The dental practice and the dental operatory in particular is rapidly changing. The explosion of digital technologies, from cameras to radiography, is driving this paradigm shift in how we run our practices. This article will examine a number of issues that need to be answered when adding digital imaging to the dental practice. In this article, we will review the different options available and assist dentists in sorting through the myriad of choices.

**Intraoral Cameras**

Intraoral cameras have been used for dental applications since the early 1990s. One of the first products was the AcuCam, made by New Image Industries. At one point, New Image held over 40% of the market share for these systems. For many years, intraoral cameras were the cameras of choice. Although there was a bit of a learning curve, they were relatively easy to master and still have widespread acceptance today. Recent surveys have shown that intraoral cameras are found in about 50% of all dental offices, although my experience seems to indicate this number is quite a bit less. Anyone who has used an intraoral camera is aware of the advantages these systems offer:

1. Most cameras are capable of magnifying images at 40-52X normal. This can be an invaluable tool in allowing the dentist to see pathology, such as open margins, fractures, and caries, which wouldn’t easily be seen without this level of magnification.

2. The ability to have images on a computer monitor screen that is visible to the patient is a large benefit. Most experts agree that one of the keys to improving patient acceptance to our treatment plans is the concept of “co-diagnosis”. In other words, allowing the patient to see the problems we see will allow them to participate in the diagnosis of their dental problems, and they will then be more inclined to accept our recommendations for treating problems they may have been previously unaware they had.

3. The cameras allow us to have a permanent record of a patient’s condition before we begin treatment. This can be quite beneficial for cosmetic cases where we can show patients before and after photos of their teeth. Also, for legal reasons, it will often be valuable to have a record of a patient’s condition before treatment began, just in case the patient is unhappy with the results and is considering legal action.

4. For offices that don’t have digital radiography, the cameras can be used to take photos of x-rays, which frees us from having to send in our original radiographs to the insurance companies. Also, adding photo documentation to an insurance claim will often speed up the approval of that claim.

When evaluating intraoral cameras, there are a number of factors to consider. I would highly recommend anyone considering the purchase of an intraoral camera should attend a dental meeting where many of the different vendors will be on hand, so that you can evaluate the different aspects of the cameras:

a. Ability to handle multiple views. According to Clinical Research Associates, there are six standard intraoral camera views that should be evaluated when choosing a camera. These are divided into intraoral and extraoral views. The intraoral views are the distal of the upper last molar, the buccal of the upper last molar, and the lingual surfaces of the lower anterior teeth. As far as the extraoral shots are concerned, test the camera’s ability to take a full lower arch, a full-face photo, and a photo of a bitewing radiograph that is being lit by an x-ray view box. Test all of these shots to see which camera can handle the majority of them with ease.
b. Portability. Many dentists have large offices and to save costs, they will consider using a camera that can easily be moved from one operatory to another. Most manufacturers have come out with USB models that make it easy to move a camera from room to room. Popular models that allow for USB convenience are manufactured by SOPRO (Mediadent, DEXIS), Schick, RF System lab, and OraCam (Video Dental Concepts).

c. Ease of focus. Does the camera require manual focus or is it auto focus? Most cameras have an adjustable focus, so you should evaluate how easy it is to change the focus. The focus should be well labeled, and should have a range of motion that is less than 100 degrees so that you can easily change the focus setting with one hand.

d. Built-in freeze-frame. Only a few models have this.

e. Capture button location. Most units use a foot pedal to capture individual images, but other models have the capture button right on the handpieces. For many dentists, this is simply a matter of personal preference, so you should try both types of systems to see which feels most comfortable for you.

f. Maximum number of images displayed. The standard number is four images that can be displayed simultaneously. However, I’ve seen systems that only allow one image at a time, and other systems that can allow 16, 20, or 25+ images to be displayed.

g. Unique features. Most camera manufacturers will add special features to their systems to differentiate themselves from their competitors. Some of the features that you will see include flexible cords, extraoral light adjustments, printing from a portable unit, light and color adjustments, and image scrolling through the foot pedal.

Extraoral Cameras

While intraoral cameras have many benefits, there have always been some roadblocks for dentists who wished to use them in the office. As I stated earlier, there is a learning curve associated with their use; most have an inverted image and so using them is similar to using a mirror in the mouth. The earlier units had a tendency to fog up, and you need to use a disposable sheath between every patient. The units also tend to still be on the expensive side, and better models still sell in the $4,500-$5,500 range for the basic system. What most dentists wanted was a way to use cameras they were already familiar with, which is the extraoral camera. The problem, for a long time, was the unavailability of digital cameras. While there are many ways to get traditional photos into a digital format (more on that later), it is still much more desirable and easy to have digital images from the start.

When the first digital cameras for consumer use were introduced, they were very expensive and while still suitable for the home, they did not meet the criteria for producing diagnostic dental photographs. The first units that came out were 1.3 megapixel cameras. Since then, we have seen 2.1 megapixel units, 3.3 megapixel units, and lately, 5 and 6 megapixel cameras.

Remember, pixel count doesn’t determine how good the image is—only how big you can make a good print! Image quality is determined more by lens quality, the imaging chip and its control circuitry, etc., not to mention the ability of the photographer to control those factors. To put the “how big” issue in some kind of perspective, the rule of thumb I use is that (with a continuous-tone print device such as a dye-sub or good quality ink-jet printer) you need to provide 300 pixels per inch in the print to provide “high quality” photographic results—ones that will stand up to close scrutiny and still look photographic. If you can settle for “snapshot” photo quality, i.e. images that will be examined casually at normal reading distance or better, then you can get by with 200 pixels per inch in the print, and for “display” quality, meaning prints that will be viewed from several feet away, you’re fine with 100 pixels per inch or even less. (Keep in mind that these quality levels are strictly my own personal preferences; some people might be perfectly happy with 50-pixels-per-inch images.)

Anyway, if you’ve got a 2-megapixel camera (typically about 1200 x 1600 pixels in the image) the biggest print you can make and retain what I think of as “high quality” is 4 x 6 inches. A 3-megapixel camera (let’s assume it’ll be 1500 x 2000 image pixels) will let you make a print of 5 x 7 inches at the same “high quality” level. That’s a difference of about an inch each way. If your usual need is for “snapshot” quality, you can bump up these figures by 50%. Regardless, I think it makes it pretty clear that the 5 and 6-megapixel cameras won’t make a BIG difference, unless you plan to actually print 8 X 10 inch photos; the image on the computer monitor screen will look the same whether you are using a 2, 3, or 6-megapixel camera. If you have a choice of a 4-megapixel camera that’s perfect for your needs and preferences, or a 6-megapixel camera that would force you to compromise on the features and controls you want, don’t buy the 6-megapixel model just because it has more pixels.

When you are evaluating digital camera systems, I would recommend that you work with a company that specializes in systems designed for the dentist. Two well-known companies are PhotoMed International and Lester A. Dine, Inc. Both produce...
From Analog to Digital

For many dentists, the transition to digital photography is exciting and opens up many new possibilities for them. The difficulty for most, however, is trying to figure out how to digitize their current photos and slides. There are a number of methods of getting your prints and slides onto a computer, where they can then be manipulated and output to different sources:

1. **Photo or Picture CD.** For film that hasn’t been developed or with negatives, you can ask the photo developer to put your images on a Photo or Picture CD. These CDs can be read by all but the most ancient CD-ROM players, and can then be downloaded onto your computer’s hard drive.

2. **Scanner.** This is currently the only method for getting existing photos or slides into a digital format. I would recommend that when you search for a scanner, find one that has both a backlight and a transparency adapter. Models that I have found to be particularly good are the Epson Expression 1680 Professional Series and the Microtek 9800XL. You should look for a scanner that has the highest dpi (dots per inch) resolution that you can afford. Better models have at least a 1200 X 2400 dpi; the Epson, for example, has a 1600 X 3200 dpi resolution.

3. **Online.** There are numerous online companies that offer online storage and scanning of existing photos. While these online services are an option, they are hardly the cheapest. Expect to pay from $1-10 per scan, which can get very expensive if you have hundreds of photos and slides to be scanned.

Once you find a method of getting your analog or digital photos and slides on to a computer, you need to have some method of storing, cataloging, and manipulating these images. The only method before true integration became a reality was to use a stand-alone image management program. Some of the better and more popular ones are Apteryx XVa3, ADSTRA, DentalEye3, and TigerView. As dental practice management software has
evolved, there was a need to find a way to integrate these image databases with the management program, so most of the developers of these programs built “bridges”. Most bridges, however, are still one-way, in that you can call up the image management program from the patient screen, and all that patient information will already be transferred. This method, however, does not allow images you capture to be transferred back to the patient file in the practice management program. To accomplish this, you need true integration. This type of integration is found with some of the more prevalent programs, such as DENTRIX DDO, SoftDent PowerCase, and EagleSoft.

Output
Once you have access to your images and have manipulated them to your liking, the final piece in the puzzle is to determine how you want to output these photos. Obviously, this will depend a lot on how you plan to utilize the images, such as patient presentations, dental lab communication, lectures, insurance documentation, or online collaboration. Some of the various choices include:

a. Inkjet printers. It is important to use a printer that is not only capable of printing medical quality images, but using the right paper is also important. An example of a good quality printer is the Canon i960. The paper and supplies will tend to be more expensive for these type of printers; ink cartridges run about $50 and a high-quality paper costs $.50-60 per page.

b. CD/DVD Writer. Most new computers come with CD burners, known as CD-R and CD-RW drives, and DVD/RW is becoming a new standard. These drives are capable of writing the images (or any other files you designate) directly to the CD-ROM, so that you can easily send the CD through the mail or make backup copies for yourself.

c. Removable media. There are many types of removable media that can be used, depending on the amount of storage capacity that is needed. Some of these options include external hard drives and Zip drives.

d. Email. Once you have a digital image, any email program will allow you to attach files to be emailed. You should ensure the images are in a standard format that can be read by other programs, and just as importantly, that the files are compressed. An image created with a 3.3-megapixel camera can be many megabytes in size. Converting this to a JPEG file (these are files that have the .jpg extension on the end) will reduce them to 500-750k on average. Keep in mind many people still use a dial-up connection to the Internet, and downloading large files can be very time-consuming; compressing the images makes a lot of sense.

e. Online collaboration. There are many services that will allow you to upload your digital files to a site that will store and catalog these files for viewing by other people. The most basic ones, which are not necessarily designed for dental applications, are quite easy to use and most are free of charge. Sites that are built around online dental collaboration, such as TigerView’s Digital Lightbox, are excellent for this purpose.

Digital Radiography…the next “Big Thing”?
In the past 12-18 months, the interest in digital radiography has exploded. For the dentist considering this technology, he/she should be aware of the three systems available for digital radiographs in the office: scanners, phosphor plates and direct sensors.

Scanners
Although it is certainly not a “digital” system in the purest sense of the term, many offices use scanners to digitize their existing x-rays. Even offices that have elected to purchase a true digital system must deal with the issue of having years of x-rays that ideally should be part of the patient’s digital record. Scanners are also an excellent option for the office that desires some of the advantages of digital, but finds the costs to be prohibitive. For example, scanning radiographs is far preferable than sending originals to the insurance company.

Films are developed in their usual fashion and are then scanned into software. Many scanners come with their own software, although I would recommend using dental image management software. The key feature when choosing a scanner is the Transparency Unit Adapter (TPU), which is a light source in the lid of the scanner rather than the base. Many mid-priced scanners only have a 4 X 5 inch TPU, and while it’s fine for bitewings or a few PAs, would not be adequate for a pano or full mouth series in its mount. In these cases, a full sized TPU is needed, and there are only a few scanners that meet this requirement. The Epson 1680 Professional is the industry-standard, and the Microtek 9800 is also a good choice.
**Phosphor Plates**

While some people consider phosphor plates to be positioned between scanners and direct sensors, these systems are actually very highly developed and produce diagnostic quality images. The plates are “scanned” in a special machine, which is basically a laser that reads the phosphor plates. The main advantages of phosphor plates are the ease of use and transition for your staff. They are as thin as film packets. The staff can take images with the same RINN kits and methods they use for film, they take the plates to a centralized “processor” to “develop” them, and they mount the images afterwards. The one difference is that the mounting occurs in software templates, not cardboard or plastic mounts. Also, unlike direct sensors, the plates are relatively inexpensive.

On the downside, the plates are easy to scratch and while they theoretically can last through hundreds of uses, damage will normally require they be replaced more frequently. Phosphor plates have less resolution, in line pairs/mm, than sensors. While this would not make a difference when viewing images on a typical 17 inch monitor, it can make a difference if you are magnifying the image to a great degree or printing out images that are larger than 8 X 10 inch. Also, because of the steps needed to get an image, the time needed to take phosphor plate images is very close to the time needed for film.

**Direct Sensors**

Direct sensors are silicon-based receptors, often encased in protective coating, that mimic the size and shape of PA film. These sensors, which are either CMOS or CCD, are connected to a thin cable which runs from the sensor to some device that would then connect to the computer. The sensors range in thickness from about 3 to 8mm. The main advantages of sensors are speed and image quality. Images taken with a sensor appear almost immediately on the screen, making them the ideal choice for an office that needs instantaneous images. They are comfortable, sturdy, and have excellent resolution; many can produce a highly diagnostic image when used with the proper software.

However, they are thicker than film and have cables running off the sensors, which some patients don’t tolerate well. Patients who are gaggers will definitely have trouble with sensors. Also, they are not inexpensive, as a #2 sensor can range in price from about $5,000 to $14,000.

**Conclusion**

The world of digital imaging has continued to grow over the past couple of years, and this is to the advantage of the dentist. Prices will continue to drop, image quality continues to improve, and the products and systems are becoming easier and easier to use. For any dentist considering the addition of digital images to their dental practice, the time to take the plunge is now!

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