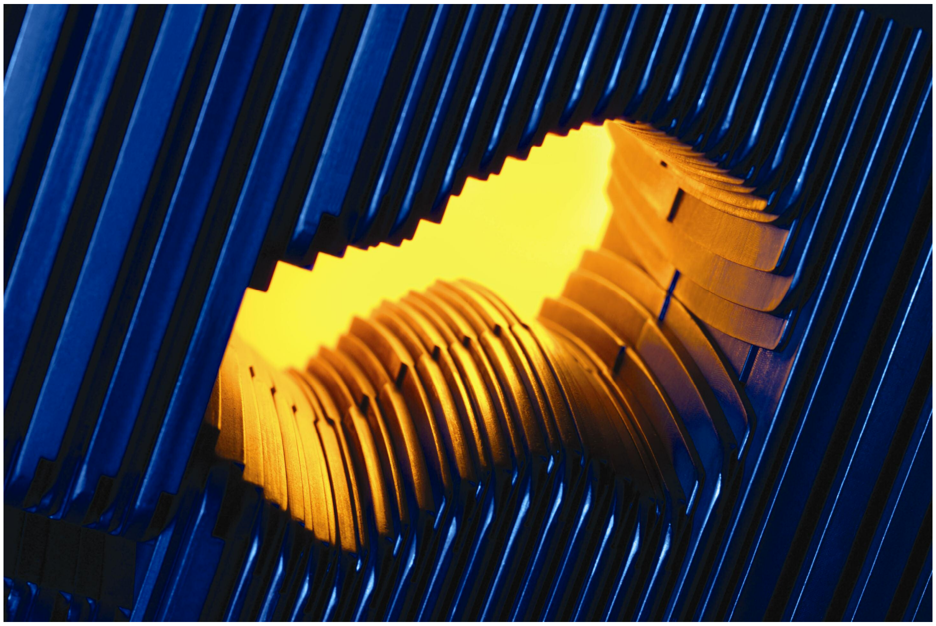
Intensity-Modulated Radiosurgery System

Engages a shape-shifting multi-leaf collimator to focus radiation on tumors while protecting surrounding healthy tissue in sensitive areas of the body.

The problem can be a matter of life and death to the patient. Until a few years ago, head and neck tumors could not be safely bombarded with radiation without the possibility of damaging organs like the spinal cord or salivary glands. Doctors were forced to keep radiation doses low – too low to be completely effective in eradicating tumors – in order to avoid paralyzing or even killing their patients. Many spinal column tumor treatments ran the same risks. The situation presented doctors with a Hobson’s choice. A tumoricidal radiation does might cure the cancer but seriously harm the patient. On the other hand, lower radiation doses could fail to stop the cancer.



Hospitals needed a machine that combined superior technology with an efficient, reliable process for targeting tumors while sparing normal healthy tissues. The components had to deliver radiation in different modes, including segmental, dynamic, combinations of the two, and ‘conformal arc’ radiation treatment, all on one treatment machine. A computer system had to be able to translate multiple views of a single tumor into three-dimensional anatomical images. Using this image data, a complex radiation therapy treatment plan would be created. From the treatment plan, the computer would create the instructions needed to operate the motion system used to provide treatment.

Healing Capabilities
Cancer treatment technology from Varian Medical Systems is aimed at being able to ‘paint’ or conform a radiation dose very tightly to a small or irregularly shaped target. These systems have the ability to minimize hot spots, improve target dose homogeneity, and sculpt dose delivery around critical structures more effectively.

These systems are used accurately and repeatedly to treat tumors very close to sensitive structures like optic nerves, spinal columns, and other glands and organs. Despite their complexity, the high-resolution treatments are delivered quickly, fitting into the conventional 10- to 15-minute time slots generally reserved for such treatments. The process is further streamlined through automation and the ability to customize a process, save it, and repeat it. Varian also provides software that incorporates data analysis and reporting tools.

The Technology

Varian has received FDA 510(k) clearance for its latest high-definition multileaf collimator (MLC), an ultra-fine beam shaping device for radiosurgery. The HD120 MLC consists of a computer-controlled array of up to 120 parallel, individually adjustable tungsten slats or leaves that can block the path of an X-ray beam. The MLC is attached to the head of the medical linear accelerator, which generates the beam. The leaves of the MLC situated in two parallel rows, and can be moved in and out to create an adjustable aperture through which radiation beams are directed at a patient's tumor. The shape of the aperture is dynamically changed as treatment progresses, to match the shape of the tumor as seen from each of the angles from which the beam is being delivered. By using the MLC to precisely shape the beams from multiple angles, it is possible to deliver a radiation dose that closely matches the three-dimensional volume of the tumor.

The MLC also facilitates intensity-modulated radiation therapy (IMRT). Using the adjustable leaves of an MLC to shape the beam and by controlling exposure times, clinicians can deliver a different dose to different segments of the tumor, modulating the dose intensity across the entire treatment field. Consequently, the dose can be higher in the most aggressive areas of the tumor and lower in areas where the beam is near or passing through sensitive healthy tissues.

Prior to the new HD120 MLC multileaf collimator, Varian's finest MLC had a central group of beam-shaping leaves that were each 5 mm wide. The HD120 has reduced the width of the central leaves to just 2.5 mm, increasing the beam-shaping precision by 100 percent. Each side of the Varian collimator is configured with 60 leaves distributed in an 8 cm wide central region with 32x2.5 mm leaves, flanked by two 7 cm wide outer regions with 14x5.0 mm leaves, for a total width of 22 cm. The HD120 MLC was also designed for durability, so that it could be relied upon during continual use in a busy clinic.

If the leaves are designed too tightly together, they jam. If the leaves are designed too loosely, radiation leakage occurs. Consequently, careful engineering that optimized how the leaves were packaged into the system was critical. The leaves move in and out through the use of 120 tightly packaged motors manufactured by Maxon Motor USA (Fall River, MA).

Maxon motors are known for their long life due to their unique construction, and the fact that they are manufactured on specialized machines. Yet, above and beyond their longevity, the motors offered Varian engineers excellent packaging options. Packing 120 motors into a 40cm by 40cm space meant that motor size was almost as critical as motor specifications. Through the use of Maxon's RE 8, RE 10 and RE 13 motors, Varian was able to package 120 tungsten leaves into the limited space available. While the motors are indeed small, the truly impressive miniaturization occurred with the required encoder feedback. Each motor has an encoder to close the servo loop that must deliver suitably high resolution while remaining as small as possible in order to meet the packing requirement. Further, these encoders must be modified to be radiation resistant as the high field dose would destroy conventional encoder technology.

Varian's radiation system was designed to deliver distinct radiation doses to thousands of different segments per tumor – almost like a free-flowing radiation gun. To do this, the multileaf collimator reshapes the opening for radiation quickly and automatically according to preprogrammed data. Consequently, each motor must handle high torque and high speed to create the programmed shape changes as quickly and accurately as possible. Motor torque needed to be at a level where the plates could operate in a tightly synched formation, even against the high friction that could occur.

Additional motor features include powerful rare earth magnets to maximize the torque that is available in such a small package. The patented rhombic moving coil design provides for long life, low electrical noise, fast acceleration and high efficiency. An ironless rotor allows for zero cogging and simple accurate control. The motors are rated between 0.5 and 1.5 watts, are 17 mm to 24.6 mm in length, and offer a maximum continuous torque up to 1.61 mNm (0.23 oz-in).

Maximum motor efficiency is up to 76% depending on the winding. Ambient temperature range is from –20 to 65° C. Several different windings are available to match desired speed with available voltage. Matching gearheads are also available with ratios ranging from 4:1 up to 1024:1 capable of delivering up to 200 mNm (28 oz-in) of intermittent torque. Encoders are available down to 8 mm in diameter with resolutions up to 100 lines per turn.

Due to their high performance and small size, Maxon's motors are also suitable for a variety of other medical applications including miniature pumps, surgical devices, air samplers, micro-stages, and laser measuring devices.

For information:
maxon precision motors, Inc.
101 Waldron Road
Fall River, MA 02720
P: 508-677-0520
F: 508-677-0530
S: http://www.maxonmotorusa.com