
# Digital Knights

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## DIGITAL RADIOGRAPHY

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Market research indicates one of the high tech components dentists are most likely to purchase in the coming few years is a filmless digital x-ray system. Up to now the market has been dominated by two main systems, Schick and Trophy. This is changing, as the market matures; new companies and new systems are emerging which will influence what is available how it integrates, how we diagnose disease and what we will pay for digital x-ray systems in the future. The following article takes a brief look at the concept of filmless x-ray and then examines the confusing changes taking place in the market.

**Basics:** There is a good reason many dentists are considering digital radiography systems. They will truly revolutionize how we use x-rays in the future. Digital technology is the first fundamental change in radiology since Roetengen zapped the first molar over 100 years ago. To understand all the excitement you need to understand the basic process and the advantages it offers

Digital Radiographs were developed by Trophy in Europe as a means to lower radiation exposure. The system replaces the traditional film pack with a special sensor. The sensor looks like a chubby black x-ray film with a cord attached.

The sensor detects radiation and transmits the information to the computer. The software then displays the image on the computer screen. The images look like a traditional black and white x-ray film.

"Digitize" is one of those common computer terms often tossed about and sometimes not well understood. All it really means is to turn data into numbers or digits, which can be read and used by a computer. Data in this case is not limited to letters and numbers but can be almost anything including pictures. The term “capture” is used to refer to the process of creating the digital image. Once something is digitized it can be manipulated,

analyzed, stored and transmitted electronically. Digital radiography technology is truly amazing and offers some clear advantages over old photographic film techniques.

**Less Exposure:** Digital Radiographs require far less radiation to create an image than film. At least 60% to 90% less radiation. You can use any current x-ray unit usually set on the lowest settings or with filters installed. That means you can take more images with less exposure. And your patients, who generally view x-rays as slow death, will love it. It also means you can safely take x-rays on a pregnant woman if needed.

**No Chemical Developing:** Another major advantage of digital x-rays is that the image is produced with in seconds. If it isn't accurate you know immediately and can retake it. Or even better you can manipulate the image if needed. For instance the contrast can be raised or lowered to create a better image. No developing will save considerable time, but even more significant is that it will reduce one of the biggest hassles in the dental office. How many times have you seen a good x-ray ruined by poor developing, weak chemicals or light exposure? No developing also means no chemicals, no developer, no pollution, no film and no mounts

Automatic developers are a lot nicer than the old tanks, but they are expensive to buy, are constantly breaking down, are expensive to maintain, need chemicals and generally are a nuisance.

**Digital Images:** Once the image is digitized it can then be manipulated electronically. For example it can be stored on an electronic database and integrated with an electronic chart. No more bulky old x-rays filling out a paper chart and yellowing with age. It can be transmitted via modem to an insurance company or a specialist. It can be enlarged, and specific sections can be viewed even larger to aid in diagnosis and to show patients. The contrast can be adjusted to enhance diagnosis or the image can be colorized or filtered to bring out greater detail.

Other features depending on the software allow the operator to rotate images. Take measurements directly on the screen and to add written notes to be stored with the image. Diagnostic software will even analyze the image for signs of disease.

**Two Basic Approaches:** Development of this technology has been following two basic but separate paths. The primary path represented by Schick and Trophy is the use of a sensor wired directly to the computer to capture digital images. This is the direct approach. The second approach represented by Gendex and Digora is a reusable film like pack without wires which records an image which then must be "developed" by using a scanner to digitize the image and send it to the computer. This is the indirect approach, which is sometimes referred to as a cordless system.

The indirect approach is very similar to how we work now, and is appealing for that reason. It has the advantage of reduced radiation exposure and image manipulation but it takes much longer to see the image, usually several minutes, and offers little cost savings.

The only advantage to the indirect approach may be with panoramic films. At this time direct panoramic sensors are very costly, $17-25.000 and can only be used with special

machines or adapters. Indirect sensors are less expensive and easier to adapt to existing panoramic units. However since it is not possible to mix and match the systems with current technology most dentists will get much more service and cost savings from the direct sensor method.

Rapid Change: The digital radiography market is changing rapidly. For example in the last year industry standards called DICOM have been adapted. Cygnus Imaging has introduced a new system based on a high resolution Panasonic sensor. Trophy the original developer of filmless x-ray technology from France has been purchased by Trex a large US based medical X-ray Company. Now Called Trex Trophy they have introduced a new sensor which they claim has even better resolution and the first true diagnostic software. And Schick, the largest US provider of digital dental x-ray systems, has introduced a new sensor based on a CMOS chip and with a USB connection. As a profession we will have an opportunity to guide this emerging technology based on our input and most importantly our buying decisions.

**Carts and Horses:** The third of Steven Covey's “Seven Habits of Highly Effective People” is “Put First Things First”. That’s another way of saying, “Don’t put the cart before the horse.” Or better yet in terms of digital radiography get computers in the treatment rooms before you try to use computerized radiographs.

That might seem like a pretty obvious requirement but some digital radiograph vendors more concerned with sales than service, encourage dentists to do otherwise. It is possible to use digital radiology with a cart system rolled from treatment room to treatment room or worse yet to use a laptop but it isn’t a very effective way to do it. The end result is a system about as useful as a cart with a rear mounted horse.

Digital x-rays are a remarkable developing technology and it easy to understand why a dentist would be anxious to get involved. However there is a logical sequence to the development of the high tech office and if you don’t put first things first you are likely to get bogged down spending a lot of money on technology systems that don't get used because they are too difficult to employ.

A high tech office must start with a good networked management system with clinical workstations. Once the computers are in the treatment rooms then it is reasonable to add on digital components. These can include, digital x-rays and much more such as, digital image management, cosmetic imaging, computer based interactive patient education, computerized perio systems, voice charting and more. The first step is the computer then add to it what you want.

To say all this another way, if you are buying a computer from the digital radiograph company you are probably making a mistake. You will do much better adding digital radiographs to an existing networked system supported by a local computer vendor. However the machines must be capable of supporting radiographic sensors and the local vendor should have knowledge of system requirements and have installed and serviced digital radiographic systems in the past.

**Choose with Care:** There is a famous story of a traveler riding the back roads in a Jeep. The ruts and rocks keep getting bigger. Finally dropping into a deep valley the ruts grew even bigger. There beside the road was a carefully hand written sign. "Choose your rut with care, you will be in it for the next 43 miles". When purchasing a digital x-ray system choose with care. Basic systems cost from $9,000 to $12,000. You will be stuck with it for a long time.

With all the changes and new companies entering the market it is a confusing time for a dentist to be considering digital x-rays. The market is dynamic and aggressive. Some of the loud talk we hear from the various vendors is irrelevant market driven hype. On the other hand digital filmless x-ray will be the technology of the future, it has some definite advantages over film, but it is a costly investment with long-term consequences.

**Software vs. Hardware:** At this time all the digital radiography companies are selling their products as stand alone complete systems. That is they sell the sensors, capture system, software and usually a computer as a package. These packages are specifically designed, sometimes due to patent considerations, so that they will not interact with each other.

When evaluating a digital x-ray system there are two distinct parts to it. The capture, hardware component and the storage and manipulation software component. At the moment every system is proprietary. That is, it is not possible to mix components. A user can not capture an image with a Schick sensor and store or view it with Trophy software. It is not possible to transfer stored images from one database to another in bulk.

The developers of every system agree that compatible systems would be better for the consumer, that is the dentist. They also all say they would be glad to do it but are limited by what other developers are willing to share regarding product development and patent rights. And finally they all agree that truly compatible systems are five years or more in the future. The significance of this is that whatever system you start with you will be stuck with it for the foreseeable future.

In other words it is not practical to buy a Schick system today, use it for a year and then switch to Trex Trophy, Dexis or Cygnus next year if they come out with an improvement. You will not be able to use your existing sensors with a new system and even more significantly you will not be able to transfer your stored images to a new database unless you are willing to do it by hand one image at a time.

**Sensor Hype:** Sensors are the key to any system and the major cost. Sensors cost between $4-6,000, depending on the size and type. They connect to the computer with a capture card. The raging debate in the last year has been which sensor captures the best image, closest to film. The fact is there are many differences between the various sensors but it is almost impossible to develop meaningful caparisons to film. Beware of marketing ploys, which use film to sensor comparisons. The only real way to compare sensor image quality is with side by side on screen images. But even this type of comparison has some hidden problems

Photographic film works with fine grains of silver which when exposed to light are either black or white. The closer the grains are packed together the better the definition of the x-ray. Digital images use pixels instead of silver grains. Pixels can't be packed together nearly as tightly as silver grains. However pixels aren't just black or white, they can be one of hundreds of shades of gray. Does that mean one pixel is equivalent to a hundred silver grains? Not exactly. Pixel size also effects resolution. The comparison is made even murkier because of software manipulation.

**Firmware:** Digital images on the way from the sensor to the monitor pass through internal software called firmware. These internal software programs change the image to conform to the manufacturer's specifications. The intent is to create more accurate film like images. However the fact remains the image we finally see on the monitor is not directly captured form the sensor and sensor comparisons, which do not account for software manipulation, are meaningless.

According to an article in the *Wall Street Journal*, this is especially significant with CMOS sensors. CMOS (pronounced sea moss) chips are claimed to produce a much lower quality image than CCD chips. The article also stated that CMOS sensors produce the same quality images as CCD sensors. CMOS sensors are less expensive to produce and have been used in the past for inexpensive toys. They are just now being developed for advanced high-resolution uses. According to digital image engineers I spoke with CMOS chips are plagued by high noise levels, which create dots or scratches on the image. To compensate internal processors are built in to the chips and the capture software to filter out noise. If the engineers are correct this makes for a nice looking film like image but makes it harder to evaluate the true diagnostic qualities of the image.

David Schick, the founder of Schick Technologies says that the Schick CMOS sensor does not rely on internal manipulation or firmware to produce an image; therefore true diagnostic qualities are not compromised. Based on personal experience when looking at on screen images there was little difference between the Trophy, Schick and Cygnus systems.

**Resolution and Diagnosis:** The standard measurement for resolution has become line pairs per millimeter (lp/mm). There are some other factors, such as pixel size, which also influence resolution and there is little evidence that lp/mm can be translated into real clinical significance. Never the less lp/mm is a good quick number for comparison. Scanned film has a resolution of about 16 lp/mm. Early sensors are about 8 lp/mm. The Cygnus Panasonic sensor was an improvement at 12-13 lp/mm. Then this year Trex Trophy introduced a sensor at the Chicago meeting with a resolution of over 20 lp/mm. For the first time according to Trex Trophy digital sensors have surpassed film.

However the real issue isn't how close is the image to film but how useful is it as a diagnostic tool? For the most part digital images are not as easy to read as film but they are adequate for diagnosis. Actually a digital x-ray has more data than a traditional film, but we are limited in how we interpret the data based on the old film model and what the dentist can observe with his/her eyes. We can only distinguish about 22 shades of gray

with our eyes. On the other hand computer software can distinguish over 200 shades of gray.

In the future digital images will be analyzed by diagnostic software, which can be programmed to search for caries, periodontal bone destruction or even bony lesions. These programs, which will surpass the diagnostic ability of the human eye, are being developed now.

Trex Trophy introduced the first of these, Logicon Caries Detection, at the 1998 ADA meeting. This is a remarkable first step in the development of these products. Logicon evaluates interproximal surfaces for decay and gives an analysis based on clinical studies. This is a true diagnostic software not just an enhancement tool. There is no other true diagnostic software available at this time.

**Software:** Once the x-ray is captured as a digital image then the display software takes over. It is the software that most dentists see and judge when comparing systems. Each major software program has the same basic features. That is a system to save and retrieve images to a patient name on a database. A search feature to find saved images. And various tools to enhance or manipulate the images. These tools usually include brightness and contrast controls, a zoom to enlarge the image, colorizer, density analysis, reverse image, on screen measurement, rotation and annotations.

Compare these features: Is it simple to capture an image? Can you capture multiple images? Is it easy to find a patient and retrieve a selected image? Are images stored in familiar forms or templates similar to film mounts? Is it easy to move or change images within a patient file? Are the tools easy to use? Do the tools offer real advantages either diagnostically or for patient education?

**Computer Interface:** Another area of great change and confusion is the connection of the sensor to the computer. There are four different types of ports or interfaces currently being used for computer connections. These are ISA, PCI, USB and PCMCIA. Any of these connections can be used with a traditional tower PC. In addition USB and PCMCIA can be used with a laptop. There are some differences in each connection and also some potential problems.

ISA and PCI are slots in a computer motherboard. Cards are attached to these slots with ports the digital sensor then plugs into. ISA is an older, slower 16-bit technology, which is being phased out. PCI is a faster 32-bit system. Either will work just be sure if you get a system with the older ISA attachment it can be easily and cheaply upgraded in the future.

USB (Universal Serial Bus) connections are new and offer fast universal connections for a variety of uses. If you have a new computer properly configured with Windows98 USB is a good choice. However you may not be able to easily use USB with older computers running Windows95.

PCMCIA slots are the credit card size attachments primarily designed for use with a laptop computer. Laptops are great for taking on an airplane but are not really a good

choice for most dental office uses. There are a lot of reasons for this, but that is another article.

**DICOM and Compatibility:** Most new technology markets begin with vendors attempting to control market share with proprietary systems as we see now with digital x-rays. Then as the market matures vendors are forced to create standards and the most successful companies are those who are the most compatible. This pattern is easily seen in the development of personal computers or even VCRs.

The ADA infomatics task group, under the direction of Dr. Brent Dove from the University of Texas, San Antonio working with industry leaders has developed a standard for all digital images. This standard is based on a widely accepted medical standard called DICOM. It specifies file format and allows images to be viewed cross platform from Windows to Mac or Unix applications. Dicom compliance means that saved x-ray images can be transferred from one software data base to another with ease. It means the images retain their original features including patient name, tooth number, date etc. even if they are transferred to another system. It means images can be transmitted to another office such as a specialist and they can be viewed with any other DICOM compliant system. This is a very important project, which will influence the development of all digital x-ray systems in the future.

The ideal situation for the dentist would allow you to use any sensor with any capture system and any software. For example you could choose the newest Cygnus sensor to plug into your existing Schick software. Then you could use the flexible Gendex panoramic imaging plate to make a digital pano and view it with your existing Trex Trophy system. If a new improved x-ray software application comes along you could install it and use it to manipulate images already stored in the patient chart or capture new images with your old sensors, and finally you could transmit your image stored in your Schick system to a colleague who has Trex Trophy software. None of that is possible with current systems.

We will see continued change in filmless x-rays over the next several years. Buying now will put you ahead of the technology curve. However as an early adopter you will have some risks as well. If the system you choose does not conform to standards or the developer goes out of business you could be betamaxed. Whatever system you choose remember that for the foreseeable future you will be stuck with it. One safe guard against this possibility is to be sure that any system you purchase is DICOM compliant

Successful companies respond to consumer needs. Digital radiographs will be a huge business in the next decade and the companies selling these products will comply with standards and compatibility if the dental profession demands it. As a profession we will have an opportunity to guide this emerging technology market based on both our input and our buying decisions. The winner won't necessarily be the best system or the most compatible system unless we choose it with our buying decisions.

**"The future is coming and it will be amazing!"**