

# advance for Imaging and Oncology

ADMINISTRATORS™

THE SOURCE FOR MEDICAL IMAGING, RADIATION ONCOLOGY, AND CARDIOLOGY DECISION MAKERS



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# RAD ONC

**ROOTS TO  
REFINEMENTS**

Absolute  
210.0 cGy  
190.0 cGy  
170.0 cGy  
140.0 cGy  
120.0 cGy



# SEEING. BELIEVING.

## **Dynamic Targeting® IGRT**

### **A Leap in Cancer Treatment Accuracy**

Advanced imaging technologies from Varian Medical Systems are helping neurosurgeons and radiation oncologists target tumors more accurately than ever before. Varian's tools for Dynamic Targeting® IGRT are helping clinicians pinpoint tumors with unparalleled speed and accuracy.



## Tumors Move, Treatments Should Adapt

Advanced imaging technologies from Varian Medical Systems in Palo Alto, Calif., are helping neurosurgeons and radiation oncologists target tumors more accurately than ever before. Varian's Dynamic Targeting image-guided radiation therapy (IGRT) tools are helping clinicians locate and target tumors with unparalleled speed and accuracy.

After all, tumors do not stand still. Embedded within vital, living systems, they are subject to physiological processes that cause them to move between and during daily radiotherapy treatments. "Interfraction" motion—motion between treatment sessions—is due to unavoidable day-to-day variations in anatomy or in how patients are positioned for treatment or even

radiation beam delivery machines can be equipped with On-Board Imager® kV X-ray imaging systems and PortalVision™ megavoltage (MV) imaging systems. A linear accelerator equipped in this way can support several imaging modalities, including kV and MV planar radiographic imaging and kV volumetric cone-beam computed tomography (CT) imaging (for patient repositioning), as well as fluoroscopic imaging to check on respiratory gating strategies. Such a system configuration also incorporates features that allow for automated tumor marker detection, as well as monitoring and gating for tumor motion.

## The On-Board Imager Device and PortalVision

The On-Board Imager device gives clini-

use this image set as the basis for repositioning the patient. These images can be "gated" snapshots taken at a predetermined point in the respiratory cycle if motion is a factor.

- In "fluoroscopic" mode, the On-Board Imager generates a moving sequence of images that show how the anatomy is moving over time, usually due to the patient's respiration. By analyzing these images, doctors can determine the optimal window in a patient's breathing cycle for delivering the treatment. They can then use a tool like Varian's RPM™ (Real-Time Position Management) respiratory gating system to turn the treatment beam on and off, delivering the radiation only during the specified part of the patient's breathing cycle. This is very important for the precise treatment of tumors in the abdo-

## VARIAN MEDICAL SYSTEMS HAS DEVELOPED A SET OF TOOLS THAT WORK TOGETHER TO ACHIEVE BETTER TARGET LOCALIZATION DURING THE CLINICAL RADIATION THERAPY PROCESS.

to shrinkage that occurs as a tumor responds to treatment. "Intrafraction" motion is due to respiration and other physiological processes that occur while the patient is being treated.

Before the advent of IGRT, doctors had to treat a larger margin of healthy tissues around each targeted tumor to account for uncertainties due to tumor motion and location.

## Dynamic Targeting IGRT

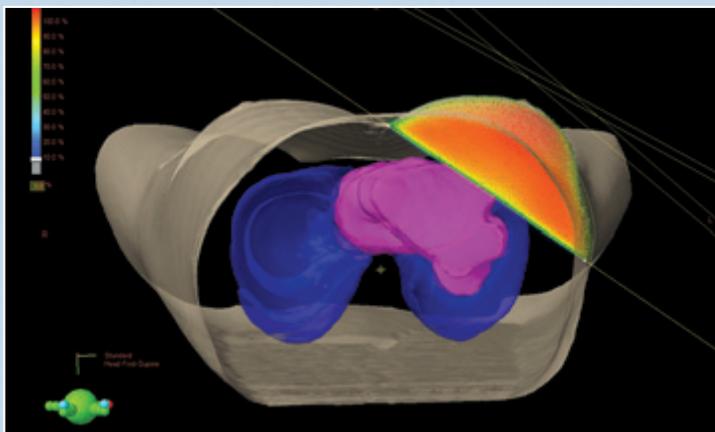
To contend with the challenges of tumor motion, Varian Medical Systems has developed a set of tools that work together to achieve better target localization during the clinical radiation therapy process. Varian's approach starts with a Clinac® or Trilogy™ medical linear accelerator. These

clinicians three powerful ways of imaging a patient's anatomy prior to treatment:

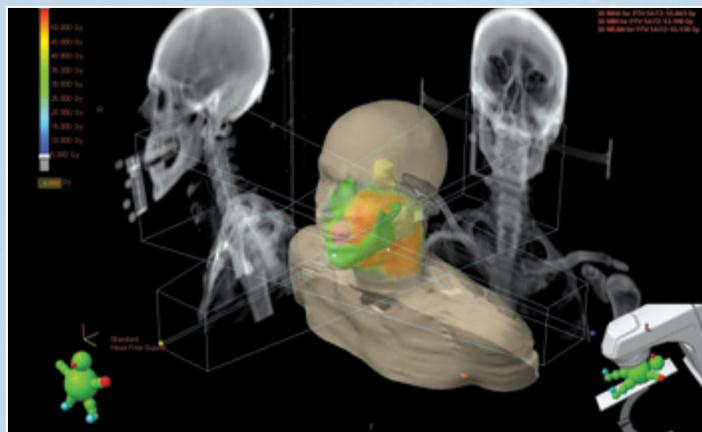
- In "radiographic" mode, the imager generates an orthogonal set of two-dimensional X-ray images which show detailed bony anatomy and any implanted fiducial markers, such as gold seeds, that have been placed into the tumor area to facilitate visualization. The On-Board Imager device can take the data from the two images and calculate how much the patient should be shifted in three-dimensional space in order to bring the tumor directly into the path of the treatment beam. In some clinics, clinicians generate a kV image using the On-Board Imager and an immediate orthogonal MV image using the PortalVision electronic portal imager, and

men and thorax, particularly the lung.

- Finally, in "volumetric cone-beam CT" mode, the On-Board Imager can generate images that show the patient's anatomy in three dimensions. These images are best for pinpointing soft-tissue structures (organs such as the prostate, or the tumors directly), and checking for changes in tumor size or position. "The cone-beam CT imaging capability gives doctors an important third modality for pinpointing the exact location of the tumor," says Timothy E. Guertin, president and chief executive officer at Varian Medical Systems. "It is especially useful when the tumor is far from any bony landmarks, and hard to distinguish from surrounding soft tissues. Having access to volumetric cone-beam



An image shows dose distribution for a conformal breast cancer treatment.



This 3-D model view of a head-and-neck cancer case, generated with Varian's Eclipse™, shows set-up fields for positioning the patient.

CT data has the potential to significantly improve tumor targeting in these difficult cases.”

### RPM™ Respiratory Gating: Managing Intrafraction Motion

Thoracic tumors have been shown to move as much as 4 centimeters (more than 1.5 inches) as the patient breathes. To manage intrafraction motion as a result of breathing, Varian offers its RPM respiratory gating system, which synchronizes imaging and dose delivery with a patient’s breathing cycle.

The RPM respiratory gating system uses an optical camera to track a special marker placed on the patient’s chest or abdomen. Breathing can be monitored while taking CT scans for treatment planning and simulation, as well as during treatment sessions, allowing doctors to pick the best moment in a patient’s breathing cycle to turn on the beam, defined by transition points called “thresholds.” Clinicians can confirm the consistency of the motion of internal anatomy, and verify the accuracy of their gating thresholds using the On-Board Imager in fluoroscopic imaging mode. As a result, the margin of treatment around the tumor can often be significantly reduced, and the total dose to the tumor can be increased without harming the surrounding healthy tissue.

With access to clinically viable tools for dealing with tumor position uncertainties, radiation oncologists are becoming interested in using extremely accurate stereotactic approaches to deliver higher doses more precisely over a smaller number of treatment sessions.

### Stereotactic Strategies in Radiation Oncology

Because Dynamic Targeting IGRT improves accuracy and precision, it also raises the



possibility of reducing the 30 to 40 daily treatment sessions or “fractions” normally needed for delivering a total dose of radiation. With improved imaging and delivery technology, some small lesions could be treated in a single session with stereotactic radiosurgery. Others could be treated in as few as three to five sessions with stereotactic radiotherapy.

In the past, stereotactic approaches were not widely used for treating many extracranial tumors due to tumor motion issues and setup uncertainties. With the added precision afforded by Dynamic Targeting IGRT methods, stereotactic approaches for more disease sites are becoming feasible. Consequently, Varian has introduced the Trilogy linear accelerator, optimized for radiosurgical procedures (stereotactic radiotherapy and stereotactic radiosurgery) as well as standard radiotherapies, including 3-D conformal, IGRT and IMRT.

### An Explosion of Data and Images

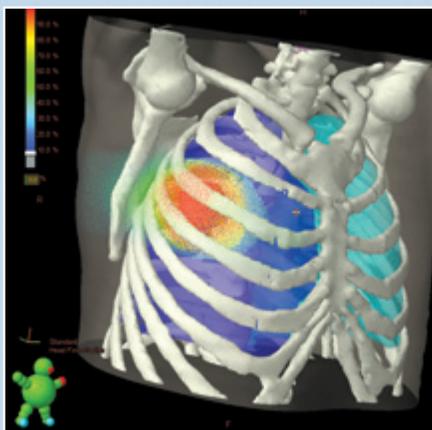
All of these developments have led to an explosion of digital data and images that must be managed and made useful at every step of

the treatment process. To meet this challenge, Varian has designed its suite of products—for imaging, planning, simulating, verifying and delivering treatments to be able to work together in a highly integrated network of radiation oncology tools. Varian calls this its Inspiration™ integrated oncology environment. At the heart of Inspiration is the ARIA™ oncology information system, a comprehensive software program that links clinical operations with patient information, making administrative, clinical and financial information readily available to clinicians when and where it is needed. Built using industry standard communication protocols and an open architecture design, ARIA is a complete electronic medical record that provides virtually unlimited enterprise-wide connectivity.

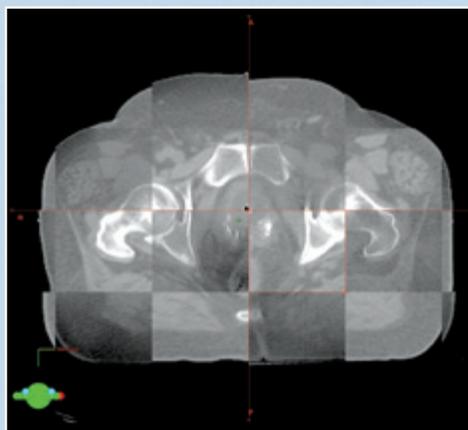
All the products within the Varian Inspiration environment—including tools for simulation, treatment planning, plan verification, image review and patient setup verification, treatment delivery and quality assurance—are engineered to work together intuitively, facilitating clinical workflow patterns so that patients can be treated with the most appropriate and advanced therapy within the normal 15-minute appointment. With IGRT, the state-of-the-art in radiation therapy is moving quickly in the direction of ever-increasing accuracy and precision. That’s good news for cancer patients undergoing treatment today.

### References

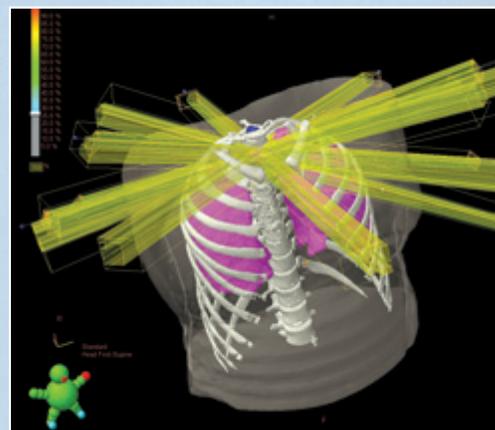
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 Huntzinger, C., Munro, P., & Johnson, S., et al. (2006). Dynamic targeting image-guided radiotherapy. *Medical Dosimetry*, 31, 113-25.



A treatment plan for lung cancer shows the tumor enveloped in a dose “cloud.”



Planning and cone-beam CT images are superimposed to position a prostate cancer patient.



A radiosurgical treatment plan for spinal lesions is featured.

# Cancer Treatment Centers Around the

At the end of July 2006, Varian Medical Systems announced that more than 250 of the company's On-Board Imager™ devices for image-guided radiotherapy had been shipped to health care sites around the world. Here are some of the clinical challenges that have been addressed by clinicians using these imaging modalities along with RPM™ respiratory gating for motion management.



At Community Care Physicians in Latham, N.Y., Arun Puranik, MD, says Varian's On-Board Imager is a fast, accurate method for localizing prostate tumors.

## ■ CLINICAL CHALLENGE

*Prostate Cancer—Dealing with setup uncertainties and inter-fraction tumor motion*

## ■ DYNAMIC TARGETING IGRT SOLUTION

*Cone-beam CT or radiographic kV-kV or kV-MV imaging with marker matching*

Arun Puranik, MD, director, Image Guided Radiation Therapy at Community Care Physicians in Latham, N.Y., treats a lot of prostate cancer patients, and his goal is always to deliver the maximum radiation dose to the tumor while sparing normal tissues.

Consequently, Dr. Puranik uses cone-beam computed tomography (CBCT) imaging to visualize the soft tissue of the prostate and make corrections to his patients' positions prior to every treatment session. The CBCT mode generates a 3-D dataset that can be directly matched against the images that were used to create the treatment plan. In Dr. Puranik's case, treatment plans are based on a fused set of CT, magnetic resonance imaging (MRI) and sometimes additional positron emission computed tomography (PET) images.

"Currently I am using CT plus MR for treatment planning to localize the prostate apex and penile bulb for potency preservation," Dr. Puranik says. "Then, just prior to each treatment, the kilovoltage cone-beam CT modality provides us with excellent images for exactly reproducing the patient's setup. I would not be comfortable delivering this type of treatment without CBCT guidance."

Varian's software interface guides the user through the matching process, and computes a 3-D couch shift that compensates for any difference between the two image sets. The couch shift can be applied by the therapist from outside the treatment room.

"There is always a correction because there is always some displacement of the prostate from day to day—anywhere from as little as 2 to 3

millimeters up to 1.5 centimeters," he says. "That's a lot of motion from day to day, and before now, we had no way to deal with it," Dr. Puranik says. "In my experience, Varian has a highly reliable radiation therapy system, and with the On-Board Imager—we call it the OBI—we can accurately match the radiation beam with the position of the tumor at the moment of treatment. Varian's OBI enables the fastest, most accurate technique I have seen for localizing the prostate every day, prior to treatment."

By contrast, Arno Mundt, MD, chairman of the radiation oncology department at the University of San Diego, uses kV-kV imaging with marker matching in the routine treatment of prostate cancer.

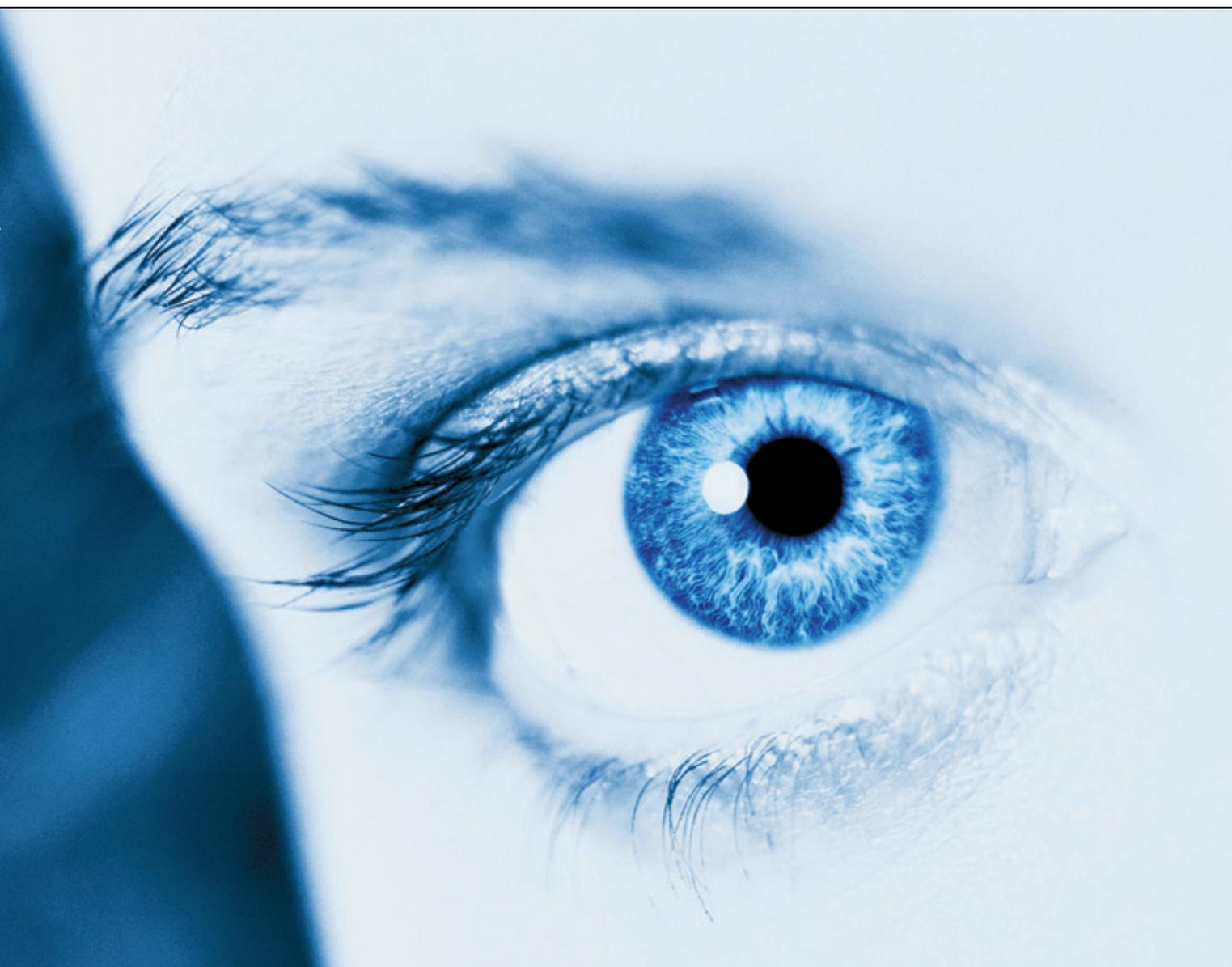
"I was an ultrasound user before this, and I've switched," Dr. Mundt says. "We do this for every single gynecological and every single prostate cancer patient. Once you use these techniques, you would never go back. I won't treat a patient now without the seeds in the prostate and kV-kV imaging. It gives us confidence that the patient is set up and aligned correctly. It's a perfect modality for making sure that your IMRT fields are set up right."

Clinicians at the Lindenhofspital in Bern, Switzerland, take a slightly different approach to localizing the prostate for daily treatment. They are using kV-MV imaging for localizing the prostate before treatment.

"The prostate patients have two to four gold markers implanted into their prostate as part of their preparation for the planning and treatment process," explains Hans Neuenschwander, PhD, medical physicist. "They are CT scanned, planned, simulated and treated with the markers in place. In several internal studies, we determined that registering on the bony anatomy is just not good enough for localizing the prostate."

Lindenhofspital clinicians take a kV-MV image pair every day over the whole course of treatment. They take a kV image laterally from

# World Adopt **Dynamic Targeting™** IGRT



RADIATION ONCOLOGY



the patient's right side, and then an MV image in the AP direction. They register images on the OBI workstation and then automatically apply the resulting couch shift.

"Compared to kV-kV imaging, our procedure saves some time; compared to cone-beam CT, it saves even more time," he says. "We don't need kV imaging from the AP direction because MV imaging is good enough. We like the lateral kV images, though, which show a clear advantage compared

to lateral MV images. Summarizing, we wouldn't gain in the accuracy of positioning with kV-kV imaging or CBCT, compared to our procedure."

According to Dr. Neuenschwander, the kV-MV imaging process goes very quickly. "It barely slows down treatments," he says. "The process of taking images, matching and applying couch corrections is quite smoothly integrated. We can still run our prostate patients in a 10-minute slot as we did before."

A Varian Dynamic Targeting system for IGRT at Hirslanden Klinik in Aarau, Switzerland, includes a Clinac accelerator outfitted with the On-Board Imager device and the PortalVision MV portal imaging system.

## ■ CLINICAL CHALLENGE

*Gall bladder cancer—dealing with respiratory motion*

## ■ DYNAMIC TARGETING IGRT SOLUTION

*Radiographic imaging/kV-kV marker matching and RPM respiratory gating*

Jerome Landry, MD, professor of radiation oncology at Emory University's School of Medicine,



Physicians at Emory University's School of Medicine use Varian's On-Board Imager to deliver doses directly to targets.

Atlanta, treats abdominal cancers using Varian's On-Board Imager device in radiographic mode to detect the position of radio-opaque clips implanted into the tumor bed during surgery. In the case of a 68-year old male patient with cancer of the gall bladder, he was particularly concerned about delivering a very precise treatment.

"The challenge to us was to irradiate the tumor bed after the tumor was removed surgically from the gall bladder to destroy any remaining cancer cells. But the gall bladder area is right next to the small intestine, which cannot tolerate much radiation. And to further complicate matters, the whole area moves as the patient breathes," Dr. Landry says.

Dr. Landry's team started with four-dimensional computed tomography (CT) scanning to reveal how the patient's anatomy was moving as he breathed. "We were able to see the point in the patient's breathing cycle where the tumor was furthest away from the small intestine," Dr. Landry says. "We planned the treatments accordingly."

According to Timothy Fox, PhD, chief medical

physicist at Emory University's School of Medicine, the team also used respiratory gating while imaging with the On-Board Imager device to position the patient for treatment. By using respiratory gating in this way, the team could generate images during the specified respiratory phase and then match them up to reference images from the same part of the breathing cycle.

"It's nearly impossible to deal with a tumor that is moving under the skin, using marks on the skin surface," Dr. Fox points out. "But the implanted clips are right at the target. With the On-Board Imager, we can see them, so we know exactly where to aim."

"We're showing that we can deliver a dose directly to a target—even a moving target—using modern image-guided radiation therapy (IGRT) technologies. We hope to take what we have learned and expand on it so that we can begin to offer patients stereotactic radiosurgery for tumors outside the head," says Lawrence Davis, MD, chairman of the Department of Radiation Oncology at Emory University's School of Medicine.

## ■ CLINICAL CHALLENGE

*Breast Cancer—An older patient cannot complete a full six-week course of radiotherapy*

## ■ DYNAMIC TARGETING IGRT SOLUTION

*Accelerated partial-breast irradiation with radiographic (either kV-kV or kV-MV) and fluoroscopic imaging plus RPM™ respiratory gating*

Michael Greenberg, MD, medical director at the Dale and Frances Hughes Cancer Center in East Stroudsburg, Pa., is using limited-field external beam radiation—IMRT—for some breast cancer patients with small primary tumors.

"Someone who has a long life expectancy should get a more conventional treatment because the long-term results are known," he says. "For elderly patients, our preference is to use IMRT once a day to a limited field, but if they can't travel that much, we hypofractionate the dose to complete the treatment in one week."

Dr. Greenberg has a surgical clip placed into the tumor bed at the time of excision. His team can then use the On-Board Imager in radiographic imaging mode along with marker matching software to position patients for treatment. Real-Time Position Management (RPM) respiratory gating is used to monitor the patient's respiration and trigger the treatment beam on and off to deliver the dose only when the targeted tumor is directly in the path of the narrow beam. With fluoroscopic imaging, the

clinical team can check how internal anatomy is moving over a normal breathing cycle in order to choose the optimal respiratory phase for treatment and to verify the gating strategy.

"The On-Board Imager enables us to pin down the exact location of the tumor at the moment of treatment so we can fine-tune the patient's position and deliver the dose more precisely," says Dr. Greenberg. "With respiratory gating, we can synchronize our treatments with the patient's natural breathing cycle. The two technologies enable us to deliver high doses quickly and accurately while protecting the surrounding healthy tissues."

At Duke University, Durham, N.C., Lawrence Marks, MD, professor of radiation oncology and director of the residency training program, also uses planar imaging—either kV-kV or kV-MV—in the treatment of breast cancer with partial breast irradiation. In cases when the tumor is in the inferior left breast, Dr. Marks seeks to further reduce the dose to the heart by using RPM respiratory gating in conjunction with a breath-hold technique.

"Planar imaging is appropriate whenever we can use fiducial markers that establish the tumor location or when the tumor's position relative to bony structures is largely fixed," he says.

Dr. Marks chooses between kV-kV and kV-MV imaging based on clearance or timing issues. "The kV-MV imaging process enables you to save time because you don't have to rotate the gantry," he says. "If you can see what

you need to see, it's easier. For very large patients, we can use it to avoid collisions. And sometimes, depending on the tumor site, MV images are better than kV images. But either usually works well and makes it possible for us to keep a tight margin and hit what we want to hit. For our partial breast treatments, we often use planar imaging on a daily basis."

Dr. Greenberg points out that his image-guided radiation therapy (IGRT) tools from Varian function seamlessly within a highly integrated and automated environment that is coordinated through sophisticated and interconnected treatment planning and information management software products. "For example," he says, "the On-Board Imager calculates how much a patient should be moved in order to align the targeted area with the treatment beam, based on the most recently generated images. All the therapist needs to do is push a button to automatically shift the patient into the correct position for treatment."

According to Dr. Greenberg, the automation built into the technology is what makes it possible for clinicians to administer these highly sophisticated, targeted forms of radiation on a routine basis. "Image-guided therapies are becoming a new standard of care here—one that is not yet available in many university settings. We are pleased to be offering the most advanced forms of treatment available anywhere in the world."

## ■ CLINICAL CHALLENGE

*Metastatic liver tumor*

## ■ DYNAMIC TARGETING IGRT SOLUTION

*Radiographic kV X-ray imaging and cone-beam CT to deliver stereotactic body radiosurgery (SBRS)*

Todd Scarbrough, MD, director of the Cancer Center at Melbourne Internal Medical Associates (MIMA), Melbourne, Fla., discovered a small metastatic lesion in the liver of a 64-year-old male patient who had been treated a year earlier for lung cancer.



Todd Scarbrough, MD, director of the Cancer Center at Melbourne Internal Medical Associates, and Joseph Ting, PhD, chief medical physicist at MIMA, use the system pictured here to deliver IGRT treatments.

“We had three choices,” Dr. Scarbrough says. “We could do nothing. We could treat him with chemotherapy. Or we could use our new image-guided technology to deliver a very high dose of radiation directly to the tumor in what’s known as a ‘radiosurgical’ treatment. This requires us to target the lesion very precisely and compensate for any tumor motion.”

In the past, radiosurgical procedures have been used primarily to treat tumors in the brain because the head can be effectively immobilized, which renders brain tumors motionless and facilitates accurate targeting. “Body radiosurgery is a new procedure, made possible by technologies like the On-Board Imager, which helps us ensure that our treatment beams accurately hit the tumor,” Dr. Scarbrough says.

To position the patient for treatment, Dr. Scarbrough and his clinical team utilized two of the imaging modalities available with the On-Board Imager: radiographic kV X-ray imaging and three-dimensional cone-beam computed tomography (CBCT) imaging.

“Prior to each treatment, we used the On-Board Imager to take orthogonal X-ray images of the liver and used them to calculate how to shift the patient to make sure the tumor was lined up precisely with the treatment beam,” Dr. Scarbrough says. “We were amazed at how well the liver showed up on the radiographic X-ray images. We could see enough detail to

make the necessary positioning corrections. We then generated a three-dimensional cone-beam CT image as a check to verify that our calculations were correct in all three dimensions.”

To address the problem of tumor motion due to respiration, MIMA clinicians used a CT scanner outfitted with Varian’s RPM™ respiratory gating technology to generate the images used in treatment planning. “This enabled us to choose the optimal point in the patient’s respiratory cycle for delivering each treatment,” says Joseph Ting, PhD, chief medical physicist at the MIMA Cancer Center.

The novel radiosurgical procedure involved three treatments delivered every other day over a five-day period.

“Our goal was to see if we could eradicate the liver lesion using a method that has essentially zero toxicity, sparing him the more toxic effects of chemotherapy,” Dr. Scarbrough says. At four weeks post-treatment, the patient was doing very well and had suffered no side effects. A CT scan in early March showed that the liver lesion had regressed dramatically.

Virtually all cancer patients treated with conformal radiation therapy at MIMA now receive image-guided treatments. “We use every tool at our disposal to set up the patient more accurately for treatment,” says Dr. Ting. “With IGRT, we are very confident we’re targeting the right place.”

## ■ CLINICAL CHALLENGE

*Meningioma (a benign, slow-growing brain tumor)*

## ■ DYNAMIC TARGETING IGRT SOLUTION

*Radiographic kV X-ray imaging for image-guided radiosurgery (IGRS)*

Diana Mitchell had already been treated surgically in 1996, when she was 31 years old, for a meningioma—a benign, slow-growing brain tumor. At the time, major brain surgery was the only available treatment, and it involved several days in intensive care and a 12-week absence from work. Furthermore, doctors warned her that there was an 80 percent chance that the meningioma would recur.

Sure enough, a recent magnetic resonance imaging (MRI) scan revealed the meningioma was slowly growing again. But this time, Mitchell was relieved to discover a new and dramatically different treatment option—stereotactic radiosurgery, which delivers highly concentrated doses of radiation to small tumors and early metastases using very tiny beams delivered from

many different angles.

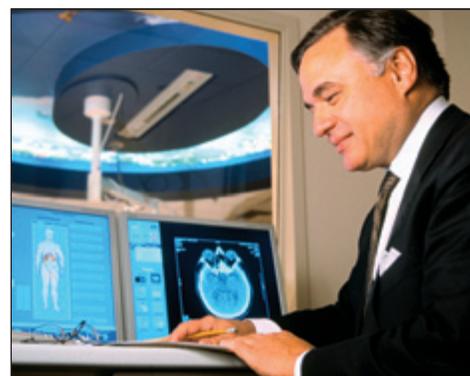
Frank Holladay, MD, a board-certified neurosurgeon on staff at the Providence Medical Center in Kansas City, Kansas, was one of a growing number embracing Varian’s Trilogy™ technology for stereotactic radiosurgery as a major step forward in imaging and treating difficult-to-reach tumors.

“Varian radiosurgery has applications beyond treating cancer,” Dr. Holladay explains. “It is enabling us to visualize and treat inside the central nervous system with unprecedented accuracy, and this includes recurring and nonmalignant tumors that can be just as incapacitating or life-threatening as cancer.”

Dr. Holladay and other physicians at Providence Medical Center have used the Trilogy to treat a broad range of disorders using IGRS, including brain metastases (in a lung cancer and a melanoma cancer patient), acoustic neuroma, arteriovenous malformation, glioblastoma and a metastatic lesion in the sternum, which appeared in a patient being treated for squamous cell cancer of the tonsil.

“This new technology offers hope and treat-

ment to patients who might not have other options. It helps protect healthy brain or organ tissues. In the case of head and neck tumors, for example, we can target a tumor while preserving the patient’s ability to talk and swallow,” says Dr. Holladay.



At the Providence Medical Center in Kansas City, Kansas, Frank Holladay, MD, a board-certified neurosurgeon, has embraced Varian’s Trilogy for stereotactic radiosurgery.



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**True reliability assures peace of mind.** This is why year after year clinicians have rated Varian number one for reliability. Our accelerators have an uptime of 98.5% or better and approximately one-third of our employees are engaged in supporting our customers. We make supporting you a priority so that your patients can be treated without any delay. Trust in your technology generates confidence in your quality of care. Confidence in quality of care instills trust in your patients.

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