A guide to managing **digital images in dentistry**

Dr. Larry Emmott

Digital technology is changing the way we take and use photos and x-rays. In this guide, Dr. Larry Emmott looks at the elements involved in managing digital imaging in dentistry, including the following:

See also:
"**Advantages of a digital image"** (page 40) and "**What's the difference: Digital vs. analog"** (page 42).

—The Editors

By Dr. Larry Emmott

If you have ever viewed a picture on a computer screen, you have used digital image management. In the dental office, image management can range from simply viewing a patient photo to enhancing a digital radiograph with advanced diagnostic software. In its simplest form, image management is like an electronic photo album. It allows you to capture, store, retrieve, and display an image. However, unlike a paper photo album, with digital image management you can do two additional things: transmit the image and, most importantly, enhance it.

We mentally distinguish between two image types, x-rays and photos (visible light). In many ways, though, there really is no difference between the two as far as the computer is concerned. Just as a 35mm color slide and an x-ray transparency are different versions of the same photographic technology so, too, are a digital color image and a digital x-ray different versions of the same digital technology. The primary difference between a digital color image and an x-ray is in how the image is acquired. Once it is digitized, though, the computer software needed to work with x-ray or visible-light images really is the same.

Here is a guide to capturing, storing, and enhancing your digital images.

1 Image capture
TYPICAL DEVICES

There are many ways to create or acquire a digital image, including using intraoral video cameras and video capture cards; digital cameras and memory cards; Webcams, which connect directly to computers; radiography sensors and photostimulable phosphor plates; and scanners that convert analog images to digital formats.

Intraoral video cameras/capture cards

Video capture converts an analog video image to a computerized digital image (see also "What's the difference: Digital vs. analog," on page 42). There are many ways to convert an analog image, but most dental offices will use a video capture card installed in the treatment room computer. To do the conversion, the video output from an intraoral camera is connected to a capture card, which then converts the analog video to a digital format. Once you freeze the video image, computer electronics can capture, store, enhance, or print the image. In other words, the computer takes the place of a video printer, which was at the heart of the old intraoral video camera system.

Today, any existing intraoral camera can be used with a video capture card. It is not the camera that makes it a digital system; it is what you plug it into. In the old analog systems, you plugged the camera into a printer; in the new digital systems, you plug the camera into a card in the back of the computer.

Using a video capture card makes an intraoral camera much more effective and saves you thousands of dollars over hard-wired video (TV) systems. An analog video printer costs at least $1,500, plus the cost of wiring docking stations and TVs. A video capture card costs less than $200 and plugs into an existing computer.

Digital cameras/memory cards

The second way to create a digital image is with a digital camera. These cameras use traditional photographic cameras and lenses, but they capture the image with a CCD (charge-coupled device). The chip converts the light image to a digital format.

The digital image is then stored on a removable memory card, which takes the place of traditional photographic film. The most common cards are CompactFlash and SmartMedia. These cards are smaller than a business card. They can store hundreds of images, and they can be used over and over again.

A good digital camera, capable of taking high-resolution intraoral images, will cost at least $1,000. (For more information on digital cameras, see Dr. Emmott's "Guide to digital cameras," in DPR's January 2001 issue[1] and a profile of nine "Digital cameras for your practice," compiled by the editors, in DPR's September issue.[2])

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Common image formats for storing and exporting digital images include the above four: .jpeg (pronounced *jay-peg*), .tiff., .bmp (pronounced *bitmap*), and .gif.

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Webcams

An alternative to a good digital camera is an inexpensive live Web camera, better known as a Webcam. These cameras connect directly to the computer; that means no media cards and no image downloads are needed. They create a low-resolution digital image and can make both full-motion video or still images. Images from these cameras are not good enough for cosmetic imaging, but they can be used as full-face identification photos. Since they are low-resolution, they take up very little memory and load quickly. Webcams sell for well under $100.

Sensors (CCD, CMOS, PSP)

Another way to acquire a digital image is with a digital radiography sensor. A sensor converts x-rays to light and then uses a chip, similar to those used with digital cameras, to create a digital image.

There are two types of sensors: corded sensors that capture a digital image for immediate display; and cordless phosphor plate sensors, which capture an image that then is processed in a scanner to transfer the image into the computer in a digital format for display.

Corded sensors use either CCDs or CMOS chips with active pixel sensors (APS). A wireless sensor or plate is coated with a phosphor material sensitive to x-rays and called a photostimulable phosphor plate (PSP).

Corded sensors look like chubby black film packs, with a cord attached. Wireless sensors look like the typical white film packs we are accustomed to using. For more details on sensors, see Dr. Emmott's article, "Making sense of sensors: A guide to choosing digital radiography sensors" in DPR's March issue.[3]

Scanners for analog images

Another way to acquire a digital image is with an optical film scanner. A scanner is a hardware device, which reads an analog image, such as a photograph or x-ray film, and converts it into a digital format. To scan x-ray film, the scanner needs a transparency adaptor or tray.

Scanners typically are used to scan 35mm slides, but they also work well for x-ray film. Scanners are a nice tool to use to convert existing images; however, for new images, it is much more efficient to acquire the image directly with a digital camera or x-ray sensor.

2 Image storage
COMMON FORMATS

The higher the image resolution, the more electronic memory is needed to store an image. At one time, this was a concern. The fear was that dental offices would run out of electronic hard-drive storage and need to store images on alternative media like CDs. Don't worry; this is not going to happen. The growth of memory storage capacity has far outpaced our ability to fill it up.

Digital images are stored in one of several image formats. The format is indicated by the extension, which is the three letters following the dot after a file name.

Common image formats include .jpg or .jpeg (pronounced *jay-peg*); .tif or .tiff; .gif; and .bmp (pronounced *bitmap*).

As long as an image is stored in a common format, there is no concern. However, some dental imaging programs have stored images in proprietary formats that are unique to that software. This can create problems when transferring images to other applications or other users. Usually, the image can be converted to a standard format. However, this involves a time-consuming extra step. Increasingly, companies are moving toward open or

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standard formats. When evaluating software ask about the image format. Is it unique to that product? If so, can the images be converted to a standard format?

One of the tools to ensure image compatibility is DICOM (Digital Image Communication in Medicine). DICOM is an international standard for both digital x-rays and visible light images. Images that are DICOM conformant can be transferred cross-platform (from Microsoft Windows to Mac to UNIX) and retain all attached data.

A great advantage of digital-image storage is that the images can be searched electronically. That means you can find a patient's images easily by name just by typing in a few letters. Or you could search for images based on tooth numbers or image features. It also is possible to link images to the patient's digital chart. In other words, the electronic chart could indicate which teeth had specific images or x-rays.

3 Image enhancement BENEFITS

Although the ability to store and transmit digital images electronically is nice, it is the ability to alter or enhance the image that really makes digital image management a powerful tool. It is similar to the difference between typing and word processing.

In its simplest form, image enhancement can be used to make an average image great. For example, if the image is too dark or the color is off, it is a simple matter with image management software to alter the picture to an ideal state. The image can be made brighter or the reds

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Advantages of a digital image: THE DIGITAL DENTIST NERVOUS SYSTEM

In his best selling book, *Business @ the Speed of Thought: Using a Digital Nervous System* (Warner Books, 1999), Bill Gates says: "Business will change more in the next 10 years than it has in the last 50." In large part, he bases his prediction on what he calls "the digital nervous system." This is the complete connection of all parts of a business through computer networks; then the connection of all businesses to each other through computer networks; and, finally, the complete connection of customers through computers and the Internet. This digital nervous system will allow for the instant flow of information, transforming everything we do.

The dental office's "digital nervous system"

In the dental office, the "digital nervous system" would do the following:

- Connect treatment rooms to the front desk . . . but it won't stop there.
- Connect an office to insurers, suppliers, laboratories, and specialists.
- Connect patients to an office, enabling patients to get appointment and account information, arrange financing, contact a third party, or learn about dentistry—all through the Internet anytime, from anywhere.

Digital information includes words, numbers, photos, sounds, movies, and x-rays. No matter what the item, once it is digitized, you can do three key things with the information: store it, transmit, and manipulate it electronically. *That's it*; that's the digital revolution. At first glance, this may not seem important, but in action, it literally changes everything. The digital exchange of data is what's behind the PC revolution: it's what powers the Internet; it's Gates' digital nervous system; it's the essence of the information age.

Advantages of a digital image for dentistry

Digital imaging illustrates the advantages of this digital exchange of information for dentistry, as follows (In this case, "image" refers to a photograph or radiograph. Once digitized, the images are essentially the same):

1. Fast image acquisition. Whether taking a digital photo or a digital radiograph, an image is produced on a computer screen in seconds. Compare that to the hassle of developing a film x-ray (it takes five minutes), or to the bigger hassle of taking photographic film (going to a developer and waiting days to get prints).

2. Images can be copied and transmitted instantly and electronically. To send a digital image to a colleague or third party, simply click on the image and send it. It takes seconds, goes to the recipient instantly, and costs nothing. Compare that to sending a traditional photo or x-ray copy. First, it must be copied. This usually decreases the quality and takes from 15 minutes to days. Then, there's film and reproduction costs. Next, it must be mailed. When the recipient gets it a day or more later, there are paper and postage costs.

3. Images can be enhanced and manipulated. If you take a digital image and it is flawed (underexposed, or has the wrong colors or alignment), you will know it in seconds. Digital imaging allows you to retake the image or, better yet, use image management software to correct the image in seconds. Compare that to a film image. If it is flawed you won't know it until the image is processed, which could be days later. Then, your only recourse is to have the patient return, retake the images, and hope it is right this time.

4. Images can be analyzed by a computer. Digital images have more data than our eyes can see. Diagnostic software and enhancement tools allow dentists to actually see more and diagnose with greater accuracy than with film images.

5. Digital images can be stored electronically. At one time, image storage was a concern, as digital images take a lot of electronic memory. We thought we'd have to transfer images to a CD or other storage media. Storage capacity has grown so fast, though, that this is not an issue; it's growing faster than we can fill it. Now we can store all of our images in a patient's digital record. Compare this to photos, which bulge out of a chart and turn yellow with age. (Electrons do not turn yellow with age.)

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can be reduced. The user also can zoom into a specific area of concern and crop out any unwanted elements.

With digital x-rays, the ability to enhance the image greatly increases our diagnostic efficiency. For years, there has been a discussion in dentistry: "Are digital x-rays as good as film?" The answer is, "They aren't as good, they are better!" A digital x-ray has more data than our eyes can see, and using software to analyze that data makes us better diagnosticians.

For example, a study reported in the July 2002 *Journal of the American Dental Association* found that using caries detection software to examine digital radiographs enabled dentists to find 20% more caries penetrating into dentin than they were able to find without it.[4] In addition, the dentists conducting the study did not mistreat any healthy teeth.

Previous research has shown that den-

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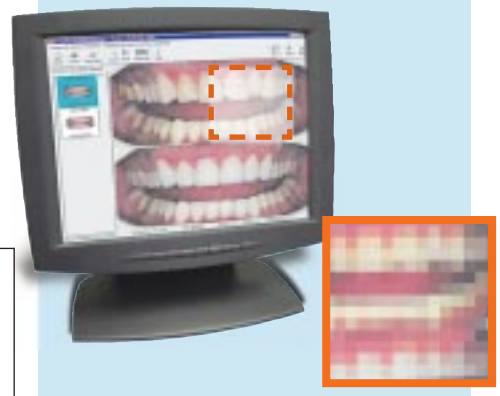
What's the difference: DIGITAL VS. ANALOG



In the most literal sense, to *digitize* something means to turn it into digits or numbers. In a more practical sense, it means turning something into the electronic language a computer can understand.

Analog

The opposite of digital is *analog*. An example of an analog device is a wristwatch with hands that move continuously around the face. Such a watch is capable of indicating every possible time of day. In contrast, a digital clock is capable of representing a limited number of times (every tenth of a second, for example).

Humans experience an analog world. Vision is an analog experience, because we see infinitely smooth gradations of shapes and colors. However, most analog events can be simulated digitally. For instance, photographs in newspapers consist of an array of dots that either are black or white, a classic digital format. From a distance, a viewer does not see the dots but only lines and shading, which appear to be continuous.

Digital

Although digital representations are approximations of analog events, they are extremely useful because they are easy to store, transmit, and manipulate electronically.

This is the principle behind a digital image. The image itself exists in an analog form, as visible light waves in the air. These light waves are captured and translated into a digital form—that is, into numbers that represent an approximation of the image similar to the dots in a newspaper photo. When you view the image, the computer reads the digital data and sends it to the monitor, which displays the digital image as a series of pixels, or colored dots. You view the image, and your brain converts it back to a continuous analog image.

The more dots, or digital bits, used to simulate the image, the higher the resolution. A 1.0-megapixel camera uses 1 million dots per image, while a 2.0-megapixel cameras uses twice as many. In dentistry, a 1.0 megapixel camera is adequate for most uses.

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tists using film radiographs misdiagnose the depth of caries up to 40% of the time, and that healthy teeth are misdiagnosed as having caries up to 20% of the time.

Most dentists think of image enhancement in terms of cosmetic imaging. Cosmetic imaging uses specialized photo-enhancement software tools to allow users to alter a digital smile photo to demonstrate the results of cosmetic treatment. The common photo manipulation tools, such as those used in Adobe Photoshop, are customized for easy dental applications. For example, there are tools to simplify tooth whitening or to move, rotate, reshape, or replace teeth. (For more information , see Dr. Emmott's article, "Digital cosmetic imaging: Tips and tools to keep you and your patients smiling," in DPR's May 2002 issue.[5])

Digital technology has completely revolutionized photo and x-ray imaging. The past was confined to analog technology; the future will be digital. The future is coming and it will be amazing! DPR

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