Performing safe neurosurgery has historically posed many challenges. Because brain and spinal lesions are located adjacent to many critical structures, it is paramount for the neurosurgeon to precisely plan the surgical procedure. This means localizing the tumor, clearly establishing its margins, finding the most direct pathway to the lesion while avoiding critical structures and determining when the entire tumor has been resected.

Before the advent of advanced imaging technology, such planning relied on indirect information derived from projection radiographs and clinical findings from neurological examinations. Often, surgical exposures were much larger than otherwise necessary in order to permit the surgeon to find the lesion. Sometimes it was still difficult to localize the tumor.

The development of CT and MRI revolutionized neurosurgery, as these imaging techniques now allowed surgeons to “see” the lesions they were trying to eliminate. CT and MRI became critical planning tools for neurosurgical operations. However, the images from such scans still reflected preoperative conditions and did not reflect any subsequent intraoperative changes.

Image-guided procedures likewise reflected preoperative conditions, and such restrictions made it impossible to perform minimally invasive image-guided neurosurgical operations in near real time with good tissue resolution.

Intraoperative MRI (iMRI) was welcomed for its ability to change this without requiring physicians to invest in new technology. iMRI uses the same imaging modality for localization during surgery as for preoperative diagnosis.

With iMRI, physicians now can view images during the actual operation rather than having to look at images made preoperatively and postoperatively. The MRI offers real-time visualization during all stages of brain surgery so that surgeons can clearly see where the tumor begins and normal tissue ends. This allows clinicians to verify that the entire tumor has been removed prior to ending the surgery—decreasing the chance that a second operation might be required for some patients. It also aids in quickly detecting possible intraoperative or postoperative problems.

In contrast with standard open MRI machines, the iMRI unit is a vertical “donut.” Parts of the magnet are on either side of the patient, and the machine has a 45-centimeter slot where surgeon and assistant stand to operate and obtain MRI images at any point during the procedure.

In the preoperative planning phase, a 3D model is reconstructed from the MR images. The surgeon can plan the operation, select the best path to target and indicate landmark and risk zones using this model. During the operation, the surgeon views this reconstructed image set by using a navigator, which shows what is ahead of and around the instrument.

New images are added to the archive throughout the procedure. A whole new 3D image set can be taken and used instead of the preoperative image set to reflect significant or even minor changes. This allows the surgeon to adjust to these changes and modify his/her microsurgical technique for even more precise control and accuracy.

The Impact of iMRI

In the future, different kinds of imaging modalities will be combined to provide more informative images. For example, combining angiographic images to T1-weighted images will allow the surgeon to better avoid important blood vessels.

Such projected developments will surely add to the rapidly evolving field of MRI-guided neurosurgery, but iMRI already represents a substantial improvement in the microsurgical treatment of tumors, vascular malformations and other intracranial lesions. In fact, an article published in Neurology India in 2003 proposed that iMRI could...
soon become the standard of care. According to the authors, this possibility depends on several factors, including whether time and increasing experience in iMRI demonstrate a significant benefit for the patient with respect to postoperative quality of life and/or survival. In addition, they asserted that if open MRI units can be integrated into neurosurgical clinics in a cost-effective manner with probable interdisciplinary, resource-shared use, the integration of sophisticated MRI imaging may become the standard of care for neurosurgical patients. [Selkert, V et al., “Intraoperative MRI in Neurosurgery: Technical Overkill or the Future of Brain Surgery?,” Neurology India, 2003;51: 329-332.]

A review conducted at the Department of Neurological Surgery at the University of California San Francisco also found definitive benefits of iMRI in neurosurgery. Specifically, intraoperative use of MRI was demonstrated to be a safe technique enabling the neurosurgeon to update data sets for navigational systems, evaluate the extent of tumor resection and modify surgery if necessary, to guide instruments to the site of the lesion and to evaluate the presence of intraoperative complications at the end of surgery. [Keles, GE, “Intracranial Neuro-navigation with Intraoperative Magnetic Resonance Imaging,” Current Opinions in Neurology, 2004 Aug;17(4):497-500.]

Resecting Pituitary Tumors with iMRI

CASE REPORT: Pituitary Macroadenoma in a 72-year-old patient

A 72-year-old male presented with a 7-day history of headache, dizziness, nausea, vomiting, visual disturbances, hyponatremia and was diagnosed with pituitary macroadenoma. MRI revealed 3.5x2.5 cm size lesion impinging on the optic chiasm and encasing the carotid arteries bilaterally (Figure 1). Utilizing a minimally invasive transsphenoidal approach, Boulder Neurosurgical Associates neurosurgeons were able to completely resect the tumor (Figure 2) through a small incision in the posterior nasal mucosa without the need for any external incisions or postoperative scarring. IMRI unit in conjunction with real-time intraoperative computer volumetric navigation and endoscopy was utilized in order to minimize the risk of complications and maximize the outcome. Total operative time was less than 90 minutes, with a total estimated blood loss of less than 25 ml. The patient was discharged home in less than 48 hours and returned to the clinic in three weeks with his symptoms completely resolved except for some mild residual diplopia that was rapidly improving.

Pituitary Tumors

Pituitary adenomas are tumors located next to or within the pituitary gland. Almost all pituitary adenomas are benign. However, “macroadenomas”, which are 10 mm or larger in diameter, often cause pressure effects and resultant neurological injury and deficits. The symptoms of a pituitary adenoma depends on its size and what hormone it secretes. Increased growth hormone causes gigantism in children and acromegaly in adults. Prolactin secretion in males can produce infertility and enlargement of the breasts. In females, it may produce no symptoms. ACTH (Adrenocorticotropic hormone) secreting tumors produce Cushing’s syndrome. If a tumor extends above the sella turcica, it may compress the optic chiasm causing the loss of peripheral vision.

The surgical removal of pituitary tumors is performed via one of two main approaches: cranial or transtemporal. Transsphenoidal describes the path the surgeon follows to reach the pituitary gland, meaning through sphenoid sinus. The minimally invasive transsphenoidal approach allows the surgeon to reach pituitary tumor through the nostril on one side, without the need for an incision under the lip or on the external nare. This method is minimally invasive because it directly approaches the tumor through the patient’s nostril, thus limiting facial swelling, decreasing postoperative pain, and making recovery quicker. The sphenoid sinus is entered and an opening is made in the wall of the sella turcica to expose the pituitary gland.

A Partner in Progressive Care

Boulder Neurosurgical Associates provides state-of-the-art neurosurgical care that can improve survival and quality of life and help those with previously untreatable or difficult to treat conditions. With investment in IMRI, our surgeons are offering those superior results.

Neurological disorders are highly individual challenges that require close focus and unwavering commitment. As a center of excellence, we pride ourselves on being able to offer some of the region’s best results by tailoring our care to each patient’s unique circumstances. We are also committed to serving the needs of physicians looking to give their patients the most effective treatment options available.

If you have a question about iMRI and how it can benefit your patients or want to arrange a consultation or referral, please call us at (303) 938-5700.