

ANALOG FILM, DIRECT-DIGITAL, INDIRECT-DIGITAL

There are two ends to the radiography system. You need a source of radiation, for which I strongly recommend a wall-mounted dental x-ray machine. I wrote about this a while back (see <http://www.toothvet.ca/PDF%20files/Radiology.pdf>). At the other end, you need something to collect the radiation. That is, you need a medium to collect and store the image. For this, you have the three options listed in the title above. There was a fair amount of discussion on analog film in the article linked above. I want to look at the other two options in comparison to analog film.

I recall when the first digital cameras were hitting the consumer market. The image quality was really poor and there was very little flexibility and few features. People were all gaga for these early offerings none-the-less, simply because it was digital and that meant 'cool'. While digital dental radiography has been around for a while, it is really being marketed heavily at present and unfortunately, there is a lot of hype. I want you to look past the 'cool factor' when making your choice.

I have been taking intra-oral dental radiographs now for over 15 years. Until very recently I was using analog film. Most RDs (real dentists) still use analog film. The following piece was first written in November of 2005. I had tried a direct-to-digital system in February of 2005 but returned it to the vendor after two weeks. I have edited the original essay to reflect some recent changes.

The question of film vs. digital intra-oral dental radiography comes up frequently. The proponents of digital are very enthusiastic about this up-and-coming technology and I am glad that it is working well for them. However, I fear that beginners are being made to feel that they will somehow be doing a second-rate job if they do not go digital. Those marketing digital systems and those who love them (and there are many) will be happy to share with you the advantages of digital. I would like to share with you my thoughts from the other side of the coin so that you can make an informed decision, looking at the "Cons" as well as the "Pros".

The most important message is that every single clinic that offers any form of therapeutic dental care MUST be taking intra-oral dental radiographs. This is not open to debate. The only question is what technology should one use to capture the images?

Disclaimer – I do not sell anything. I have no vested interest in any equipment, company or material. I really do not care which way you go so long as you are happy with your choice and are taking lots of diagnostic intra-oral dental radiographs and are interpreting them well.

I am basing my comments on a number of factors, including a two-week trial with one digital system, discussions with many of the suppliers and many users of digital systems and considerable reading on the subject.

Cost:

For many general practices that are not currently doing any dental radiology, there will be an investment required to purchase and install a dental x-ray machine. While intra-oral radiographs can be taken with a standard machine, it is so impractical and inconvenient that the purchase of a proper dental x-ray machine really is necessary (~\$4 000 US). This machine needs to be installed within easy reach of the dental treatment table. For some clinics, this may mean other infra-structure changes which may cost money. Add to this the \$6000 to \$15 000 (US) extra cost to purchase the digital sensor and software and the cost becomes hard for many small clinics to justify. So, initial set-up/installation cost to purchase and install a dental x-ray machine and the necessary accessories (film, clips, chair-side developer, film mounts, processing chemicals, installation) might be around \$6 000. If you add digital (and delete film, developing, mounts...) the total cost becomes more like \$11 000 to 20 000.

Some digital users claim that going digital actually saves money as there is no ongoing expense to purchase film, chemicals, mounts and there is less labor cost involved in processing,

storing, retrieving images. These cost savings may appear in a high-volume dental referral clinic but are not as likely to be realized in a small general practice.

Size/Flexibility:

With film, you have the option of purchasing a variety of film sizes from size 1 to 4. I tend to use size 1 (1 1/2 X 15/16 inches), size 2 (1 5/8 X 1 1/4 inches) and size 4 (2 1/4 X 3 inches). Size 1 is good for kittens, small cats and micro-dogs. Size 2 is a good, general size for cats, small dogs and for single-tooth shots in larger dogs. Size 4 films are excellent for large areas such as the rostral mandible of a large dog, a large grouping of adjacent teeth, nasal and TMJ radiographs and much more.

Digital sensors are available in sizes 0, 1 and 2, but the sensors are so expensive that few clinics would ever own more than one size, so you have to pick just one. Most clinics will go with the size 2 sensor which is roughly the size of a size 2 film but actually has a smaller active sensor area. Digital sensors are much thicker than film packs and are rigid. Therefore, fitting a digital sensor into the back of the mouth of a small dog (under 10 pounds) to radiograph the second and third molars can be difficult. Similarly, getting good images of the periapical region of mandibular third premolar in a cat (the first tooth distal to the canine) is more difficult with a rigid digital sensor than with film.

In the diagram below, the black box indicates the outside dimensions of a size-2 film (left) and a size-two sensor (right). The white rectangles inside represent the dimensions of the actual piece of film within the flexible vinyl or paper packet and the digital sensor chip within the rigid plastic frame. While they may look the same size on the outside, you can see that the digital sensor chip is considerably smaller and

even with the frame apparently well positioned in the mouth, the chances of missing your target are greater.

Some digital sensors are thinner, but then may be more delicate and subject to damage. Others may be thicker and stronger, but then harder to place in the mouth. Then there is a bump on the back of the sensor where the cable attaches, which takes up more space.

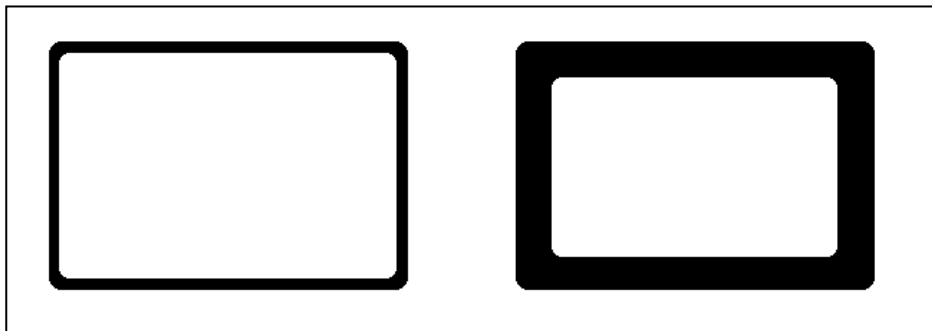
It is very unlikely that an affordable size four sensor will ever be available. I will not go into details, but I have had the manufacturing process explained to me well enough that I can see why we should not anticipate a size-four sensor anytime soon if ever.

I found the weight of the cable attached to the digital sensor made positioning more challenging than with film. I would place the sensor where I wanted it, pack it off with paper towel and let go, often to have the weight of the cord pull the sensor out of position. With film, I place it, pack it off and it stays put.

I have heard that the difficulty in getting the digital sensor to stay in position has led some clinics to require that a staff member remain at the patient's side to hold the sensor in place during exposure. This is unacceptable as it unnecessarily exposes staff to increased doses of radiation.

All of the direct-digital sensors I have seen are black. The inside of most dog and cat mouths is dark. I found it sometimes difficult to visualize the black sensor in a dark mouth to position it properly. I got around this by placing a white address label, trimmed to the size of the actual sensor area, on the face of the sensor to make the target easier to see.

Computer Needs:



Many practices are well computerized, with a mainframe (server) and then terminals and monitors at front desk, in each exam room, one or more in treatment areas and one at each doctor's desk, all networked. If you go to digital radiography, you will need this.

If your practice is not currently well computerized, plan on spending some money on this end if you go digital and plan on getting very good monitors so you can see the images to their best advantage.

And do not forget backup. These digital radiographs are part of the patient's permanent medical record and must be protected/stored for 5 – 7 years after last contact. Secure and reliable back-up of all images is a legal imperative. These images take up considerable space and your current back-up system may not have the necessary capacity.

When selecting the software to manage the images, be sure to determine if there are extra costs for installing the program on the network so that images can be accessed, edited and used from any work-station in the practice.

Reduced Radiation Exposure:

I often see in promotional materials and elsewhere the suggestion that digital radiology uses as much as 90% less radiation than film. This was not my experience.

I used to use Kodak Insight film with a Gendex 770 machine. For cats, I would expose at 4 pulses. For small dogs, 4-5 pulses: medium dogs, 5-6 pulses: large dogs, 7-9 pulses. When I used the direct-digital sensor, cats took 3 pulses and large dogs typically took 6 pulses. This is a very minor reduction in exposure/image. However, since the sensor area in a size-2 sensor is smaller than a size-2 film, a large mandibular first molar might have required two exposures (one for the mesial root and one for the distal root), resulting in a patient exposure of 12 pulses. In a medium to large dog, I might be able to get most premolars and molars on one size-four film (7 pulses), but would need three to four digital images to get as much information (18 to 24 pulses). I can often do a whole-mouth survey in a large dog (Lab, GShep...) with 10 films (some size-4, some size-2). To do the same survey with



This is an example of a Direct-to-Digital system. The solid, rigid sensor goes in the mouth. Information collected on the sensor travels along the cord to an interface and then by USB (usually) to the computer.

a size-2 direct-digital sensor would take as much as 24 images.

In my hands, digital radiology resulted in more patient exposure and more wear-and-tear on my tube head.

Time:

I used to process my films by hand in Kodak Rapid Access chemicals. Each film spent 10 to 15 seconds in developer, 2-3 in water rinse and 10 to 15 seconds in fixer before I could read them. Then they went back in the fixer for 5 minutes, water for 20, then they were dried before being stored in film mounts. The important number to keep in mind is that I could read the film and make my decision within 30 seconds of exposure.

For a single digital image, the time from exposure to image on screen may be as little as 5 seconds, which certainly seems faster. However if I am doing a whole mouth survey, I did not find any time savings.

I would place a film (from one pocket) in the mouth and expose, put that film in the other pocket, place the next film in the mouth and expose and so on until all images from that side of the patient have been exposed. I would then process, assembly-line fashion, all of the films at once. It took me less than a minute to process

and read five films. With direct-digital, I would place the sensor, expose, wait for the result, reposition the sensor, reset the computer, expose, wait for the image, reposition, reset, expose, wait... When it was all said and done, I did not find digital any faster than film. In fact, since a large dog might require 10 to 12 digital images per side versus 4 to 6 films (combination of size 4 and 2) per side, I found film faster.

Reporting and Sharing Images:

Another reported advantage of digital radiography is the ease with which you can share the images in hard-copy and email reports. This is very definitely a function of the software. Some software packages are very good at allowing for smooth and simple integration of digital radiographs, digital photographs, text and database information into reports to give to clients, referring veterinarians or experts with whom you may wish to consult. Not all packages do this well though improvements demanded by the market are being made.

It is not necessary to go to digital radiography to achieve very similar results. I have a Nikon CoolPix4500 digital camera. If I want to share an analog radiograph with a client or colleague, I can simply take a digital photograph of it. I will often insert clinical photographs and photos of radiographs into Word™ documents to send to referring veterinarians etcetera. It is no big deal.

Image Enhancement Tools:

The software that comes with a digital system allows for various image enhancements. There are some tools common to virtually all systems that allow for increasing and decreasing brightness and contrast, colorizing, spot-light tool, magnification and so on. None of these tools make up for poor positioning and they cannot repair a badly over exposed or under exposed image. Time spent fiddling around with these tools might be better put to use re-taking the image with appropriate exposure settings.

I found that with the direct-digital system I tested, the dynamic range was much narrower than with analog film. That means that if the ideal exposure for a site is 7 pulses and I am using analog film, I can still get a very good, diagnostic image shooting anywhere from 5 to 9

pulses. With the direct digital sensor, 6 pulses would be under-exposure and 8 pulses would burn through. Getting the exposure just right required more retakes with the direct digital than with film (more time, more radiation exposure). I am told by others that this problem does not plague all direct digital systems so it is a factor to evaluate when shopping for a digital system.

Image Quality – The BIG One:

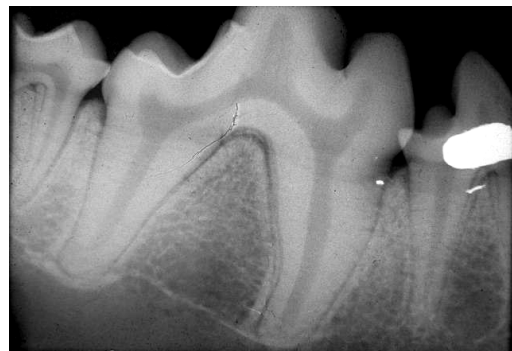
Even if all the reported advantages of savings in money, radiation, time and so on were realized, none of them would be worth a thing if image quality suffered. The whole point of taking intra-oral radiographs is to get a high-quality image upon which you can base your assessment and treatment plan.

I have not looked at image quality on many sensors compared head-to-head, so must concede that some systems may approach or meet analog film in image quality. However, not all do. While I was trying a direct-to-digital system, I took analog and digital images of the same area on a skeleton. The very white areas are amalgam filling material. Here they are.

This is the digital image



This is a digital photograph of the analog image.



If you are reading this in hard-copy, you will probably see no difference at all because of printing artifact. Go to www.toothvet.ca and look for this article on the Old CUSP Articles page. There you will see the difference, especially if you enlarge the images. The digital photo of the analog film is much crisper with cleaner margins around the amalgam filling and debris. These subtle differences may be of no significance when looking at large teeth, but when looking for a retained root fragment of a cat incisor, it starts to be a big issue.

If you are considering going to digital, do this same test. Get a digital image and a film image of the same area of the same patient (or skull) and compare them side-by-side in your practice using your computer, your monitor and lighting etc. Is the image quality with the digital system as good or better than film? If not, then none of the other advantages of digital mean a thing.

Conclusion:

If you are thinking of investing in a direct digital dental radiography system, ask the salesperson the tough questions. Do not let yourself get 'wowed' by all the image-enhancing options and the 'cool-factor'. If, after careful consideration of all the factors, you feel direct digital is right for your practice, then go ahead. Just do not feel that you have to go digital to be taken seriously or to do a good job. At present roughly 75% of dentists working on human patients are still using film exclusively.

INDIRECT-DIGITAL SYSTEMS

So far we have looked at two of the three options. For many years I refused to go digital largely because there was no way I could see getting by with just a size-2 sensor. It would be too big for small patients and too small for big patients. Recently I was reintroduced to a system that has been around for a while but which I have come to realize offers exactly what I was looking for in a digital system. As far as I know it is the only one on the market to satisfy these needs.

Just a quick reminder that I am not getting any compensation for offering this information.

Air Technologies makes an Indirect Digital system that is marketed through AllPro Imaging and sold by various distributors such as Henry Schein/Ash-Arcona (<http://www.airtechniques.com/products/detailview2.aspx?id=88>).

Very simply, there are phosphor-coated plates that are the exact same shape, size (in all three dimensions) and flexibility as analog film. These plates are placed in the mouth and exposed to radiation exactly like film (though with lower exposure settings). The plates are then placed into a scanner which extracts the latent image, digitizes it and then sends the information by USB cable to the computer.

The system I have (shown below) has four slots



so that it can be reading four plates simultaneously. It is called the ScanX I/O (intra-oral) It can be programmed to be sending images from the different slots to different patient files on different screens so if a practice is running two or more dental table simultaneously, the system can handle it. The new ScanX Duo is a smaller scanner with just two slots which costs considerably less and would work well for a smaller practice.

I am using CaptureLink software from Schein. It is not particularly fancy (in the version I have now), but it is simple and reliable. It allows me to easily import photographs into the same folder as the radiographs and also allows easy export into other documents. Another thing I like about this software is that there are no pre-set templates. I can take as many or as few images as I need whenever and in whatever order I choose without having to configure the program or prime the system (unlike many of the systems I have seen).

The reason this is considered indirect digital is because the radiation produces an analog latent image on the sensor plate and this is then converted to a digital image by the scanner and the software. There are a few other indirect digital systems on the market but to my knowledge, none of the others will accept a size-4 sensor plate. If it can't manage a size-4, I don't even want to consider it.

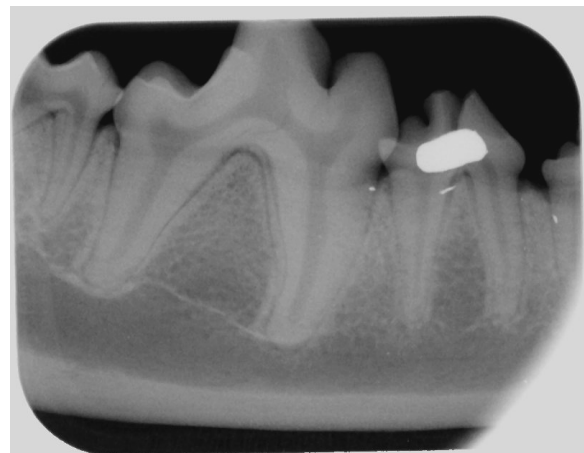
The biggest advantage I see with the ScanX system is that it allows me to use tiny, flexible size-0 plates in micro-dogs and cats as well as the large size-4 plates for medium to large dogs as well as sizes 1, 2 and 3. I have the same options and flexibility as with analog film.

“Processing” the plates takes a few seconds. Each plate must be removed from its protective envelop and placed in the scanner. As it goes through, it is read and then erased so as it drops out the bottom it is ready to be placed in a new envelop and reused (thousands of times). However, the processing is much faster than with film, there are no chemicals to manage, no risk of processing errors and there is none of the labour involved in rinsing drying, mounting and labeling films. Also there is no lead foil to dispose of.

The time between when the plate enters the scanner and the image appears on the screen is variable. Large sensors (size-4) take longer to read than smaller plates (size-2). Also, reading a plate at “super high resolution” takes longer than at “high resolution” which takes longer than “standard resolution”. The resolution setting needs to be selected before placing the plate in the scanner. In all events, the time it takes to get the first image on the screen is certainly longer with indirect digital than it is with direct to digital. However, I still find the ScanX system faster than the direct to digital system I tried. This paradox is explained by the fact that the ScanX can be processing four films simultaneously. By the time I get the four plates loaded into the scanner, the first image is waiting on the screen. By the time I have read the first image, the second is read and so on.

Actually, the way we do it is I place a plate and expose, I then hand it off to my assistant who feeds it into the scanner while I am placing the next plate. We expose and repeat. By the time I am finished exposing all the plates for one side of the head, the first few images are ready to be viewed and by the time I have viewed them, the others are there for me. It all runs very smoothly.

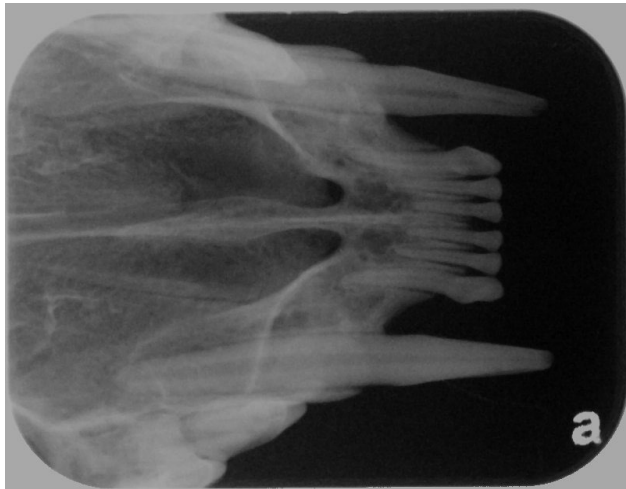
Now, the big question remains. How is the image quality? Again, you will appreciate this better if you are reading this on the web site rather than in hard copy. Here is the ScanX image of the same area as we looked at before. It was scanned at standard resolution. It may not be quite as crisp as the analog film, but I found it noticeably superior to the direct-digital image produced by the system I was assessing.



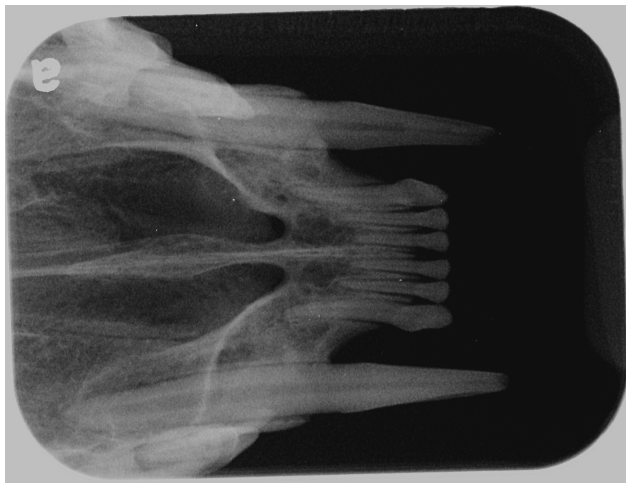
The three images on the next page are all of the same cat skull scanned at standard, high and super-high resolutions respectively.

Now, you may not be able to appreciate much difference at first, but if the images are enlarged, you will see that the super-high resolution image allows you to zoom in considerably closer without losing image quality. (I don't know for sure if this will come through after converting this document to 'pdf' format, but trust me, on my computer screen, what I say is true). So, when taking screening shots of large teeth, I will scan at standard resolution which is fastest. When looking for tiny or subtle things, I will scan at super-high resolution, allowing me to apply greater magnification.

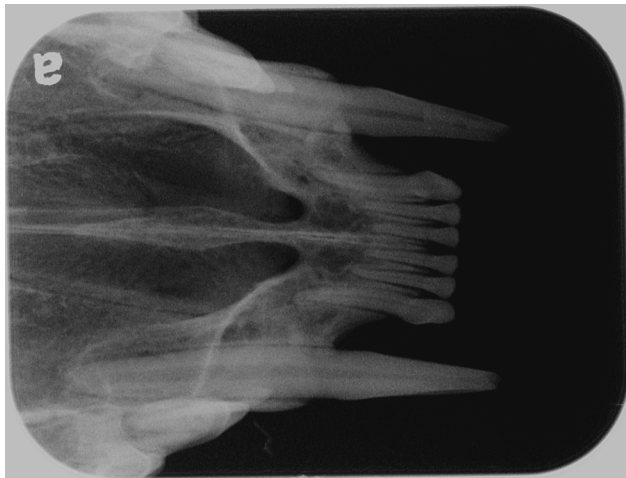
Standard Resolution



High Resolution



Super High Resolution



System	Pros	Cons
Analog film	<p>When done properly, best image quality</p> <p>Least expensive to set-up by far</p> <p>Nothing expensive or delicate to suffer break down</p>	<p>More time and labour intensive</p> <p>On-going expense for film, chemicals, mounts...</p> <p>Environmental issues with chemicals</p> <p>Many opportunities for processing errors, inconsistency in image quality and damage to films</p>
Digital	<p>No chemicals to buy or dispose of</p> <p>No processing errors (though can have setting errors)</p> <p>Less labour – faster 'processing'</p> <p>Speeds learning process</p> <p>Easier sharing of information (print, email, VIN)</p> <p>Small reduction in radiation dose/exposure</p>	<p>Image quality quite variable from brand to brand (basically proportional to cost)</p> <p>Wide range of software packages, some much better than others – confusing options</p> <p>Wide range of prices</p> <p>Requires lots of computer infra-structure and some computer competence</p>

System	Pros	Cons
Direct Digital	<p>Faster time from exposure to image on screen (but may not be faster to obtain a whole-mouth study)</p> <p>Can leave sensor in mouth to compare image with sensor position and make adjustments to improve positioning</p>	<p>Limited sensors sizes which are thick and rigid (too big for small patients, too small for large patients)</p> <p>Sensors very expensive so damage is a big issue</p> <p>More time spent 'priming sensor' and manipulating software (probably variable between programs)</p>
Indirect Digital	<p>Sensors for ScanX available in sizes 0 to 4</p> <p>Sensors are 'cheap' so no catastrophe if animal bites one</p> <p>ScanX I/O can service multiple dental teams simultaneously</p> <p>ScanX Duo less expensive than the more expensive direct systems</p>	<p>More physical 'processing' required to place sensors in scanner</p> <p>Ongoing costs of protective sensor envelopes (not a big deal).</p> <p>Need to remove sensor from mouth to get image on screen</p> <p>4-slot ScanX I/O more expensive than cheaper direct systems</p>