insights & images

The Quarterly of Digital X-ray and PACS

Winter/Spring 2005

Learning how to get the most out of digital x-ray and PACS

Zoom & Pan: PDAs bring important data right to your shirt pocket

Expert Interview: Richard Guarino on how techs make PACS better, and vice versa

Technology Consult: What you need to know about archiving of digital images

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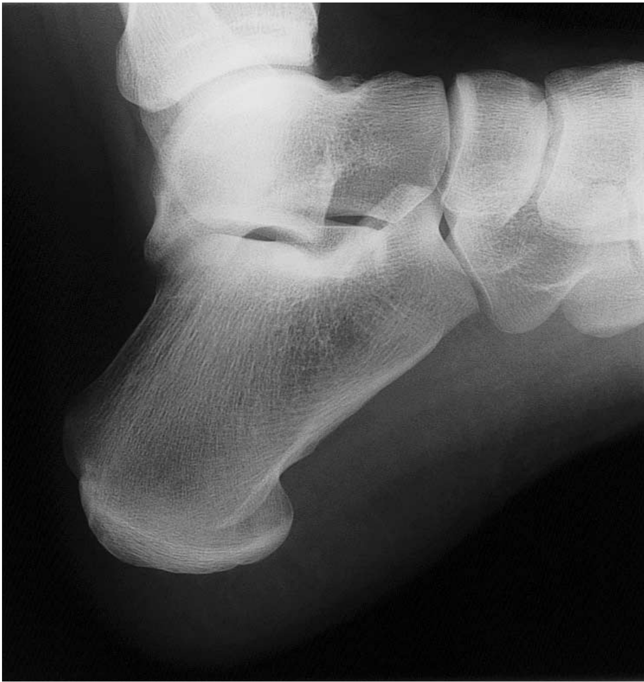
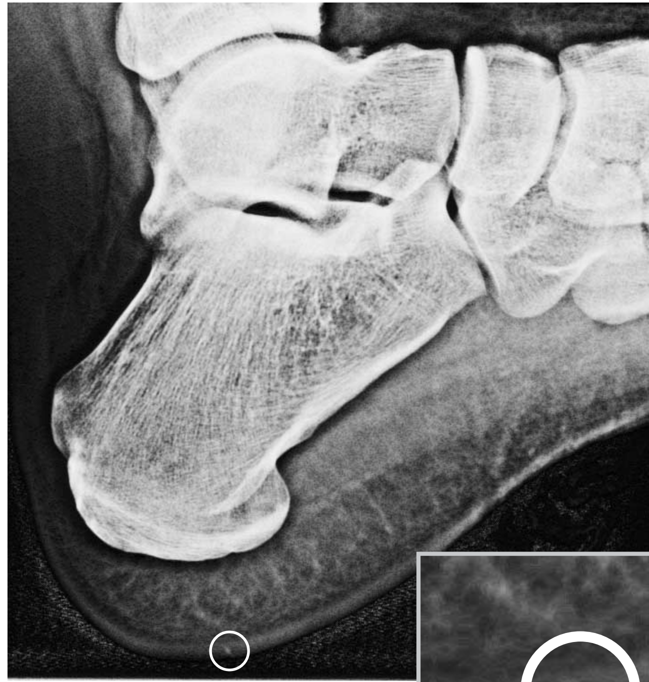
image showcase



Initial X-ray of heel shows no foreign bodies.



After utilizing Fuji's advanced image processing and edge enhancement, the small sliver of glass in the heel appears on the x-ray.

quote unquote

"We're in a maturing PACS paradigm—a transition from cost justification to total cost of ownership. This better reflects not only the cost of PACS to the radiology department, but the value of PACS to the (healthcare) enterprise."

–Dr. Matthew Morgan, radiology informatics fellow at the University of Pittsburgh Medical Center, in a scientific presentation at the 2004 meeting of the Radiological Society of North America.

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zoom & pan

PDAs bring important data right to your shirt pocket

Most people in radiology are perfectly content doing their jobs with the "personal digital assistants" otherwise known as fingers. Not radiology's digirati. For these enthusiasts, PDAs of the electronic variety untether them from desks and paper, and provide convenient access to information that makes their work easier.

They are committed to what might be called shirt pocket radiology.

The spread of wireless LANs is stimulating healthcare facilities to implement PDA technology. What people actually do with it depends on their technophilic tendencies, and the speed with which vendors jump into the market with helpful applications.

Don't expect to be able to interpret images on the small screen anytime soon; the units have neither the memory nor image resolution to permit it. In the meanwhile, there are many practical applications for PDAs in radiology beyond using them as MP3 players or for hot synching with files from a desktop PC.

Medical students and residents were early adopters of handhelds because they can store reference materials that can be easily accessed and searched. PDAs have largely replaced the stacks of index cards and reference texts that used to bulge from the pockets of student physicians.

In radiology, users are logging procedures and interesting cases on their PDAs. They are also accessing web-based radiology reference sites in wireless hot spots. At UCLA Medical Center, PDAs are used to summon images to wall-mounted monitors. And at Thomas Jefferson Hospital in Philadelphia, a program in the PACS sends out PDA-viewable reports on image interpretation workload that aid in staff planning. Scores of radiologists are using PDAs to access patient information from an EMR or RIS.

Technologists are also primed for PDAs. A new product from Fuji, called Pocket ID, allows them to access patient worklists and identify exposed imaging plates in cassettes from patient rooms and other remote locations. Pocket ID eliminates the need for paper notes or other means of identifying the patient and type of exam.

The ultimate portable computing device is yet to be realized in radiology, but the wireless PDA gets us closer. The direct retrieval of patient information from electronic systems, on the fly, is itself a potentially huge advance in reducing medical error. Capitalizing on the wealth of IT resources available in most healthcare enterprises, PDAs will soon be distributing useful data right to the shirt pockets of those who need it. ■

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expert interview

Richard Guarino on how techs make PACS better, and vice versa

Richard Guarino is the Director of Radiology Services at Newton-Wellesley Hospital in Newton, MA. He will speak this spring on "The Impact of PACS from a technologist's perspective," at the 9th Annual Digital X-Ray and PACS forum in Scottsdale, AZ.

I&I: Has PACS fundamentally changed how technologists do their jobs?

Guarino: One of the things you have to remember is that the primary function of the tech doesn't change with PACS. This function is to provide the best possible care to the patient while obtaining the best possible images for the radiologist. People don't come to radiology for x-rays; they come for diagnosis. They want the radiologist's report. PACS changes a technologist's workflow dramatically, but the crux of their job doesn't change much.

I&I: Where it's been implemented, how many techs in a department are involved with PACS?

Guarino: In a fully implemented system, all of them. Right now we're about 80% implemented here at Newton-Wellesley. We have yet to bring MRI on line. We have digital mammography, which we will eventually put into PACS as well. PACS changes the workflow for every single technologist on a fundamental level. Rather than printing films and QCing them, they're pushing the images into a PACS systems and doing the QC there.

I&I: Does this make the tech's job harder?

Guarino: I always warn techs that when you roll PACS out, it's going to seem like more work—because it is. You basically have one foot in the boat and one foot on the dock, and the tide is going out. You need to work quickly going from a film environment to a PACS environment. What you've done is added the function of pushing images into the system and QCing them to make sure they're accurate, but you haven't taken film away yet. Usually the techs are still printing film. So now in addition to bringing a patient in and x-raying them and printing the film to a printer and checking the film before sending it to the radiologist, they also have to push it to PACS and then check digital images to make sure they're displayed correctly. A lot of people will keep film for several months after they've gone digital to make sure they have a backup and that everything is working correctly.

I&I: Is PACS technology better for having input from techs who use it constantly?

Guarino: We would hope that's the case. It's going to depend on your practice. Modality vendors have been around for a long time, and they're used to teaching people how to do things a certain way. That doesn't necessarily work in the PACS world in terms of how you send images, how you segment studies, and those kind of things. How you interact with PACS depends at least in part on how your physicians work and how your practice is organized.

When we first met with Fuji and decided we were going to sign with them, we told them that we wanted to help to make their system better. We wanted them to take our feedback and turn it into a product. Some of what we ask for is not possible or feasible, but we expect there are going to be times when we give them feedback and input and then we're going to see that improvement in the next upgrade. This is input that comes directly from the staff, because they're the ones using it.

I&I: How much can PACS improve technologist productivity?

Guarino: PACS has allowed us to make a lot of changes in workflow, and to also change staffing. One of the things PACS allows you to do is relieve technologists of some of the mundane functions so they can spend more time doing the things they're licensed to do. In theory, this is a much more productive model. The tech aids who do non-technical stuff are paid a lot less, which gives you more production per dollar spent.

What we're in the process of doing right now is tracking our turnaround times. Our mean turnaround time in the emergency department was about 15 hours before PACS. Now we've got that down to three without additional staff. Our productivity has gone up simply because report turnaround time has gone down. The other issue we're trying to assess is length of stay. We tracked length of stay in the emergency department over several months before the PACS installation, and now we're going to track ED length of stay at the other end to see if it's had a dramatic effect. I would think it has, just looking at report turnaround time.

I&I: Can this sort of data make radiology look good?

Guarino: When we were first looking at PACS I had a lot of support from the executive management team, but I can think of a couple of things that would have made the process easier for us. There are a lot of soft advantages to PACS, but not a lot of hard money savings that can be documented. You want to be able to sell PACS on the basis of increased productivity and increased efficiency. If I had had numbers on how length of stay could be reduced in the ER, it would have been a lot easier to sell PACS here than it was.

I&I: What does it take for technologists to be good with PACS?

Guarino: Attention to detail is very important. One of the biggest problems with PACS is that these systems are very unforgiving. They only take the information you give them. So we try to make it as easy as possible for the techs to manage the system efficiently by having worklist management. Your list of patients is already listed by modality, and when you select a patient, all the demographic information automatically flows to the modality workstation, and then that automatically flows to the PACS. This decreases human error.

Techs can still make errors, however. You have to follow the workflow pretty exactly for everything to work properly. It only takes a second to select the wrong patient from the worklist and image the wrong patient, and it can take an hour to resolve it, depending on how complicated the study is. ■

Power of PACS benefits pediatric oncology research

Children's Hospital Los Angeles is home to a new national image repository for pediatric oncology studies designed to improve the management of young cancer patients. Using Fuji's Synapse PACS, 21 pediatric institutions in the U.S. and Canada will soon be able to share pediatric oncology exams with a centralized system.

The repository at LA Children's is separate from the hospital's main clinical network to assure quick transmission of data. The system is live at this facility, with others to follow later this year. A single laptop and PC will be available at each facility for image transmission.

Because phase-one testing of anti-cancer agents forms the foundation for advances in pediatric oncology, it is helpful to distribute results from these tests quickly to those who can use it, noted Dr. Marvin D. Nelson Jr., radiology chairman at LA Children's.

"If we can access and review studies faster and more efficiently, we can speed the availability of promising new treatments to these patients," Nelson said.

The images repository is funded by a grant from the Children's Oncology Group, a worldwide network of pediatric facilities and physicians dedicated to the cure and prevention of childhood and adolescent cancer. Without PACS, group members must print, read and store studies on film. This is a timely, cumbersome and expensive process, according to Nelson, since most of the oncology cases include complex CT and MR exams with multiple series and hundreds of images.

"To review other studies, radiologists had to board a plane and fly to another institution," Nelson said. "With the Synapse repository, the studies will be available in seconds, enabling tremendous efficiency and a much faster turnaround for determining the effects of new agents." ■

On-site training

Learning how to get the most out of digital x-ray and PACS

There are no shortcuts to the successful implementation of digital imaging. Careful planning and patience are needed to bring a film-based radiology service into the world of digital x-ray and PACS. The quality of the relationship between vendor and customer is also of utmost importance. Users who are well trained and who receive good technical support typically find the transition to a digital environment to be both professionally satisfying and a boon to department efficiency.

FUJIFILM Medical Systems, USA offers professional services that train and support its customers. A seasoned team of Imaging Specialists and Digital Solutions Advisors helps users optimize their utilization of Fuji digital x-ray and Synapse PACS. On-site training for physicians, technologists and support personnel is at the core of this service.

Digital x-ray requires a rethinking of the radiographic work process. When done well, digital x-ray improves diagnostic accuracy, presents images with consistent image quality, can reduce patient exposure to radiation by decreasing the need for retakes, and saves storage space. Unlike film, the images can be easily accessed from multiple sites on interactive PACS workstations. Digital x-ray data can be manipulated to improve radiographic quality and many technical errors can be overcome. Images can be corrected to normal density and features of interest accentuated or suppressed without having to repeat the exposure.

It takes good training, however, to capitalize on the flexibility of digital x-ray because understanding the physical principles of digital x-ray can be challenging. While the physics of screen-film radiography have never been simple, they are at least familiar. Digital x-ray takes things to a higher level, noted Melanie Bishop, a Fuji Imaging Specialist.

"A lot of technologists have used screen-film systems their entire professional lives, so switching over to CR in a few days of training can be intimidating." Bishop said. "The challenge for many is to understand exactly what's happening with the images and how they can continue to attain a good image with a low dose."

Part of how Bishop does this is to teach analogous methods for attaining image data that previously was expressed by an H&D curve with film-screen systems. This graphical way of representing how a given film records tone values when developed under specific circumstances is replaced in Fuji CR by the *s* value.

"I explain to the technologists that the *s* value is based on the dose they provide to the imaging plate, and that dose is inversely proportional," Bishop said. It's at this point that I explain that an *s* value that's too low is one where they've used too much dose, and that one that's too high is when they're not using enough. By explaining things this way, they begin to understand what they need to know to optimize an image."

Bishop is one of Fuji's team of Imaging Specialists, each of whom spends several days training staff at sites where Fuji digital x-ray and/or Synapse have been installed. All are board-certified technologists, and many have been educators or directors of radiology in community hospitals and university departments. Between them, the Fuji Imaging Specialists have accumulated more than 700 years of training experience in digital imaging.

The application to which an Imaging Specialist is assigned depends on his or her skill set, noted Anne Semanik, Fuji's Director of Professional Services. Some specialists are more oriented to PACS, while others have first-hand experience with digital x-ray. Once they have mastered one product line they gain knowledge in the other.

What distinguishes Fuji Imaging Specialists is their ability to listen to and assess the ability of people within a radiology organization, and to provide the proper level of training in response. In addition to on-site training, Fuji will soon provide customers with the option of taking Web courses. Additionally, Fuji offers an advanced "CR champions" course—a five-day intensive training program that provides 23.5 hours of continuing education credit. This course is designed for radiology technologists who have at least three months' experience with digital x-ray and who seek advanced skills so they can train others and more fully exploit the capabilities of the technology.

"It's our goal to not only teach people how to use digital x-ray and PACS but to do so as painlessly as possible, said Imaging Specialist Bill McCoy. "I do this by showing compassion for what they're doing and listening to what they say, as opposed to just walking in and giving a canned speech on what to do," McCoy said. "We have to be technically competent, but teaching skills are also important. We talk to people at their level, so they learn what they need to know to do their jobs well. We need to make sure that the customer is fully satisfied with the product after it's been delivered. And the only way they're going to be satisfied and use it to its fullest utility, is if they know how to use it properly."

Developing a plan

This commitment to effective training proved invaluable at Rose Medical Center in Denver. Referring physicians there were initially concerned about the quality of printed digital x-ray films, which created a major hurdle for staff engaged in the digital conversion. Despite the fact that the films were only an interim step until PACS workstations were installed, PACS Administrator Andrea Patterson knew she could ill afford to alienate her in-house customers during this transition.

Patterson, together with her Fuji Imaging Specialist, Melanie Bishop, developed an installation plan to address the concerns of the critics and ultimately to win their endorsement of digital x-ray.

The objective, Patterson said, was to make the films look more like what the physicians were used to while attempting to conserve the additional gray-scale content that CR images provide. "Melanie made a couple of trips between start-ups for our CR and our PACS to work with our radiologists, referring physicians and techs on these image quality issues," Patterson noted. "I'm a stickler on planning, which is why I'm so impressed with how well this implementation has gone. Melanie has been great to work with."

Rose Medical Center, where about 150,000 imaging exams are conducted annually, made its migration to filmless operation between May and August 2004. The facility now has a SmartCR® and XG-5000 multi-plate high capacity system in the main radiology department, a second XG-5000 in the emergency department, and a SmartCR in the operating room. An additional XG-5000 will soon be installed in the radiology department, at which time the SmartCR will be moved to the intensive care unit.

All users have migrated to PACS with the exception of some orthopedic surgeons and neurosurgeons who still request film for the operating room. Images not read on PACS workstations are downloaded to CDs for review on standard PCs. Despite their early doubts, neurosurgeons at Rose who are beta testing a virtual private network (VPN) being set up at its Denver area hospitals are now sold on the advantages of digital imaging. "They're so excited about it," Patterson said.

Bishop focused much of her energy at Rose on physician training. The first part of the hospital to go filmless was the emergency department, which because of its high

Rose Medical Center

demand for imaging services received her special attention. "Melanie went to the ED and sat down at their review stations and caught doctors on the fly. She explained the system, provided hands-on training and answered their questions as they worked," Patterson said.

On another occasion Bishop sent out flyers inviting physicians to an after-hours open house, at which Bishop provided hands-on training on both diagnostic and review stations, and provided a forum for answering questions. About 15 doctors attended, leaving with a better understanding of PACS.

Digital x-ray training for the 60 or so technologists was more regimented. Each was responsible for attending a 90-minute on-site training session held over the course of four days from 7 am to 6 pm. Additional training was available for those who wanted or needed it, including a 7 am question-and-answer session conducted six weeks into the digital conversion.

As a technologist herself, Bishop understands how digital x-ray can empower its users. "What I've learned is that digital x-ray can make a good tech even better," she said. "The technology is automated, but CR makes them think a little more about other factors, like positioning, centering and collimation. I think of CR as increasing their brain power." Understanding digital x-ray technology can make technologists more valuable employees. ■

Why technologists never want to go back to film

Perhaps the most common sentiment expressed by users who have adopted digital x-ray is that "we'll never go back" to conventional x-ray exams. When asked to account for this loyalty to the technology, Imaging Specialist Rex Profit offered his thoughts:

"A lot of this has to do with the repeat factor. In the past, technologists had to repeat the study if they missed the exposure. They get frustrated, especially if they have to repeat it three or four times and still don't get it right. With digital x-ray, they have the ability to possibly salvage the image if they have their exposure factors in the ballpark, and they've properly positioned the patient. With Fuji, they have access to the original image data and can go back to do some post-processing manipulation and save the image. This dramatically drives down their repeat factor.

"The average analog repeat rate runs 6% to 8% or even higher. Most departments drop below 1%, even down to a half percent in repeats, once they go to digital x-ray and become proficient. This provides significant cost savings for almost all departments, both in film and man-hours. This has been documented. Not having to do repeats is also a big psychological boost for a lot of technologists." ■

It takes good training to capitalize on the flexibility of digital x-ray technology, which includes electronic ordering of exams.

Imaging Specialist Melanie Bishop works with the staff at Rose Medical Center to maximize utility with digital x-ray and PACS.

Image and information processor console enhances productivity of techs

When Froedtert Memorial Lutheran Hospital in Milwaukee decided to complete its conversion to digital x-ray, it sought to make the technology as simple to use as possible. It was supported in this commitment by staff from the Froedtert School of Radiologic Technology, which provided in-house training of technologists.

The end result: fast and relatively painless adoption of technology that has easily met expectations for technologist workflow and image quality.

At the time Froedtert decided to complete its digital x-ray conversion in 2002, it was already using cassette-based CR systems in the ER, the GI division and for portable exams. “The transition to include Flash IIP consoles opened up new and better protocols for data entry that immediately enhanced technologist productivity,” said Tom Hanson, Supervisor of Diagnostic Radiology at Froedtert.

About 55 technologists received training in all aspects of CR operation at Froedtert Memorial Lutheran Hospital in Milwaukee.

“The older style of data entry that we formerly used worked very well, but was not as flexible,” Hanson noted. “With a Flash IIP computer and monitor in each exam room, the technologist first shoots the view, IDs it right there, inserts the cassette into the 5000 reader, and goes back to the room, where the image is sent for review. This was a beautiful set-up that we ended up using throughout our general diagnostic areas.”

About 55 technologists received training in all aspects of digital x-ray at Froedtert. Fuji Imaging Specialist Jon Lilly first provided instruction in the basics of digital x-ray operation, followed by additional visits to teach advanced QC features and to tweak image quality according to departmental protocols, Hanson said.

“The training we received from Fuji was just outstanding. I was impressed by the time Jon gave us and his willingness to come back and help us,” the radiology supervisor said. “He was there for us when we needed him, either by phone or in person.”

One of the customized features of the Flash IIP console that Hanson especially likes is called Auto Exam Select or procedure code mapping.

“What we did, with Fuji’s help, was to go into the IIP software and tell it, anytime you see this procedure code, call up this exam and these views on the IIP,” he explained. “It has eliminated several button clicks or screen touches, improving our techs’ efficiency, eliminating errors and making the system even easier to use.”

Helping the technologists learn digital x-ray were instructors from the radiologic technology school, including one charged with employee development. In addition, Lilly worked with several technologists who became in-house trainers (super-users) and who, in turn, have helped their colleagues learn the system.

“When John came back the second time, he did multiple sessions with all the techs—four or five at a time—and took them through all the features at a more in-depth level,” Hanson said. “We wanted to enhance workflow issues for our technologists, and I feel that we have definitely accomplished that.”

In addition to technologist trainers, the radiology department at Froedtert was also fortunate to have IT staff that could assist with the transition to digital imaging. “There are advantages to having a single vendor provide a site with digital x-ray, a RIS and a PACS, but this is not how things usually happen in the real world,” Hanson said.

“Trying to get disparate computer and IS systems to talk to each other—which was our situation—can be a challenge,” he said. “Fuji was willing to tackle this and had a great deal of experience to offer. They worked well with our own people, who could tell where the messages were being passed to and from, and in what format. They all worked well together and made the interfaces work.” ■

What you need to know about archiving of digital images

By Samuel J. Dwyer III, Ph.D., a professor of radiology at the University of Virginia in Charlottesville.

Samuel J. Dwyer III, Ph.D.

Traditional methods of archiving radiographic images are becoming unsustainable as the speed of health-care delivery accelerates, and the alternative of electronic storage becomes increasingly attractive. X-ray exams have routinely been stored in paper folders and archived in film libraries. Radiology departments were built around these libraries due to the need to frequently access these images. Once upon a time, space for film archiving was not a serious issue as radiology departments were remotely located, often in the basements of hospitals.

Film libraries were—and often still are—divided into three layers. The first was for a 30-day period. This short-term file was for the most recent films and usually numbered about 2000 cases. When 30 days were up, film jackets were moved to the next layer—the two-year file. This file numbered about 250,000 cases, which were often stored outside of radiology. The third layer of the film library was for older images of up to seven years. This file was large, often containing more than 400,000 cases. If a film was retrieved from either the two-year or long-term layer, it was recycled to the 30-day layer.

It's clear from this description that the retrieval of archived film has its complications, the most serious being lost or misfiled films. The cost of a film-based archive is relatively modest, but retrieval times can be unacceptably long. A better solution is needed.

PACS enters the scene

The archiving of diagnostic images has changed dramatically with the emergence of PACS. Chief among its advantages over traditional hard-copy archiving are image availability, reliability, high-speed acquisition, and, where space is at a premium, lower cost.

Because of their high volume, computed radiography (CR) and direct digital radiography (DR) have forced the more rapid adoption of digital image storage. In CR, images are acquired on a laser-stimulable phosphor imaging plate used as an x-ray detector. This plate is exposed to an x-ray beam that forms a latent image. A laser scanned across the latent image emits light photons that are then detected by a photomultiplier to form a digital image. DR, on the other hand, uses a solid-state detector in place of the phosphor imaging plate to detect the stored latent image.

Among the parameters used to gauge quality in digital imaging systems are spatial resolution, density resolution, and signal-to-noise ratio. Spatial resolution is defined as the amount of detail found in one pixel of the image, while dynamic resolution is defined by the number of pixels in each digital matrix. A common size for a digital matrix is 2048 bits, with each sample having a pixel depth of eight bits. Hence, the digital matrix of a CR or DR image of the chest is 2048 x 2048 x 8 bits, which provides an image that is accepted as an adequate alternative to a film chest radiograph.

Digital images require high-volume digital storage media. This is generally approached with a two-layer system of short- and long-term storage. The short-term archive is associated with high-speed retrieval, while long-term archiving was initially much slower on account of the use of linear magnetic tape technology. Archiving media has since moved to magnetic disks with faster data access. While disk archives are more expensive than linear tape, they have proved to be more reliable.

Information for images to be archived is obtained from the radiology information system (RIS) or PACS. Patient identity and the planned workup appear on a worklist. Most new PACS archiving systems are enterprise-oriented, meaning that storage media capacity exceeds the demands of radiology. Disaster recovery methods and additional archiving media are major costs, often totaling as much as $750,000 a year.

Pre-fetching is the ability to retrieve previously acquired images from an archive. This function allows users at a workstation to display prior exams for comparison purposes. Pre-fetching rules are difficult to develop and require careful planning to achieve the important purpose of allowing the clinical comparison of previous and current studies.

The bad news about most hospital-based image archives is that clients must share the LAN and its bandwidth with servers. Also, scalability is limited due to the bandwidth of the LAN. In addition, there are multiple potential points of failure.

Mitigating these risks is a new storage protocol called the storage area network (SAN). This high-speed switching network can be a fiber channel, or a combination of switches, hubs, and bridges, all of which form a fiber channel. Storage devices are scalable. The network can be connected to the archive library in case it becomes necessary to transfer the large digital data files to another library.

The fiber channel is an industry-standard high-speed interface for connecting PCs and storage devices. A fiber channel carries five times more bandwidth than the more commonly used SCSI (small computer system interface). Fiber channels can be constructed of hubs and switches, thereby reducing cost and enabling no single points of failure. The future of SANs is promising.

Another important consideration for digital image archiving is disaster recovery methods. One approach that's often used is to mirror data on back-up storage media that is stored off-site. Another approach is to use an application storage provider (ASP), which provides off-site mirror archiving for a fee.

Archiving systems are expensive, and the technology can be difficult to implement. Users should be involved in designing an archive to assure they get what they need. They should be engaged in the choice of technology, structure, and staffing. Costs to radiology can be moderated by sharing the archive with cardiology or other clinical services. Archiving media itself is expensive, and thus an archiving system should not be fully populated until that capacity is needed. By paying careful attention to changes in technology, one can extend the life of the archive and guard against rapid obsolescence. ■

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Have you used a vendor's applications training to train your staff? ❒ Yes ❒ No

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If positive, why?
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- ❒ Use of in-house trainer
- ❒ Quality of dependent staff
- ❒ Other (please describe)

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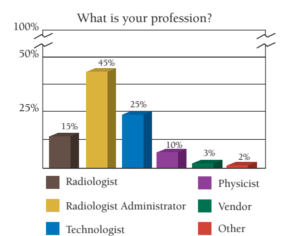
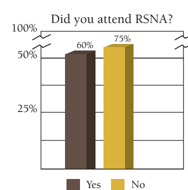
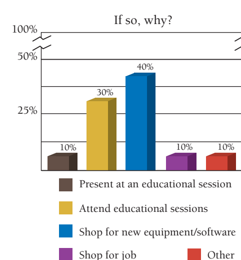
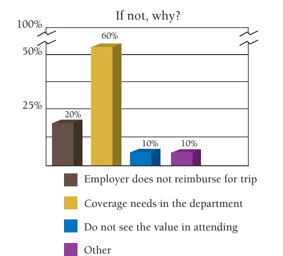
survey results

Go on-line to get the final results. A number of people responded to this survey from the Fall/RSNA issue of *Insights & Images.* Note: percentages are rounded to the nearest whole number.









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