In its ongoing mission to help clinicians save lives, Varian has continuously worked to provide new tools for enhancing the quality of care and to make important capabilities clinically practical. One pivotal innovation that continues to impact the practice of radiation oncology is machine-based imaging in the radiation oncology treatment vault. Varian’s first such device was an MV portal imager, and then, just over ten years ago, the company introduced the On-Board Imager® (OBI) kv imaging system. This development helped to usher in the age of image guidance, and clinicians are still finding new ways of using it to improve the accuracy of radiotherapy and radio-surgery treatments.

When Varian first announced its initiatives in image-guided radiation therapy (IGRT) in 2003, cancer care centers around the world were still embracing the advent of intensity-modulated radiation therapy or IMRT, a technique designed to deliver exquisitely shaped high-energy X-ray beams to tumor cells while minimizing the impact on surrounding healthy tissues. When kv imaging capabilities were added to the treatment machine, IGRT moved the standard of care even higher.
Varian’s OBI supports a variety of X-ray imaging modalities, including kV, fluoroscopic, and cone-beam CT (CBCT). In fluoroscopic mode, the OBI tracks target motion. Images generated while the patient is in the treatment position can then be matched with reference images from the treatment plan. Fully integrated with other elements of the treatment delivery system (i.e., the linear accelerator and the treatment couch), the OBI system automatically fine-tunes patient positioning based on current images to better align the tumor with the beam.

“For the first time in the history of radiation oncology, the OBI gave us the opportunity to verify that the treatment beam was exactly where we wanted it to be prior to every treatment,” says Tim Fox, PhD, who in 2004 was the director of medical physics in the Department of Radiation Oncology at Emory University School of Medicine, and who now heads up Imaging Informatics at Varian. “As soon as we began to use this device, we knew it would be instrumental in helping us to create plans with smaller margins, and to develop treatment protocols that could deliver higher, more targeted doses while sparing surrounding healthy structures.”

Early adopters saw substantial improvements

In 2004, Emory University was one of four initial sites in the United States to deploy the OBI, which also included Henry Ford Hospital, Stanford University, and Duke University. The first OBI installations in Europe were at the Karolinska University Hospital in Sweden and the Hirslanden Klinik Aarau in Switzerland.

“Many of the early installation facilities, including Emory, began publishing papers on the development of more sophisticated approaches to radiotherapy treatment made possible by imaging techniques with the OBI,” explains Fox. “Using image-guided motion management during 3DCRT and IMRT, clinicians could more accurately control the dose delivered to the tumor while reducing exposure to the surrounding structures.”

In 2006, the OBI device received an R&D 100 Award from R&D Magazine as one of the 100 most technologically significant products of the prior year, further reinforcing its game-changing role in the radiotherapy delivery process. The R&D Awards are given out annually and are widely known to industry, government, and academia as a mark of excellence—demonstrating that a product realizes one of the most innovative ideas of the year.

IGRT becomes a standard requirement

By 2008, the OBI was rapidly becoming a standard requirement of cancer centers looking to upgrade their linear accelerators. Improved imaging and processes that enabled efficient workflows meant the number of patients being treated with IGRT was climbing, and so was the increase in the types of cancer that clinicians felt comfortable treating, given the increased accuracy IGRT afforded them.

The Vanderbilt-Ingram Cancer Center at Vanderbilt University reported using Varian’s Trilogy accelerator for a hypofractionated approach, delivering stereotactic body radiotherapy (SBRT) in the treatment of certain early-stage lung tumors. At Stanford University in Palo Alto, California, radiation oncologists began using Varian IGRT to treat cancers of the head and neck, where the major challenge is the very close proximity to critical and highly radiation-sensitive tissue. Meanwhile, clinicians at the Virginia Commonwealth University Massey Cancer Center in Richmond, Virginia, were among the first in the world to attack metastatic cancer using a Trilogy machine to deliver image-guided radiosurgery (IGRS).

“It’s hard to imagine how radiation treatment was performed before the advent of the OBI,” says Dr. M. Salim U. Siddiqui, director of the Stereotactic Radiation Program at the Henry Ford Health System. “But I like to use the analogy of going from shotgun radiation to sharp-shooter radiation. Thanks to advances in imaging, we’re shrinking margins, conforming to the tumor and more precisely targeting a higher dose—all
while reducing the risk to healthy tissue. We would never have been able to do this without the OBI.”

More power to see inside

Further development in kV imaging led to the advanced capabilities on Varian’s newest treatment delivery systems, the TrueBeam® and Edge™ platforms. The machine-based imaging is more tightly integrated than ever before, offering the level of control needed for image-guided radiosurgery. On these platforms, a reengineered control system dynamically synchronizes imaging with patient positioning, motion management, and treatment delivery. This enables highly sophisticated imaging during treatment, complex motion management strategies, and most recently, “triggered imaging” for intrafraction motion review, which enables visual verification throughout a treatment that the target is correctly positioned. In turn, these developments are enabling the next generation of radiosurgical procedures and even greater insight into tumors and diseases previously considered untreatable.

Recently, the Henry Ford clinical team, which was among the earliest adopters of the Edge system (see related article on page 18), used it to treat a small tumor that appeared in soft tissue between a patient’s stomach and small intestine after a liver transplant. The patient was unable to tolerate chemotherapy at the time. “Using fiducials in the tumor, triggered imaging, and simulated gantry positioning techniques, we were able to deliver the dose when the beam was on target in five fractions of 4 Gy each,” explains Ning (Winston) Wen, PhD, stereotactic radiosurgery (SRS) physics lead at Henry Ford. “As a result, we were able to shrink a tumor that previously was treatable only with a palliative dose.”

“Functionally, this technology has changed how we localize the target site, whether we’re using CBCT, 2D, 3D, or even 4D cone-beam imaging techniques,” adds Siddiqui. “All our current practices have improved because of advances in imaging features. We can now image on demand at any time during treatment, and be confident about movement and patient positioning.”

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Intended Use Summary
Varian Medical Systems’ linear accelerators are intended to provide stereotactic radiosurgery and precision radiotherapy for lesions, tumors, and conditions anywhere in the body where radiation treatment is indicated.

Safety
Radiation treatments may cause side effects that can vary depending on the part of the body being treated. The most frequent ones are typically temporary and may include, but are not limited to, irritation to the respiratory, digestive, urinary or reproductive systems, fatigue, nausea, skin irritation, and hair loss. In some patients, they can be severe. Treatment sessions may vary in complexity and time. Radiation treatment is not appropriate for all cancers.