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Digital Radiography: Addressing the Challenges

Gordon's Clinical Observations: Digital CMOS *(complementary metal oxide semiconductor)* x-ray sensors have wonderful advantages but also some glaring limitations. Their thickness, rigidity, high cost, frequent repair, and difficulty of accurate interpretation of caries need immediate attention by manufacturers. Some of the challenges are being overcome by changes in technologies, and most manufacturers know that additional modifications are needed for this everyday technology. *CR scientists and clinicians have analyzed CMOS sensors, and they provide current information and suggestions for you in this issue.*

Figure 1: Large sensors *(top)* can be difficult to position. Options include phosphor plates and smaller sensors.

Digital sensors have revolutionized radiography—from bitewings to endodontics. Advantages include instant radiographs, patient education, reduction of x-ray dose, and elimination of wet chemistry. Clinical challenges include the size and rigidity of the sensors, and inconsistent image quality and detail. **The following report shows ways to address some of the common challenges with intraoral digital radiography, and reviews the features of eight current sensors.**

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Digital Radiography: Addressing the Challenges *(Continued from page 1)*

Common Clinical Challenges and Methods to Minimize Them

1. Bulky, Rigid Sensors

Common complaints include patient pain, difficulty positioning sensor for correct alignment, and dislodging sensor as patient closes.

- **Use phosphor plates** for indications not needing immediate images *(e.g., ScanX)*. Plates have size, thickness, and flexibility similar to film packets. *(See Clinicians Report November 2015 for information on phosphor plate systems.)*
- **Use smaller sensors** when necessary *(e.g., size 1, size 0)* for improved intraoral access. *(See Figure 1 on page 1.)*
- **Use sensors with rounded corners or thin body** *(e.g., Clio, DEXIS, DentiMax Dream Sensor, KaVo IXS). (See Figure 2.)*
- **Avoid barrier sleeves with sharp seams and edges**. Cover with finger cot, foam guard, or finger of glove. *(See Figure 3.)*
- **Manufacturers are encouraged to develop soft, comfortable sensors** *(e.g., Wave Sensor).*

Figure 2: Rounded corners can improve sensor positioning and patient tolerance.

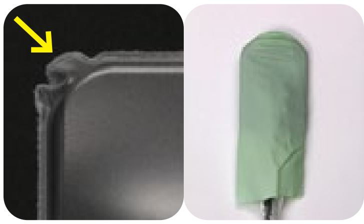


Figure 3: Barrier sheaths can have sharp and jagged edges. Cover with a glove finger, finger cot, or foam guards for patient comfort.

2. Positioning and Alignment

Proper positioning is essential, regardless of technology used. Clinicians indicated that the most common alignment challenges were periapicals of maxillary canines, maxillary molars, and mandibular centrolaterals—as well as molar and premolar bitewings! Unfortunately, the ease of acquiring digital images can inadvertently lead to sloppy technique.

- **Demand good radiographs**. ***Learn anatomy and evaluate landmarks as sensor and tube head are being positioned***. Don't blindly trust the positioner. *(See Figure 4.)*
- **Bar and ring positioners** *(RINN style)* have proven most effective for holding and aligning rigid sensors. Bite tabs and improvised holders are frequently needed for some alignments.
- **Position sensor toward middle of oral cavity,** where the vault of the palate will not impinge on the sensor, using the paralleling technique. Periapicals often require the bisecting angle technique as the sensor must be tilted to capture the root tips.

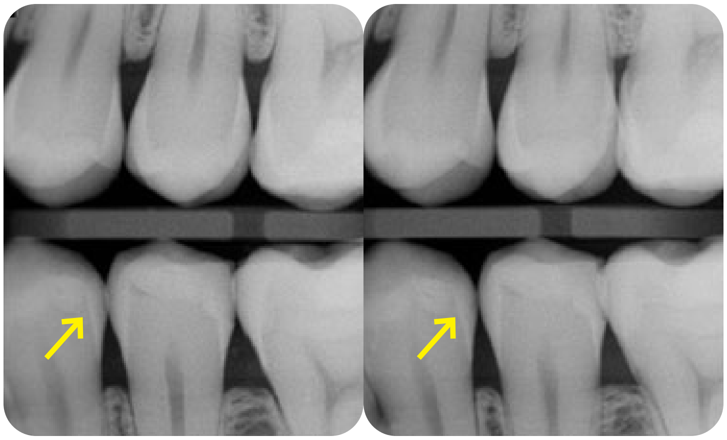


Figure 4: Opening all contacts often requires multiple bitewing orientations. Interproximal caries on teeth 20–21 are hidden by overlap in radiograph on left, but obvious in radiograph on right.

3. Resolution and Detail

Digital sensors do not equal conventional film in resolution or sensitivity to structural density. However, their instant images, diagnostic capability, patient education value, and reduced radiation are well established. Image enhancement capabilities improve diagnostic value.

- **View original image** in addition to enhanced image. Enhancement tools are a significant advantage of digital radiography, but should be used with care. Images often become **sharp but grainy, creating a false perception of detail** and possible artifacts. *(See Figure 5.)* **Re-train your brain to perceive details in the subtle shades of gray in unenhanced images.**
- **Make additional radiographs** at different angles if first image is questionable.
- **Avoid under- and over-exposure**. Image processing algorithms often optimize contrast and appearance even if poor exposure failed to capture details. Find correct exposure for your system and post it on equipment. *(See Figure 6.)*

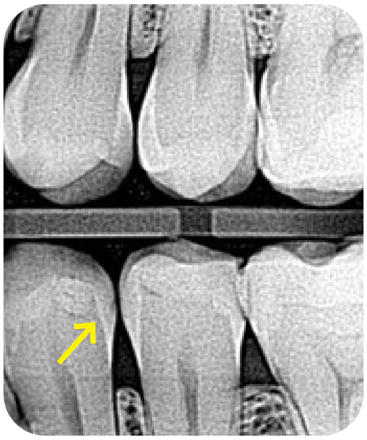


Figure 5: Image enhancement of interproximal region shown in Figure 4 makes caries more apparent, but edge effects and grainy appearance hide other details. Use enhancement with care.

4. Cost and Repairs

X-ray imaging technology is complex and expensive. Sensors are subjected to stress events every day, including bites, drops, cord pulls, and disinfection chemicals. (See Clinicians Report May 2016 for information on care and repair of sensors.)

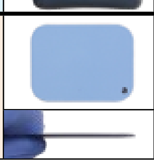
- **Use sensors with improved longevity**—durable outer housing, sealed for immersion disinfection, reinforced cord, replaceable cord, etc.
- **Consider low-cost sensors** available from some manufacturers.
- **Purchase a repair plan.** Many manufacturers offer maintenance and replacement options that cost less over time than replacing a sensor.
- **Use phosphor plates** when immediate image not required. Individual plates are available in a variety of sizes and easily replaced if damaged.

Figure 6: Underexposed radiograph where software adjusted the contrast to make it appear acceptable. However, notice the streaking effects and lack of detail.

Digital Radiography: Addressing the Challenges *(Continued from page 2)*

Features of Eight Digital Radiography Sensors

The following chart shows seven CMOS sensors and one phosphor plate sensor, listed alphabetically, that were evaluated in controlled clinical and scientific tests. An example sensor is shown *(size 2 or similar)* with key features related to ease of use.

Brand ***Company***	**Photos**	**Sensor Sizes Available** *(Approx. Price)**	**Dimensions**	**Active Image Area**	**Infection Control Options**	**Cord**	**Example Radiograph** *(Jaw Phantom)*	**Key Features**
Clio *SOTA Imaging*		Size 2: $5,995 Size 1: $4,995	*Size 2 shown* 43 × 31 mm 5.3 mm thick	900 mm^2 *~68% of sensor*	Sheath Wipe Submerse	USB 6.4 feet		• Round edges • Rounded corners • Thin • Two sizes
Dexis Titanium *KaVo Imaging*		PerfectSize: $10,995	40 × 30 mm 8.8 mm thick	790 mm^2 *~67% of sensor*	Sheath Wipe	USB 8.5 feet		• Round edges • Clipped corners • Intermediate size • Touch-free control
Dream Sensor *DentiMax*		Size 2: $6,999 Size 1: $5,999	*Size 2 shown* 43 × 31 mm 5.3 mm thick	900 mm^2 *~68% of sensor*	Sheath Wipe Submerse	USB 6.3 feet		• Round edges • Rounded corners • Thin • Two sizes
KaVo IXS *KaVo Imaging*		Size 2: $9,995 Size 1: $8,995	*Size 2 shown* 43 × 30 mm 8.2 mm thick	860 mm^2 *~66% of sensor*	Sheath Wipe	USB 8.5 feet		• Round edges • Rounded corners • Two sizes
RVG 6200 *Carestream*		Size 2: $6,000 Size 1: $6,000	*Size 2 shown* 44 × 32 mm 7.3 mm thick	930 mm^2 *~66% of sensor*	Sheath Wipe Submerse	USB 9.3 feet		• Round edges • Two sizes
Schick 33 *Dentsply Sirona*		Size 2: $7,995 Size 1: $7,695 Size 0: $5,695	*Size 2 shown* 43 × 31 mm 7.0 mm thick	910 mm^2 *~68% of sensor*	Sheath Wipe	USB module 5.8 feet User-replaceable		• Round edges • Three sizes • Replaceable cord
Wave Sensor *Vatech*		Size 2: $7,999 Size 1.5: $7,999	*Size 1.5 shown* 41 × 30 mm 7.6 mm thick	740 mm^2 *~60% of sensor*	Sheath Wipe Submerse	USB 9.5 feet		• Comfortable soft silicone • Round edges • Clipped corners • Slightly pliable • Two sizes
Phosphor Plate **ScanX** *Air Techniques*		Size 4: $180 Size 3: $73 Size 2: $58 Size 1: $60 Size 0: $60	*Size 2 shown* 41 × 31 mm 0.4 mm thick	1220 mm^2 *~95% of sensor*	Sheath Wipe Submerse	None		• Thin • Round corners • Pliable • Large imaging area • Five sizes

*** Approximate prices are shown. Actual prices can vary tremendously with promotional discounts.***

Summary of Evaluation:

- All systems tested made clinically acceptable radiographs. Images could be adjusted and enhanced to clinicians' preferences.
- Imaging software varied greatly among brands, but once learned, all were simple and fast to operate.
- CMOS sensors made nearly instantaneous images and had easier infection control *(one barrier sheath per patient)*, but were bulky and rigid. Phosphor plates had similar handling as film, but required scanning and wrapping and unwrapping individual plates.
- If looking to acquire sensors or change brand, consider features that improve ease of use such as rounded corners, smaller size, thinner, replaceable cable, etc. If staying with current brand, suggestions on previous page can help optimize use.
- A survey of 760 clinicians indicated that popular models were DEXIS *(38%)*, Schick *(27%)*, RVG *(15%)*, GXS now KaVo IXS *(6%)*, DentiMax Dream Sensor *(2%)*, plus 17 additional brands reported in use.

CR CONCLUSIONS: Digital radiography has revolutionized dentistry, but ***manufacturers need to improve sensors immediately!***

- Bulky, rigid sensors are uncomfortable and hamper proper placement and alignment in some situations.
- Image quality and detail are often inferior or inconsistent.
- Cost is high, and sensors frequently suffer damage.

Challenges can be minimized with knowledge of oral anatomy, proper clinical technique, attention to detail, and selection of appropriately sized sensors and positioning equipment. All systems tested produced clinically useful images. Individual convenience features varied among sensor brands and designs.

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