX is comparable to 2D intra-oral radiography and far lower than that of CBCT. This makes repeated imaging safe and appropriate for monitoring healing, evaluating osseointegration, assessing restoration integrity, or observing early changes in bone or pulpal health.

Lower Cost and Greater Accessibility

Unlike CBCT, Lumos 3DX does not require a dedicated room, specialized shielding, or a significant capital investment. The system's simplicity and affordability make it practical for widespread adoption across general and spe-

cialty practices. By providing high-resolution, w-dose, operator-ready imaging, Lumos 3DX fills the diagnostic space between traditional radiographs and CBCT, offering significant benefits in everyday clinical use.

Clinical Applications

Restorative Dentistry. Restorative procedures rely on precise visualization of restoration margins and tooth structure. Lumos 3DX improves identification of recurrent decay, restoration marginal discrepancies, undermined enamel, and microfractures with clarity not achievable

Improved Chairside Usability

As the CBCT unit is located in a centralized area of the practice, CBCT imaging requires escorting the patient to another room during treatment, interrupting the clinical appointment. In contrast, Lumos 3DX imaging is performed in the operator using the same setup as a periapical radiograph, enabling real-time diagnostic assessment without workflow disruption, as the patient does not need to be relocated to capture the image during treatment.

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with 2D radiography.¹⁻³ By visualizing the internal lesion depth and proximity to the pulp, clinicians can select more appropriate restorative materials and techniques while enhancing patient understanding of what is present, especially when the patient has no sensitivity associated with that tooth. Traditional 2D radiographs may not identify caries until they become extensive (Figure 3). The Lumos 3DX, by allowing visualization at different planes, can help identify early caries, allowing more conservative treatment (Figure 4).

Endodontics. The ability to visualize canal anatomy and periapical tissues critically influences the success of endodontic treatment.⁴ Lumos 3DX enables early identification of apical pathology that may not be visible on 2D radiographs until osseous destruction has advanced sufficiently to be visible on standard radiographs. The system clearly visualizes the canal system, including MB2 canals in maxillary molars or bifurcated canals in mandibular molars. Thus, it enhances the clinician's ability to locate and treat the entire canal system. The ability to examine cross-sectional slices improves confidence during access, negotiation, and obturation. Subtle vertical root fractures (VRF), especially those running buccolingually, become more readily detectable. This becomes problematic in teeth that had been previously treated endodontically and not typically detectable in 2D radiographs but may be identifiable in CBCT.⁵ Unfortunately, VRF are very difficult to identify in 2D radiographs until they have progressed through the tooth, at which time the prognosis for that tooth is often poor, and extraction is indicated.⁶ Lumos 3DX permits earlier detection of VRF that may allow the tooth to be preserved. When VRF has progressed and the patient presents symptomatic standard radiographs often are unable to identify the crack due to its orientation to the 2D radiograph and often require a CBCT to identify. As CBCT may not be available in each dental practice, Lumos 3DX allows identifica-

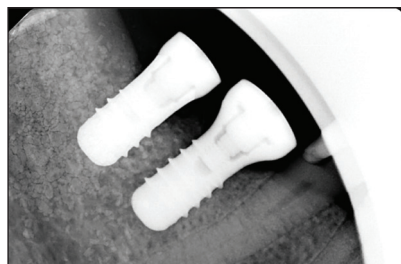


Figure 6. Periapical radiograph taken at implant placement. (Image courtesy of Dr. Rick Shamo.)

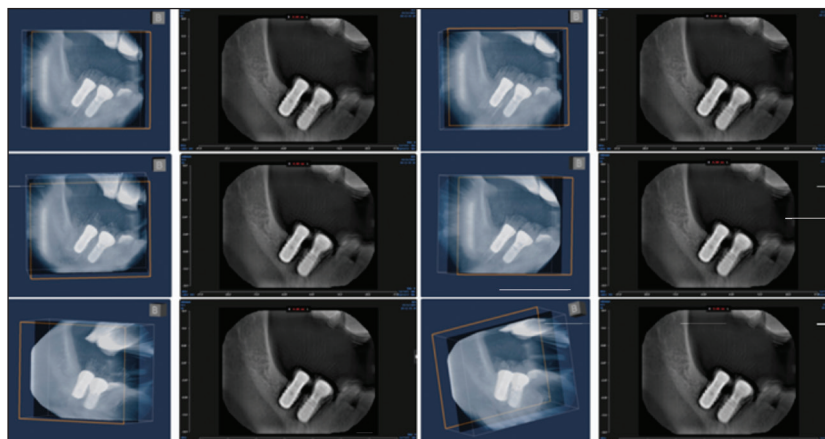


Figure 7. Lumos 3DX slices in different orientations (blue images) with the “darker” plane cutting through the 3D image and the “darker” plane to the right of the blue image to evaluate the implants at implant placement. (Image courtesy of Dr. Rick Shamo.)

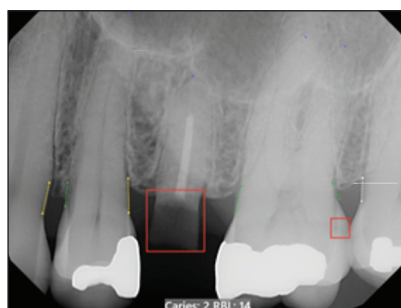


Figure 8. Standard 2D periapical radiograph of a failed restoration on an endodontically treated maxillary left second premolar (red boxes indicate caries identified in software).

tion of those VRF more easily guiding what treatment is needed (Figure 5).

Periodontics. Early periodontal changes, such as crestal bone loss, incipient vertical defects, or early furcation involvement, may not appear on 2D radiographs.⁷ Lumos 3DX reveals buccal and lingual bone levels independently, eliminating superimposition of adjacent anatomy, allowing more accurate identification and prognosis. This is especially important in regard to identifying osseous changes related to peri-implantitis.⁸ Clinical success when treating peri-implantitis and avoiding loss of the implant focuses on early detection of

the inflammatory changes affecting the surrounding bone. Clinicians can better differentiate horizontal from vertical bone loss and select treatment protocols accordingly.

Implant Dentistry. Although CBCT remains necessary for initial implant planning, not all practices have this technology in their office. This may be especially true when the practitioner

relation to the implant. This enables high-resolution assessment of crestal bone levels, buccal plate thickness, and early peri-implant changes without subjecting patients to repeated CBCT scans. Thus, enhancing patient safety while providing actionable information for long-term implant success. Standard 2D radiographs taken at implant placement (Figure 6) may give the misconception regarding crestal bone levels relative to the implant, but the Lumos 3DX by viewing slices provides a more accurate presentation of the crestal bone to implant positioning (Figure 7).

Oral Surgery. When extractions are indicated, Lumos 3DX aids in evaluating root morphology, identifying impacted roots, and assessing proximity to adjacent teeth or implants, sinus or neurovascular structures.^{9,10} Although complex surgical scenarios still warrant CBCT, Lumos 3DX offers sufficient detail for preoperative planning in numerous everyday surgical decisions. For those practices

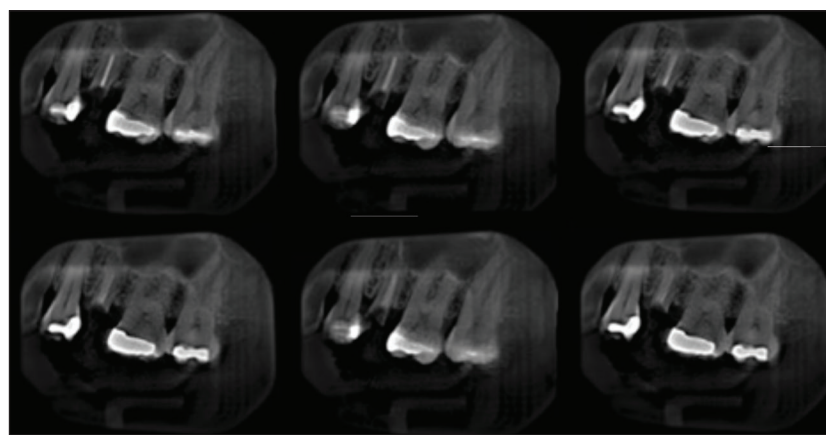


Figure 9. Various image slices utilizing Lumos 3DX of the fractured maxillary second premolar demonstrating tooth structure damage that were not evident on the periapical radiograph (Figure 8).

is referring the patient for the surgical aspects of the treatment. Lumos 3DX allows evaluation of the failing tooth or edentulous space relative to the surrounding anatomy, so the clinician can discuss treatment options with the patient. This can be done before referring them to the surgeon or when implant placement will be performed by that clinician before exposure to the radiation from the CBCT. Additionally, Lumos 3DX provides valuable diagnostic information during healing and maintenance phases to monitor adjacent bone levels in

that do not have a CBCT in the office, this decreases potential issues during oral surgery treatment, benefiting both the clinician and patient. Additionally, when potential complications are identified during the exam, the clinician has the option to refer the patient to an oral surgeon vs identifying the issue during the surgical procedure. Evaluation of a failing tooth can be challenging using 2D radiographs, as the tooth's relation to adjacent anatomy may not provide accurate information (Figure 8). Lumos 3DX, via its slices, allows bet-



Figure 10. Traditional 2D periapical radiograph evaluation of healed osseous graft of an extraction socket (red boxes indicate caries identified in software).

ter evaluation of the tooth's structure and adjacent anatomy, enabling more precise determination of the indicated treatment plan (Figure 9). Further, when site preparation includes socket grafting, 2D radiographs do not provide information on the adjacent anatomy during the implant planning phase of treatment (Figure 10). Lumos 3DX provides more detailed anatomical information to guide implant placement (Figure 11).

Patient Communication and Enhanced Case Acceptance

Patients often struggle to interpret traditional radiographs, making it challenging to explain pathology or the need for treatment. This becomes especially problematic when the patient has no sensitivity on the affected tooth or implant. Patients tend to better grasp the implications of bone loss, decay, fractures, and other concerns when shown a 3D image. This enhanced understanding increases patient trust in the clinician and leads to better acceptance of recommended treatment. By transforming the diagnostic conversation, Lumos 3DX strengthens the clinician-patient rapport and improves acceptance of treatment recommendations and clinical outcomes.

DISCUSSION

The diagnostic weaknesses of traditional 2D radiographs are well established, and Lumos 3DX addresses many of these limitations by revealing anatomical and pathological details not discernible on standard films. Because 2D imaging compresses structures along the buccolingual dimension, early periapical lesions, fine root fractures, developing peri-implant radiolucencies, or subtle marginal defects may remain

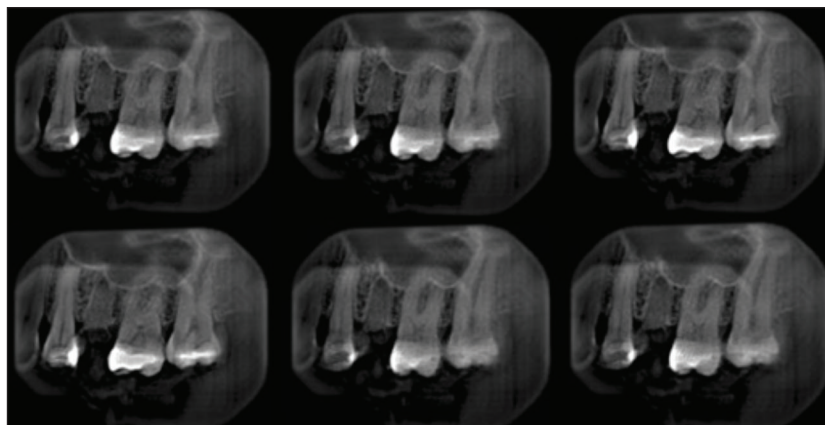


Figure 11. Various image slices utilizing Lumos 3DX of healed extraction socket grafting of a maxillary second premolar providing additional information not evident on the periapical radiograph (Figure 10).

...a low-radiation, workflow-friendly alternative ideal for everyday dentistry.

hidden. By reconstructing these structures volumetrically, Lumos 3DX enables clinicians to detect pathology earlier and with more confidence, improving overall diagnostic accuracy and treatment outcomes.

One of the most significant advantages of Lumos 3DX is its availability chairside. Unlike CBCT, which typically requires taking the patient to another room, an inconvenience or practical impossibility during active treatment, Lumos 3DX allows clinicians to evaluate the area of concern immediately using the radiograph easily obtained without the need for a CBCT. This is particularly beneficial when evaluating a questionable radiographic finding during endodontic therapy, assessing a restorative margin while the patient is in the chair, or monitoring peri-implant bone stability during maintenance visits. The ability to interpret enhanced imaging without interrupting the appointment enhances efficiency and supports more informed decision-making.

CBCT remains indispensable for complex anatomical evaluations, surgical planning, and implant placement. However, its higher radiation exposure and requirement for a dedicated scanning environment limit its practicality for routine diagnostic use. Compared with CBCT, Lumos 3DX provides a safer and more convenient alternative for single-tooth

concerns, recurrent decay detection, restorative evaluation, or early pathology monitoring. By providing meaningful diagnostic enhancement with no additional radiation exposure, Lumos 3DX expands clinicians' diagnostic capabilities while preserving patient safety and procedural efficiency.

CONCLUSION

Lumos 3DX represents an impactful advancement in dental diagnostics by bridging the gap between 2D radiographs and CBCT. By transforming standard radiographs into 3D visualizations, it enhances diagnostic capabilities with precision, improves the identification of pathology often unseen on conventional films, and provides an efficient chairside tool that strengthens real-time clinical decision-making. While CBCT remains essential for complex cases requiring comprehensive volumetric information, Lumos 3DX offers a low-radiation, workflow-friendly alternative ideal for everyday dentistry. The technology strengthens the clinician's ability to diagnose, communicate, and plan treatment, ultimately leading to improved patient outcomes and more confident clinical care. ♦

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