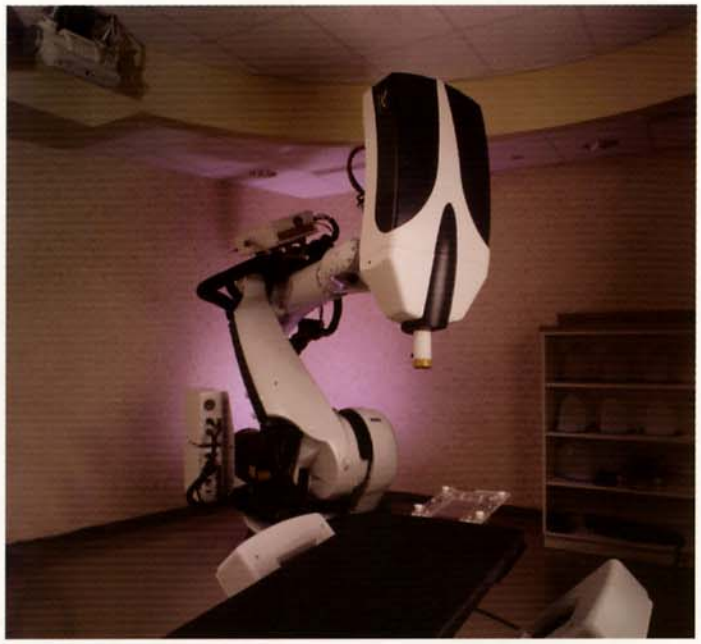
surgical director of the CyberKnife center, couldn't be happier. "It has become an integral part of my practice because it allows me to provide a full range of therapy options to my patients with brain and spine lesions," he says. "Often, patients are candidates for both traditional surgery and CyberKnife radiosurgery, and I am able to talk with the patient about both approaches and offer both options." Dr. Naff explains that, in some cases, it is advantageous to operate and remove parts of tumors that are either very large or in extremely dangerous locations, reducing the size of the tumor quickly but intentionally leaving some of it in place to be treated later in a safer fashion with the CyberKnife.

The patient's treatment is planned using a typical CT scan or MRI and those images are then imported into the CyberKnife console where the surgeon marks out the tumor. Unlike other, older methods of radiosurgery, the CyberKnife does not require that the patient be fitted with an unwieldy head frame during planning or treatment. This means that planning can take place days or even a week before treatment and that the treatment itself can be accomplished in more than one session. Elimination of the head frame also allows radiosurgery to be applied below the head.

Mark J. Brenner, M.D., chief of the Department of Radiation Oncology at Sinai and medical director of the CyberKnife center, says, "The CyberKnife also incorporates one of the hottest aspects of modern radiation oncology—inverse treatment planning. When treating any tumor, I must always also keep in mind the radiation tolerance of the surrounding normal structures. With inverse treatment planning, I not only state the dose I want to give to the tumor, but I also delineate the surrounding critical structures and specify the maximum dose I will allow them to receive. The treatment planning software then takes all of that information and comes up with a solution that meets my strict specifications."



PHOTOGRAPHY BY MARK MOLESKY

CyberKnife Treatment Sequence

Patient is placed in a position approximating that of the CT scan.

Image detectors acquire radiographs of the tumor region.

Image guidance system software compares the live images (radiographs) with the CT information to determine location of the tumor.

This information is transmitted to the robot to initialize the pointing of the linac beam.

The robotic arm then moves the linac through the sequence of preset nodes surrounding the patient.

At each node, the linac stops and a new pair of images is acquired, from which the position is redetermined.

Corrected position is transmitted to the robot, which adapts beam pointing to compensate for any movement.

Linac delivers the preplanned dose of radiation for that position.

Entire process is repeated at each node. The total time from imaging to robot compensation is about seven seconds.

The CyberKnife incorporates an advanced image guidance system based on the same type of artificial intelligence used in the cruise missile systems to "lock on" the target. A linear accelerator mounted on a robotic arm is used to deliver highly focused beams of radiation to the tumor. The robot circles the patient and stops at 100 different spots in an imaginary sphere. At each of those stops, or nodes, the radiation source can assume 12 different angles, giving a potential 1,200 beams of radiation that can be selected by the CyberKnife to accomplish the goals of the treatment team. Doctors don't operate the device during treatment—the robot does the work. Dr. Brenner says there is a kind of beauty to it. "It looks like computerized Tai Chi!" he says.

Seventy-year-old Anna Steele of Hagerstown, MD, was experiencing difficulty with her peripheral vision about five years ago and thought her glasses needed changing. Her problem turned out to be a pituitary tumor behind her eye for which she underwent surgical resection. As predicted by the surgeon, the mass grew back several years later. "This time, it hadn't reached the eyes but was wrapping itself around the blood vessels that were leading to the eyes," she says. "Although it was benign, it had to come out. It could cause blindness and eventually death because it would keep growing."

Mrs. Steele's choices were to have another brain surgery, take radiation treatments or receive radiosurgery with the CyberKnife. After reviewing those options, she chose radiosurgery. "This case points out a major advantage of the CyberKnife," says Dr. Naff. "Because we don't