Computed Radiography Digital Imaging Solutions for Radiation Therapy

an interview with
Peter Geyer[1] *and* **Greg Gibbs**[2]

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Peter Geyer is a Medical Physicist at the Universitätsklinikum Carl Gustav Carus an der TU in Dresden, Germany. He has more than 20 years experience in radiotherapy. Dr Geyer's special interests are in the field of electron beam portal verification, treatment planning and advanced methods of quality assurance.

Greg Gibbs is a Medical Physicist and has been wortking in the field of radiation therapy and diagnostic radiology since 1979. Dr Gibbs runs a small private consulting firm, Colorado Assosiates in medical physics, based in Colorado Springs, US.

The radiation therapy department in the 21st century is a gradually being revamped and becoming a highly digitised experience. Many major radiation therapy departments have transitioned away from film for all modalities and embraced the great benefit of digitally stored images.

Generally, three digitally oriented environments now exist: strictly computed radiography (CR), strictly or digital radiography (DR), or a combination of the two.

The converting to CR is often been described as a 'retrofit' approach. Many of the original elements of the film environment are maintained, and enhancements can be merged existing systems or structures. One of the many reasons quoted for choosing CR technology, as opposed to a DR technology, relate to cost. The bottom line is that CR is cheaper than DR. CR technology However, there are many other reason for converting.

The CR format is filmless, and image capture is accomplished by a digital recording plate that replaces the film in the standard cassette. This means that darkrooms and associated chemicals also become obsolete. A reader scans the plate and the image is processed and assembled on a monitor for viewing and distribution. In the meantime, the imaging plate is erased, and ready for re-use.

Dr Peter Geyer and Dr Greg Gibbs speak about their unique experiences with CR systems

Dr Peter Geyer's department runs three linear accelerators for about 1,800 new patients per year. The department offers all conventional irradiation techniques and special techniques, such as intensity-modulated radiation therapy (IMRT), whole-body irradiation, stereotactic irradiation, image-guided techniques and prostate seed implantation.

Dr Greg Gibbs runs a consulting group of 12 physicists. They practice in centres that have either two or three accelerators. His practice uses a Kodak 2000RT CR System

Q. What are the main reasons to go to CR technology, as opposed to a direct-capture technology?

Dr Peter Geyer: In most of the beams, we are using the electronic portal imaging devices (EPIDs) of our linacs for portal verification. But if this method failed, due to an insufficient image quality or due to the impossibility of its application, we applied films for portal verification. We were also using films for geometric and dosimetric quality assurance (QA). A breakdown of the film processor provided the opportunity to replace the film applications with the CR technology, which is expected to be less expensive than film.

Dr Greg Gibbs: We needed to move using CR because of film processors going away. We have been using CR for approximately three years for IMRT dosimetry and we have been happy with the experience. We have found that with the direct capture systems, there is limited spatial resolution; there are things that you would not see that you would want to see, on the direct capture systems because there are limited directions of the radiation field, either high spots or low spots that would could happen between the detectors. This is why we prefer CR.

Q. Are you happy with the quality of the CR simulation and portal images compared with film and DR devices?

PG: We found that the combination of EC film and EC-L cassettes is the 'gold standard' for portal verification of high-energy X-ray beams under optimal exposure conditions and the quality of the CR image under those same conditions is only slightly poorer. However, under routine conditions the quality of the CR portal images was found to be slightly better than the EC films and remarkably higher than the images of the EPID based on a charge-coupled device (CCD) camera. The advantage of the CR images on the EC film was mainly based on the better brightness and the possibility of the processing of the rough image. With respect to the geometric evaluation we found only negligible magnification or distortion effects in the CR images compared to film. Because

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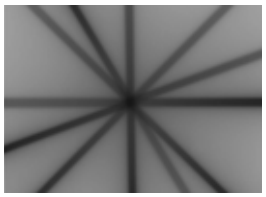

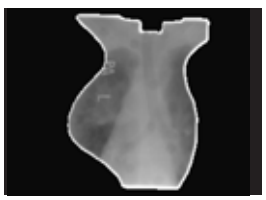

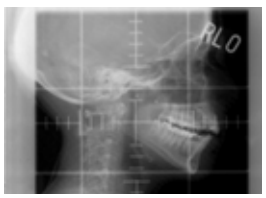

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we are using a simulator with integrated digital imaging, there was no need for the application of the CR simulation.

GG: CR imaging provides better quality than film, from the perspective that you can perform window width and level (the ability to adjust density and contrast of the image). This means that you can adjust the image if you have either an over- or under-exposed image, plus you can do adaptive histogram equalization or other types of image-processing techniques that can bring out details in the images.

Q. What other benefits have you seen as a result from using the CR?

PG: The wide dynamic range of CR imaging prevents nearly any exposure failure, thereby saving time and money. That is why the CR images can be obtained both by short or long time exposure by high-energy X-rays. The CR images show all advantages of digital images, including the possibilities of comparing to images to other sources and to electronic archives.

GG: With CR systems you can use them for other things, not just IMRT dosimetry. You can use them for portal imaging as well. And in portal imaging you can perform much bigger fields. You can do 35 x 43cm fields, so it is better from that perspective.

Q. Do you believe that CR has a place in all radiation oncology departments or is its usefulness limited to those initially converting from film to digital?

PG: The EPID will bear the brunt of portal verification. But I see some important niche applications for CR systems. For example, for anatomical regions with low tissue contrast the image quality of EPIDs may become insufficient. Furthermore, the application of special irradiation techniques will limit the application of EPIDs, for example, in the case of an irradiation technique with non-coplanar beam directions, where a collision between EPID and the treatment table or the patient may occur. The CR screen has the same advantage as the film in that it is independent on the linac gantry. So the screen can be attached to the treatment table and in a fixed position with respect to the patient. Based on this geometric condition, abutted beams can be imaged at one screen, shifting the treatment table between the exposures.

Q. Does the software meet the specific needs of your radiation oncology environment?

PG: In principle, the software for the Kodak 2000RT CR System met our specific needs. The latest version provides the advantage of connecting different clients to the CR scanner and workstation, thereby improving the workflow of evaluating the images by the physicians. But we would like to have a connection between our verify-and-record system and the CR system, thereby avoiding the twofold input of patient data and beam data.

GG: One of the problems with CR, because of the way the reader functions, is that the image may not be uniform, and the Kodak software performs filtering which essentially removes the non-uniformity out of the equation. So all we do is come up with a flattening profile and run a plate through with its own flattening profile and the image that comes out is flat. It basically compensates for the non-uniformity that is put into the image into the process. It corrects for the non-flat image field. Basically, if you just put the zero plate into the reader and tell the reader what plates you have in the reader, it will compensate for the non-uniform profile of the plate in the reader. It comes out with a digital image in units of CR numbers, and flat, so then you take that image and process it with a second set of software (a third-party QA analysis software) that converts those numbers into dose. This third-party software also calculates the connection of the points of equal doses into isodose curves, so it will do the comparison between the plan coming from the therapeutic computer and the image that is collected from the CR plate.

Q. Have you been able to utilize CR for any procedures other than traditional Simulation and Portal imaging? Please could you describe them.

PG: We demonstrated that the CR system was able to obtain high-quality images of electron portals using the low photon contamination. These electron portals were also imaged together with abutted photon portals at one screen, both portals exposed by the same magnitude of dose in the screen plane. For QA applications we aligned the room lasers to the irradiated CR screen by exposing the unwrapped screen after its irradiation for a few seconds to the room lasers. A common QA tool in the stereotactic radiotherapy is the Winston-Lutz test, where a lead sphere is irradiated with a small collimator (about 5mm in diameter) for different angles of the gantry and the treatment table. We use the CR screen for this check applying a special exposure technique to make the sphere visible in the small beam.

Q. Would you recommend a CR for use in a radiation oncology department?

PG: I would recommend the use of a CR system for a radiation oncology department. The need for such a system has to be considered in comparison to the image quality of the EPID. I see a stronger need to use a CR system for highly specialised departments. Another point for a decision may be QA applications, like using the dosimetric properties of the CR screen for 2-D IMRT verification.

GG: I think that CR has a place in all radiation oncology departments. We use it a lot for IMRT dosimetry, for QA in terms of radiation field/light field congruence, and multileaf performance. We have a whole battery of tests that we perform on a multileaf collimator using CR as well. We think that it is an important part of the QA program even without IMRT. Also, film is so odorous in terms of film processors and it is much cheaper to have a CR system where you can reuse the plates. You don't have wet chemistry. It's a lot better. ■