Kenneth F. Lyon, DVM, Diplomate AVDC, Fellow AVD, Arizona Veterinary Dentistry and Oral Surgery, PLLC, Gilbert, Arizona

Dental Radiography

There are many benefits to dental radiography, including the ability to focus directly on the teeth that are clinically relevant to the diagnosis of the patient's dental problem. By using dental radiography to isolate the tooth image, an appropriate treatment plan can be formulated according to both it and the clinical presentation. During dental procedures, radiographic images can be produced by using intraoral dental film or digital sensors (**Figure 1**).

Then & Now

Before the 1980s, most dental radiographic images were produced by using large x-ray film cassettes and extraoral techniques. Veterinary hospitals used stationary x-ray machines that operated on 300 milliamperes (mA) with a 150 kilovolt peak (kVp), and the images of teeth were often unclear. In the 1980s, intraoral dental film techniques were introduced more widely in small animal dentistry. Installation of dental x-ray equipment has provided progressive veterinarians with the biggest improvement to veterinary dentistry practice. Dental x-ray machines can be mounted to the wall or ceiling or can be mobile.

Debut of Digital

The next improvement in dental radiography came when digital radiography was introduced in 1987. In the future, by combining sophisticated software with three-dimensional imaging capabilities, veterinarians will be able to integrate diagnostics, planning, and treatment.

Digital sensor in position with dental x-ray unit

Digital (filmless) intraoral radiography has had a profound impact on the quality of veterinary dental care and is becoming a primary fixture in the modern veterinary office. The main benefits of digital radiography are improved practice management, clear images, less radiation, accurate diagnosis, faster work flow, and a safer environment for staff and patients. Disadvantages include an image quality that is inferior to that provided by conventional film and technical problems associated with computerization. *For a more comprehensive discussion of digital radiography and its features, see the article series in* Clinician's Brief *published in 2005: July (pp 47–49), August (pp 41–42), October (pp 44–45), and December (pp 17–18).*

Digital radiographic software enables images to be manipulated, enlarged, reoriented, and duplicated. Zooming, colorization, before-and-after comparisons, and adjustments (such as for contrast and brightness) facilitate evaluation of image quality. A display filter can be used to improve diagnostics. Images can be stored in each patient's digital dental record. Digital radiology will eventually replace film because of its speed (images are viewable in 3 to 10 seconds), enhancement capabilities, and electronic format and associated improved communication with clients.

Dental radiographic devices include dental x-ray equipment, ultra-speed intraoral dental film processed by using rapid developing chemicals, digital intraoral sensors with integrated computer software, and, in the near future, three-dimensional imaging systems.

continues

Dental Radiographic Units

Dental intraoral x-ray generators generally have preset kilovolt peak (usually 70 kVp) and milliamperes (usually 8 mA). The timer is the only adjustable control; its settings generally range from 0.01 (for AFP Image-Vet) to 3.0 seconds. Dental x-ray machines can be wall-mounted or ceiling-mounted units (**Figure 2**), a mobile unit on a set of wheels, or a hand-held battery-powered portable unit. Many dental x-ray generators are available, varying in price from $2500 to $6000. Dental x-ray machines can be purchased from various dental companies (**Figure 3**).

Machines commonly available for veterinary use include the following:

- Corix Pro 70 Vet Dental X-ray (Dentalaire; www.dentalaireproducts.com); $3295 with 1-year warranty
- Elity 70 (Dr. Shipp's Laboratories; www.drshipp.com); $3195 with 2-year warranty
- Image-Vet 70 ACP (AFP Imaging; www.afpimaging.com); $3250 with 2-year warranty (**Figure 4**)

Dental Intraoral Digital Sensors

The intraoral digital sensor consists of a large-area silicon chip (charge coupled device [CCD]/complementary metal oxide semiconductor [CMOS]) with an x-ray transducer screen placed in a small metal or rubberized enclosure. Sensor sizes are the same as those for intraoral dental film: 0, 1, and 2. Digital sensor systems dramatically reduce radiation; eliminate the use of chemicals; and instantly produce images that can be enhanced, duplicated, and displayed in the operatory. Images are produced and transmitted from the sensor to a computer. Some systems are more expensive because of enhanced sensor resolution, pixel size, and active image area (**Table 1**). In addition, software that features integrated records and presentation templates for clients can raise the costs of digital systems. Keep in mind that you have to invest in the computer, monitor, and software. For a superior image, the combination of a high-quality monitor, computer, software, and sensor is needed.

In selecting digital dental sensors, the following technical information should be considered (**Table 2**):

- **Pixel size:** A pixel (short for "picture element," with the common abbreviation "pix" used for "picture") is a single point in a graphic image. It is measured in microns. A smaller pixel size provides better resolution by making the image much less grainy.
- **Resolution**—measured vs theoretical: Most companies report only the theoretical, not the measured or actual, resolution. The better the resolution (ie, line pairs per millimeter), the better the definition between shades of gray and the better the image quality. Therefore, the higher the number for the resolution the better the image should be. Resolution is measured by obtaining an x-ray image of a line pair test pattern in a laboratory setting. Theoretical resolution is calculated by multiplying the pixel size by 2 and then dividing 1 by that product; for example, for the Bio-Ray SDX sensor, theoretical resolution is determined as follows:

$$20 \text{ pixels} \times 2 = 40;$$
$$1/40 = 0.025 \text{ or } 25 \text{ line pairs/mm.}$$

2

Wall-mounted dental x-ray unit set between dental operatory tables at Arizona Veterinary Dentistry and Oral Surgery in Gilbert, Arizona

3

Dental x-ray unit available in most dental offices (Promeca dental x-ray unit [Planmeca; www.planmecausa.com])

Table 1. Suni Sensor Formats*

Sensor Type	Sensor Package Dimensions (mm)	Image Active Area (mm)	Pixel Size (μm)	Pixels in Sensor (no.)
Type ØSR	32.5 × 26.4	26.0 × 21.0	45 × 45	270.5 K
Type 1HR	37.8 × 24.7	31.9 × 20.0	22.5 × 22.5	1.26 M (high resolution)
Type 2SR	43.0 × 31.8	36.0 × 26.0	45 × 45	462.4 K
Type 2HR	43.0 × 31.8	36.0 × 26.0	22.5 × 22.5	1.80 M (high resolution)

*Sensors are available in the same sizes as film: 0, 1, and 2.

- **Fiber optic plate:** By keeping unconverted x-rays from interacting with the CCD or CMOS sensor, these plates minimize the noise in the signal and extend the life of the sensor. The graininess in the x-ray image represents the noise.
- **Scintillator technology—granular vs needle:** The scintillator converts x-rays into light. A granular scintillator consists of gadolinium oxysulfide. When viewed under a microscope, this substance appears granular. For an analogy, think of water streaming out of a hose and striking some balls. When the water hits the balls, it scatters. The same thing happens to the x-rays when they hit the granular scintillator. This action causes noise, which is characterized as graininess on the x-ray image. A needle scintillator, in contrast, consists of cesium iodide. When viewed under a microscope, this substance looks like needles. Following the preceding analogy, think of water striking some needles; instead of scattering, it passes right through the needles. When the x-rays hit the needle scintillator, they do not bounce around and therefore do not generate noise in the signal or graininess in the image. Needle scintillators are more expensive than granular scintillators.

continues

Table 2. Comparison of Sensor Technologies*

Variable	Old Bio-Ray	Bio-Ray SDX	EVA	Schick
Pixel size, µm	22.5 × 22.5	20 × 20	30 × 30	40 × 40
Resolution (theoretical), line pairs/mm	22.2	25	16.6	12.5
Resolution (measured), line pairs/mm	10	20	NA	NA
Fiber optic plate	No	Yes	No	Yes
Scintillator technology	Granular	Needle	Granular	Granular
Sensor technology	CCD	CCD	CMOS	CMOS
Sensor construction	Aluminum	ABS plastic	Carbon shell	Aluminum
Hardware warranty, years	1	3	3	2
Sensor warranty, years	1	3	3	2
Software (stable, easy to use)	Yes	Yes	No	Yes
Thickness, mm	3.2	4.9	4.75	< 5
Radiation exposure	Low	Very low	Low	Low

*ABS = acrylonitrile butadiene styrene; CCD = charge coupled device; CMOS = complementary metal oxide semiconductor; NA = not available

Most sensor shells consist of thin plastic or aluminum. The shell of the Bio-Ray SDX sensor is made from a high-quality acrylonitrile butadiene styrene plastic that is very resistant to denting. Some sensor shells tend to dent more easily than the Bio-Ray SDX sensor; as a result of this sensor's enhanced durability, it has a 3-year warranty. Dental intraoral digital sensors vary in size, price, and warranty coverage and include the software needed to use the digital technology. Following are some examples:

- Bio-Ray SDX (Dentalaire; www.dentalaire-products.com); $8895 with 3-year warranty
- Dentrix ImageRAYi (Dentrix; www.dentrix.com); $13,090 with 2-year warranty (warranty extension available)
- DEXIS (www.dexray.com); $13,995 with 1-year warranty (warranty extension available at $1495/year)
- Dr. Suni Plus (Dr. Suni; www.suni.com); $9995 with 5-year warranty
- EVA Vet (AFP Imaging; www.afpimaging.com); $5500 with 3-year warranty
- Inovadent Vet-X Digital X-ray Sensor (Dr. Shipp's Laboratories; www.drshipp.com); $8395 with 2-year warranty
- Kodak RVG 6000 (Kodak Dental Systems; www.kodak.com/dental); $13,895 with 3-year warranty (warranty extension available at $588/year)
- Schick CDR (Schick; www.schicktech.com); $11,794 with 2-year warranty (warranty extension available at $795/year)

Hand-Held Battery-Powered Portable Dental Intraoral X-ray Generator

The Nomad x-ray generator (Aribex; www.aribex.com) is portable and easy to operate, produces good images, and exposes the operator to low amounts of radiation. However, it is expensive ($6995). Because the Nomad generator is not mounted, it can be used in multiple locations, including field operations. It has a 1-year warranty, uses two rechargeable nickel-cadmium batteries, and weighs 4 kg.

4

The Image-Vet 70ACP control is designed to accommodate all anatomical parameters and delivers a precise selection of exposure times. A large 4-figure display in hundredths of a second accompanies indicators for image sensitivity. All functions can be controlled from the compact hand-held device shown above. There are cat and dog settings as well as individual tooth selections.