

Varian's New RapidArc™ Delivery: The Next Dimension in Speed and Precision

By Corey Zankowski, PhD

RapidArc*, a major advance this year from Varian Medical Systems, will improve dose conformity while significantly shortening treatment times. RapidArc will achieve a physician's treatment objectives better than today's best IMRT techniques—two to eight times faster than our fastest dynamic treatments can be delivered today. **What multislice did for CT scanning, RapidArc will do for radiation therapy.**



Volumetric modulated arc therapy

RapidArc is a volumetric arc therapy that delivers a precisely sculpted 3D dose distribution with a single 360-degree rotation of the linear accelerator gantry. It is made possible by a treatment planning algorithm that simultaneously changes three parameters during treatment: the rotation speed of the gantry, the shape of the treatment aperture using the movement of multileaf collimator leaves, and the delivery dose rate.

Volumetric modulated arc therapy differs from existing techniques like helical IMRT or intensity-modulated arc therapy (IMAT). Helical IMRT treatments apply dose in thick overlapping slices that take more time to deliver. IMAT, which uses five to seven concentric arcs to deliver a conformal dose distribution, takes up to five times longer to deliver than a treatment using RapidArc, which delivers dose to the whole volume rather than slice by slice.

Although it represents a major advance in radiotherapy treatment technology, RapidArc is easy to implement. It requires no major process changes from the physician, physicist, dosimetrist, or therapist, as the steps for planning and delivering treatments are virtually unchanged.

From funded research to product roadmap

Varian began looking for different ways to deliver a single-arc IMRT treatment more than five years ago. Our objective was to treat the tumor as conformally as possible in the least amount of time, while being extremely efficient in the amount of radiation dose used. Our requirements were stringent:

- Use nearly every degree in a 360-degree arc to provide the best chance of finding the optimal dose distribution for the patient.

- Simultaneously modulate the shape of the treatment aperture, the dose rate at each gantry angle, and when necessary, the gantry speed.
- Minimize the total monitor units required to generate the optimal dose distribution.
- Minimize the treatment delivery time.
- Calculate the optimal plan in a clinically useful time frame (less than 60 minutes).

Some early solutions gave us the dose distributions we needed, but they took too long to plan. Other solutions required multiple arcs and isocenters, which took too long to deliver and were too complicated to be practical. Work by Cedric Yu, DSc, at the University of Maryland demonstrated that single-arc IMRT could equal or exceed the target volume coverage achievable with conventional multiple-field IMRT. Finally, thanks to some important innovations by physicist Karl Otto, PhD, as well as productive, sponsored research projects at the British Columbia Cancer Agency and the University of Maryland, we now have an efficient, accurate, elegant treatment planning algorithm that meets all of our requirements.†

The new RapidArc planning algorithm carefully exploits many of the characteristics of Varian's modern linear accelerators and multileaf collimators, including:

- Leaf interdigitation, which is uniquely possible with a Varian multileaf collimator
- Varian's dynamic "sliding window" approach to beam shaping
- Varian's patented "gridded gun," which makes it possible to vary the dose rate as a function of the gantry angle

Varian sponsored the RapidArc research and development effort with a primary goal of improving clinical outcomes. In the process, we discovered that we could improve dose conformity and simultaneously improve treatment efficiency significantly, as RapidArc delivery is anywhere from two to eight times faster than was possible before. We are pleased to have introduced this exciting new development at this year's ASTRO meeting in Los Angeles. *

Corey Zankowski, PhD, is senior director of software systems marketing at Varian Medical Systems.

* Pending FDA 510(k) approval; not available for sale in the United States at this time.

† Researchers Karl Otto, PhD, James Morris, MD, and Tom Keane, MD, of the British Columbia Cancer Agency, and William Regine, MD, and Cedric Yu, PhD, of the University of Maryland Cancer Center, contributed to this project through research funded in part by Varian Medical Systems.

ASTRO Round-Up

Varian exhibited a range of new technologies at this year's meeting of the American Society for Therapeutic Radiology and Oncology (ASTRO), held October 28 through November 1, 2007, at the Los Angeles Convention Center. On display were Varian's new RapidArc™ delivery technology*, a high-definition multileaf collimator for radiosurgery, and updated tools for planning and delivering LDR and HDR brachytherapy treatments.

RapidArc Delivery

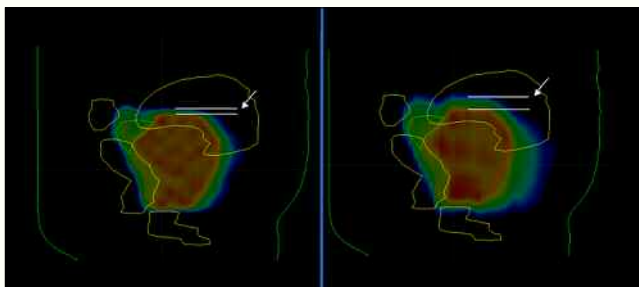
RapidArc* is a major advance that will enable clinicians to improve dose conformity and significantly shorten treatment times. RapidArc delivers a complete intensity-modulated radiation treatment during a single 360-degree rotation of the linear accelerator gantry around the patient.

RapidArc is made possible by a powerful new software algorithm that can control changes in three parameters simultaneously: 1) the speed of the gantry rotation, 2) the shape of the aperture created by the movement of multileaf collimator (MLC) leaves, and 3) the dose delivery rate.

"The algorithm is designed to generate highly conformal dose distributions while taking advantage of the specific capabilities of the Varian linear accelerator," says Karl Otto, PhD, medical physicist, British Columbia Cancer Agency (BCCA), a researcher and major contributor to RapidArc R&D efforts. "The speed of MLC motion, gantry rotation speed, and dose rate are all used by the algorithm to ensure the treatment is delivered efficiently and accurately."

Varian researchers have found that RapidArc dose distributions are fast to deliver, and they are equivalent to or better than conventional IMRT or helical IMRT for a variety of clinical sites. In one example, a multitarget cancer of the nasopharynx, RapidArc plans were found to be equivalent or better at target coverage for all targets, and superior in protecting critical structures including the spinal cord, brain stem, eyes, optic nerve and chiasm, parotid glands, and brain. In this test, the RapidArc delivery took only 110 seconds and used only 585 monitor units (MUs). Other tests showed that even complex RapidArc treatment plans can be delivered in less than 2.5 minutes, with fewer than 750 MUs. In comparison, Varian's best IMRT treatments, delivered one field at a time, require approximately one minute per field to deliver, while the average multislice helical IMRT treatment requires 10 to 15 minutes.

"Previous approaches to arc IMRT therapy have been restrictive. Some are limited by machine design, and deliver treatments in the axial plane only, making it impractical to treat certain



In this prostate cancer treatment plan, volumetric modulated arc therapy shows superior conformity in the superior-inferior direction when compared to helical IMRT.

anatomical sites," says William F. Regine, MD, professor and chairman of the Department of Radiation Oncology at the University of Maryland School of Medicine and chief of radiation oncology at the University of Maryland Medical Center, where research into single-arc dose painting has been taking place for some time. "Varian's technology for image-guided radiation therapy was technically ahead to

begin with, and now Varian is adding efficient arc therapy that can be delivered in multiple planes, i.e., volumetrically. With the same technology we use to deliver noncoplanar treatments, we can now also offer very fast arc therapy. It's a testament to what can happen when the thought leaders in industry work together with innovative clinical researchers. The result is something that makes a practical difference to patient care and to our ability to offer whatever is best for each of our patients."

According to Cedric Yu, DSc, the Carl M. Mansfield, MD, professor of radiation oncology at the University of Maryland Medical Center and another important contributor to RapidArc research, his studies of single-arc IMRT have shown it to be equal to or better than multiple-field IMRT in terms of target volume coverage and normal tissue sparing. He found that a single arc can deliver essentially similar dose distributions compared with IMRT plans that incorporate as many as 36 fields.

"Clinicians everywhere are rapidly adopting online IGRT technologies like Varian's On-Board Imager® system," BCCA's Otto points out. "Patients benefit from a focus on accurate patient positioning through daily imaging. RapidArc is extremely time efficient, which contributes to patient comfort. It is likely that we will see image-guided arc therapy sessions take less than 10 minutes, including imaging and treatment."

Varian customers who adopt RapidArc will gain this new clinical capability without sacrificing the ability to deliver other forms of treatment if needed. A Trilogy® or Clinac® iX accelerator outfitted to deliver RapidArc can still deliver static fields, noncoplanar treatments, electron therapy, and conventional forms of IMRT, IGRT, SBRT, and SRS. *

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