Stereotactic radiosurgery: quo vadis?

JASON SHEEHAN, M.D., PH.D.,¹ AND NADE POURATIAN, M.D., PH.D.²

¹Department of Neurological Surgery, University of Virginia Health System, Charlottesville, Virginia; and ²Department of Neurosurgery, David Geffen School of Medicine at University of California Los Angeles, California

The etymology of the words “stereotactic” and “radiosurgery” tells us a great deal about the past of this field; it may also predict some of its future. “Stereosurgery” tells us a great deal about the past of this field. The etymology of the words “stereotactic” and “radiosurgery” comes from the Greek word “stereos,” meaning “solid” and “3-dimensional,” and “tactic” comes from the Latin word “tactus” (derived from tangere, “to touch”). “Radio” is from the Latin word “radius” and means “beam.” It is this 3D touch with beams that has altered the landscape of modern-day neurological surgery and radiation oncology.

Stereotactic radiosurgery has become an important treatment option for many patients with intracranial and spinal disorders. Lars Leksell originally proposed to use radiosurgery for the treatment of patients with intractable pain or movement disorders.6,9 Ironically, these applications represent only a small fraction of contemporary radiosurgical practice. In modern practice, the most common indications for intracranial radiosurgery include meningiomas, metastases, schwannomas, pituitary adenomas, trigeminal neuralgia, hemangiopericytomas, ependymomas, chordomas, arteriovenous malformations, cranioopharyngiomas, and gliomas.

Despite the radiobiological dogma that fractionation is preferable for rapidly proliferating tissues, the radiosurgical treatment and outcomes of metastatic disease have led to an explosion in the field of stereotactic radiosurgery. Much like other innovative technologies (for example, deep brain stimulation), our understanding of the biology (or radiobiology) of stereotactic radiosurgery lags behind its clinical application.7 The efficacy and low morbidity associated with radiosurgery for metastatic disease is not easily explained by the linear quadratic equation or other models.1,3,4 Nevertheless, the utility of radiosurgery for metastatic tumors is undeniable.5 Basic, translational, and clinical scientists will have to lead the way in developing a better understanding of the biology of radiosurgery in order to enhance outcomes, expand indications, and instigate further innovation. In the meantime, neurosurgeons and other clinicians will have to continue to define the precise indications for radiosurgery such that the balance between radiosurgery, open surgery, and conservative management optimizes outcomes and minimizes morbidity.

Technological innovations (for example, PET, SPECT, 3-T and higher field strength MR imaging, and dynamic MR imaging) and agents used to alter the sensitivity of both tumor and normal tissue to radiation will lead to further refinement in the field. Also, new energy sources such as focused ultrasound are being explored for radiosurgery applications in the brain and spine.²

This issue of Neurosurgical Focus examines the current state of intracranial and spinal radiosurgery and reflects the breadth of investigation in the field. The first article reviews mechanisms of radioresistance and presents a broad framework within which to consider the design and implementation of radiomodulating agents, while subsequent articles consider technological and medical innovations in the field, including frameless image-guided radiosurgery, applications for head and neck cancer, and treatment of pathological spine fractures. Likewise, articles range from considering radiosurgical treatment of complex skull base tumors to treatment of spinal (both intradural and intramedullary) and head and neck cancers. The current issue of Neurosurgical Focus represents a snapshot of contemporary radiosurgical practice.

References