CyberKnife®: A Robotic Radiosurgery System

Annette Martin Quinn, MSN, RN

The CyberKnife® is a radiosurgical system consisting of a linear accelerator and robotic arm. Using guidance imaging, the system precisely locates tumors and delivers multiple beams of radiation therapy directly to the tumor site while minimizing radiation exposure of surrounding tissue. The CyberKnife has the capacity to treat tumors up to 6 cm in size and holds promise as a new radiosurgery treatment modality.

Stereotactic radiosurgery has been used for more than 30 years to treat abnormal areas in the brain, such as tumors or vascular malformations. For many years, the Gamma Knife® (Elekta Instrument, Stockholm, Sweden) has been considered the "gold standard" in this area by allowing safe and highly effective treatment of problem areas in the brain without invasive surgery. Developed in the 1950s by Swedish neurosurgeons Lars Leksell and Borje Larsson, the Gamma Knife allows neurosurgeons to operate on intracranial problems with radiation instead of scalpels. With the use of highly sophisticated, three-dimensional treatment-planning equipment, the Gamma Knife can deliver a single, highly concentrated dose of radiation to a small area, while sparing critical structures located near the target. It has been used successfully for many years to treat a variety of tumors and nonmalignant conditions, including acoustic neuromas, pituitary adenomas, pinealomas, craniopharyngiomas, meningiomas, chordomas, chondrosarcomas, arteriovenous malformations, brain metastases, and glial tumors (Boyd & Mehta, 1999; Chang, Adler, & Hancock, 1998; Yamamoto, 1999).

Until recently, the Gamma Knife has been considered the mainstay of therapy in stereotactic radiosurgery. Recently, however, the CyberKnife® (see Figure 1) (Accuray, Sunnyvale, CA) has gained much recognition in this field. John R. Adler, associate professor of neurosurgery and radiation oncology at Stanford University Medical School, formulated the idea for the CyberKnife while serving a fellowship in radiosurgery at Karolinski Institute in Stockholm, Sweden. This new device employs a lightweight radiation source in conjunction with a robotic arm to circumvent the limitations of present day forms of stereotactic radiosurgery. With its robot-like appearance, the CyberKnife is capable of precisely targeting a tumor from virtually any direction. The advantage is its ability to direct highly focused beams of radiation without using rigid immobilization, such as a head frame screwed into the skull. It can compensate for any small head movement, unlike other radiosurgery devices, which require a frame to lock the head in one position (Adler et al., 1997; Fink, 1997). With the CyberKnife, a custom-fit facemask is used to stabilize and protect a patient's head.

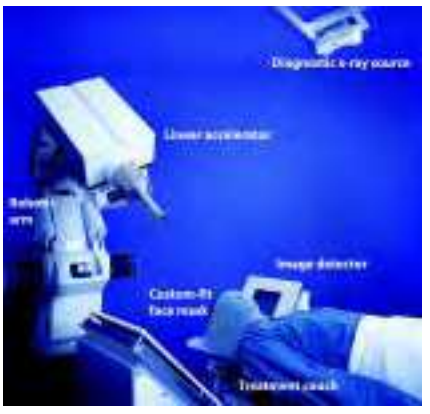

FIGURE 1. CYBERKNIFE® USED FOR STEREOTACTIC RADIOSURGERY

Note. Photo courtesy of Accuray, Sunnyvale, CA. Used with permission.

A candidate for CyberKnife therapy first undergoes a treatment-planning computerized tomography (CT) scan and, possibly, a magnetic resonance imaging scan. These data then are integrated into the treatment-planning software, and a series of digitally reconstructed radiographs showing a range of patient positions are correlated with stereo x-ray images of the affected area so that the computer knows exactly where, in three-dimensional space, the tumor or lesion is located (Fink, 1997).

Comparing the x-ray images to those obtained from the CT data allows the computer to precisely locate the patient and the target treatment area. Once a correlation is made, the information is transmitted to the robotic arm, and beams are fired at the target from numerous directions.

Treatment time ranges from 45–60 minutes and can be given in one fraction or several fractions, depending on the condition being treated and size of the affected area. Unlike other forms of radiosurgery, which cannot treat lesions larger than 3 cm, the CyberKnife has the capacity to treat tumors up to 6 cm in size.

In October 2001, the CyberKnife received clearance from the U.S. Food and Drug Ad-

(Continued on page 156)

This article originally appeared in the November 2001 issue of the Oncology Nursing Society (ONS) Radiation Special Interest Group Newsletter. *Reprinted with permission. (Mention of specific products and opinions related to those products do not indicate or imply endorsement by the* Clinical Journal of Oncology Nursing *or ONS.)*

Digital Object Identifier: 10.1188/02.CJON.149