A novel computer-assisted volumetric stereotactic approach for resecting tumors of the posterior parahippocampal gyrus

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The authors report their experience using a novel surgical approach for resecting tumors located in the posterior parahippocampal gyrus. Prior attempts to resect epileptogenic foci in this location have been limited by a significant risk of injury to lateral temporal lobe cortical and vascular structures. To avoid these potential complications, the authors have used a lateral occipitosubtemporal, computer-assisted stereotactic volumetric approach to resect radiographically defined tumors in seven patients with intraaxial neoplasms of the posteromedial temporal lobe. This series included one female and six male patients, ranging in age from 15 to 67 years, who presented with seizures, visual field loss, or headache. Gross-total resection of three high-grade gliomas, two gangliogliomas, and one mixed glioma was accomplished with no permanent morbidity or operative mortality. The authors conclude that this approach is advantageous for resecting tumors in this location because, by avoiding unnecessary brain resection or retraction, it significantly reduces the risk of injury to lateral temporal lobe structures, helps maintain precise spatial and anatomical orientation for the surgeon, and, like all computer-assisted volumetric approaches, delineates the margin between the tumor and surrounding neural tissue.

KEY WORDS • brain neoplasm • computer • hippocampus • stereotaxis • temporal lobe

TUMORS of the posterior parahippocampal gyrus represent a formidable technical challenge to neurosurgeons. The proximity of such lesions to vital structures surrounding the posterior mesial temporal lobe in the dominant hemisphere, including the brainstem, cranial nerves, posterior cerebral and anterior choroidal arteries, basal vein of Rosenthal, as well as the vein of Labbé and the language cortex, raises the possibility of potentially disastrous operative morbidity. Several surgical approaches to this region have been described for resecting epileptogenic lesions in the amygdala and hippocampus. However, these approaches require either resection or significant retraction of eloquent cortex and have been associated with several postoperative complications, including dysphasia and visual field defects. Moreover, exposure of the posterior hippocampus by means of an anterior approach is technically difficult.

Using both computer-assisted stereotactic and microsurgical techniques, the senior author (P.J.K.) has implemented a novel approach for volumetrically resecting tumors of the mesial posterior temporal lobe and parahippocampal gyrus. By avoiding resection or retraction of the temporal lobe, this approach avoids injuring surrounding neural and vascular structures. In this report, we describe our recent experience using this lateral occipitosubtemporal, computer-assisted volumetric stereotactic approach in seven patients, all operated on since 1994 by a single surgeon.

Clinical Material and Methods

Patient Characteristics

Seven patients (six males and one female) underwent stereotactic resection of posterior mesial temporal lobe tumors via a lateral occipitosubtemporal approach. The operations were all performed by the senior author (P.J.K.) at New York University Medical Center between January 1994 and March 1995 (a 15-month period). Clinical information pertaining to these cases is summarized in Table 1. Patient ages at presentation ranged from 15 to 67 years (mean 39 years). Five tumors were located in the dominant (left) posterior hippocampus–parahippocampal gyrus and two were located in the nondominant (right) hemisphere. Three patients presented with seizures, one with visual field loss and hemiparesis, one with visual field loss and dysphasia, and one with headache. One patient harbored a tumor found incidentally.
Several patients were referred for stereotactic volumetric resection after previous neurosurgical interventions had failed. One patient (Case 1) had undergone previous stereotactic biopsy and radiation therapy at another institution followed by stereotactic volumetric resection of a right posterior hippocampal oligoastrocytoma 30 months prior to his current admission. A second patient (Case 2) presented after undergoing stereotactic biopsy of a dominant-hemisphere high-grade glioma at another hospital. Another patient (Case 3) was also referred for stereotactic volumetric resection of a dominant-hemisphere hippocampal glioblastoma multiforme following stereotactic biopsy at an outside institution. A fourth patient (Case 6) was referred for resection of a right hippocampal glioblastoma multiforme after a stereotactic biopsy performed at our institution revealed the lesion. A fifth patient with a dominant-hemisphere cystic ganglioglioma (Case 7) had undergone multiple unsuccessful procedures over a 10-year period including: two subtotal surgical resections, three stereotactic cyst aspirations, two stereotactic implantations of iodine-125, fenestration of the cyst into the ventricular system, and placement of an intracystic reservoir, which eventually became infected.

The preoperative computerized tomography (CT) and magnetic resonance (MR) imaging characteristics found in this group were as follows: three tumors (Cases 2, 3, and 5) were contrast-enhancing ring lesions with surrounding T1 and T2 prolongation (Type II); two (Cases 1 and 4) showed T1 prolongation (Type III); one (Case 6) had solid contrast enhancement with surrounding T2 prolongation (Type II); and one (Case 7) showed homogeneous contrast enhancement with an associated cyst (Type I).4,5

Data Acquisition and Surgical Planning

The technical aspects of the computer-assisted volumetric stereotactic craniotomy have been described previously.4,6,7 After local anesthesia has been induced in the patient, a CT- and MR-compatible stereotactic headframe is attached to the head by means of four carbon-fiber pins inserted through holes drilled into the diploe of the skull. Data acquisition is begun as the patient undergoes stereotactic CT and MR imaging, followed by stereoscopic digital subtraction internal carotid and vertebral angiography. These data are then transferred into the operating room computer system (COMPASS Stereotactic System; Stereotactic Medical Systems, Inc., Rochester, MN). On the image-display console, the surgeon views each CT and MR image that demonstrates the target lesion. A single point located in the approximate center of the lesion on one of the CT or MR imaging slices is digitized and retained as the reference target point. The most inferior and superior slices that demonstrate the lesion are indicated, and the computer then reads in each intermediate slice. Using the display cursor, the surgeon digitizes successive tumor contours on contiguous CT and MR imaging slices by tracing the outline of the lesion. The interpolated CT and MR imaging–defined volumes are constructed around the reference target point, which is placed in the focal point of the stereotactic arc-quadrant frame. The computer then reconstructs the digitized CT- and MR imaging–defined tumor outlines into a volume within stereotactic space with reference to the target point. The computer can then slice these CT- and MR imaging–defined volumes perpendicular to any specified viewline that is expressed in arc and collar angles on the stereotactic instrument. Tumor volume slices viewed perpendicular to an intended trajectory may then be displayed with respect to the stereotactic trephine craniotomy (1.5- or 2-in diameter) or the stereotactic retractor (2- or 3-cm diameter). The tumor volume may also be superimposed on the digital subtraction angiographic images so that when planning the operative trajectory, the surgeon can avoid important arteries, veins, sulci, and gyri. The stereoscopic angiographic images of the cortical arteries and veins help to establish the sulcal anatomy.

Data acquisition and surgery take place on separate days. The stereotactic headholder is removed following CT and MR imaging and angiography and is subsequently reapplied at the time of surgery. Detachable micrometers that record the distance from the end of the carbon-fiber pins to the vertical supports of the headframe are used to ensure precise replacement of the frame for later surgical procedures. Therefore, surgical planning can take place at the computer console in a relaxed environment.

Surgical Procedure

Figure 1 illustrates the operative approach to the posterior parahippocampal gyrus that is made using a stereotactic volumetric lateral occipitotemporal approach. Each procedure is performed after general anesthesia has been induced endotracheally in the patient. The CT-compatible stereotactic headframe is replaced using the same pin placements and micrometer settings that were used for data acquisition. The patient is placed in the three-quarter prone position, with the head rotated to the 135° or 225° position for left- or right-sided lesions, respectively. After infiltrating the skin with 1% lidocaine, a pilot hole is drilled at specified arc and collar angles, and a vertical linear skin incision is made. A 2-in diameter trephine craniotomy is performed in line with the selected trajectory, and the dura is opened in a cruciate fashion. The trephine is positioned so that its diameter is two-thirds above and one-third below the lateral sinus, approximately half the distance between the torcular herophili and the vein of Labbé. To avoid potential sinus laceration, extreme care is taken to ensure that the trephine axis does not depart from its perpendicular orientation to the skull or inadvertently extend too deeply. This routine maneuver has resulted in no sinus injuries. Dural tack-up sutures are used to retract the lateral sinus inferiorly. Relaxation of the posterior temporal lobe is facilitated primarily with the aid of reverse Trendelenburg positioning, propofol-induced anesthesia, and hyperventilation to a PCO2 of from 25 to 28 mm Hg. Continuous drainage of small amounts of cerebrospinal fluid from the subarachnoid space during the procedure further facilitates mobilization of the temporal lobe from the tentorium. This maneuver has not resulted in a significant intraoperative shift of structures with respect to the imaging data and, therefore, has not compromised the accuracy of the stereotactic approach in any of the cases. The vein of Labbé is identified and preserved. Smaller draining veins from the posterior temporal lobe to the
The lateral sinus are identified, coagulated, and cut with microscissors. The posterior temporolateral occipital lobe is thereby mobilized, and the temporal lobe is lifted off the tentorium with the aid of the bipolar forceps and a suction tip protected by cottonoid strips. Self-retaining retractors are never used.

The surgical procedure is conducted with the assistance of a video display monitor in the operating room that shows the position of the radiographically defined tumor margins with respect to the outline of the trephine. Initially, the depth of the most superficial aspect of the tumor from the slice-reformatted images is measured. Using a stereotactic coagulation probe set to this depth, an entry point on the basal aspect of the temporal lobe is identified, which corresponds to the most superficial tumor slice. A cortical incision is made at this entry point using bipolar cautery and microscissors. The operating microscope is then brought into position and the remainder of the resection is performed using a microsurgical technique. Using the superficial reconstructed tumor slices as a template, the surgeon then extends the cortical incision medially and laterally. The computer-reformatted tumor slice images can be superimposed directly on the surgical field by means of the “heads-up” display on the operating microscope, facilitating the identification of the margin between tumor tissue and the surrounding brain. The surgeon always dissects the tumor totally from the surrounding structures before entering the lesion. Once the tumor is encountered, a plane is progressively developed microsurgically between the tumor and the surrounding white matter laterally, medially, and superiorly until the temporal horn is encountered. After the tumor is circumferentially dissected free from the surrounding parenchymal tissue and vascular structures, it is removed in a piecemeal fashion using bipolar cautery, suction, and biopsy forceps. In most cases, the tumor is attached to the choroid plexus of the temporal horn and the atrium of the lateral ventricle. This attachment is coagulated with the bipolar cautery and cut with microscissors. At the end of the tumor removal procedure, the ambient cistern is identified medially, the roof of the temporal horn superiorly, the temporal lobe white matter laterally, and the occipital lobe white matter medially and superiorly. Hemostasis, achieved using bipolar cautery and Surgicel, is continued until the irrigation fluid is clear. The dura is then closed in a water-tight fashion, the bone flap is replaced, and the scalp is closed in two layers.

In several cases we have also used a frameless stereotactic system (Regulus COMPASS Stereotactic System; Stereotactic Medical Systems, Inc., Rochester, MN) to supplement the frame-based method.

In each case in this series, the expressed goal of surgery was resection of the CT- and MR imaging–defined tumor volume; namely, the contrast-enhancing solid tumor tissue in the cases of Types I and II tumors, or the T1- and T2-defined signal abnormality in the cases of nonenhancing Type III tumors. Figure 2 shows pre- and postoperative MR imaging from an illustrative case.

Results

Total tumor removal was achieved in six of the seven procedures. In one patient (Case 3), the postoperative MR image revealed a small area of residual contrast enhancement anterior to the surgical cavity and signal abnormalities in the splenium of the corpus callosum and the deep white matter of the contralateral hemisphere, which indicated the extensively infiltrative nature of this tumor.

Histological examination of the series’ surgical specimens revealed three glioblastomas multiforme, two gangliogliomas, one anaplastic astrocytoma, and one mixed glioma (oligoastrocytoma) (Table 1).
The follow-up period for this study ranged from 4 months to 18 months (median 11 months; mean 8.4 months). No patient died or experienced permanent morbidity. The five patients who were neurologically intact preoperatively experienced no new neurological deficits after surgery. One patient (Case 7) who had a right hemiparesis preoperatively was initially worse following surgery. However, she experienced progressive improvement in her power and was eventually discharged on the 7th postoperative day neurologically unchanged. Another patient (Case 5) who presented with a superior right quadrant anopsia experienced transient postoperative visual worsening in the inferior quadrant as well, which resolved 1 week after surgery. Two months after surgery, one patient (Case 3) experienced a marked progression of his tumor while undergoing chemotherapy; since then he has required continual steroid administration. The patients diagnosed with glioblastoma multiforme and anaplastic astrocytoma were each referred for radiation therapy and chemotherapy.

**Discussion**

Exposure of the posteromedial temporal lobe has long been considered technically challenging. The proximity of this region to the midbrain, crural and ambient cisterns, anterior choroidal and posterior cerebral arteries, and the basal vein of Rosenthal mandates precise anatomical localization and spatial orientation by the surgeon. Moreover, standard approaches to this area have been unsatisfactory insofar as each has necessitated either retraction or resection of lateral temporal cortex, risking speech and visual field disturbances or potential injury to the vein of Labbé. Neurosurgeons have gained access to the region of the posteromedial temporal lobe via transsylvian, transcortical, or subtemporal approaches. The majority of approaches to this area already described have been directed at the removal of foci of seizure activity in patients with temporal lobe epilepsy.

Wieser, Yasargil, and others developed the transsylvian approach for selective amygdalohippocampecto-
my to minimize temporal neocortical resection, leaving the lateral surface of the temporal lobe intact and sparing speech functions of the dominant hemisphere. This approach involves opening of the sylvian fissure, subtotal resection of the amygdala, and hippocampal and parahippocampal resection through the temporal horn.3,6,17 Finding this anterior approach to the mesial temporal structures to be encouraging in the control of complex partial seizures of anteromedial origin, Kelly, et al.,8 nonetheless emphasized that exposure of the posterior hippocampus by means of this anterior approach is not adequate.

Spencer and associates14 described a technique for achieving access to posterior medial temporal lobe structures in patients with unilateral posterior hippocampal seizure foci. Their modified anteromedial temporal lobectomy consisted of en bloc removal of the anterior middle and inferior temporal gyri, resection of the remaining lateral temporal lobe, and resection of the posterior hippocampus or posteromedial temporal intraaxial mass.3,14 However, this approach is not optimal because it requires not only an anterior temporal lobectomy but also retraction of the remaining posterolateral temporal cortex with a self-retaining retractor.

Similarly, transcortical–transventricular approaches to mesial temporal structures all require some resection of cortical tissue, as well as disruption of white matter fibers of the temporal stem.3 The transventricular amygdalo-hippocampectomy described by Niemeyer,10 in which a cortical incision was made in the middle temporal gyrus, preserves the superior temporal gyrus; however, it necessitates significant resection of middle and inferior temporal white matter to gain access to the temporal horn, amygdala, hippocampus, and parahippocampal gyrus.3,10

Olivier12 described a similar approach through the superior temporal gyrus. His technique involves resection of the anterosuperior temporal gyrus, followed by aspiration of the amygdala, opening of the temporal horn, and resection of the hippocampus.3,11 Shimizu and colleagues22 approached the mesial temporal lobe through the inferior temporal gyrus, following removal of the zygomatic arch.

Kelly, et al.,8 have previously described a computer-assisted stereotactic resection of the amygdala and hippocampus via a posterolateral approach in patients with medically intractable complex partial seizures. However, because this transcortical approach involved disruption of the inferior optic radiations, all patients in their series developed nondisabling visual field deficits in the immediate postoperative period. This posterolateral–transcortical approach, identical to that used for resection of intraventricular tumors located in the temporal horn or atrium of the lateral ventricle, was selected to spare the cortical tissue related to speech function.8,15 The lateral occipitotemporal approach, described in the present report, is essentially a modification of the posterolateral–transcortical approach, designed specifically to avoid disruption of the optic radiations as well as of the speech cortex.

The subtentorial approach, as first described by Drake2 for use in treating basilar bifurcation aneurysms, avoids resection of cortical tissue. However, this procedure necessitates use of significant brain retraction to gain access to tumors located in the posterior parahippocampal gyrus.

Smith and Spetzler,13 recently described a supratentorial–infraoccipital approach to posteromedial temporal lobe lesions, in which they used a viewing wand intraoperative navigational system for guidance. Their technique differs from the one described here insofar as it is a midline approach, which is performed through an occipital craniotomy and which requires exposure of the falx, superior sagittal sinus, torcular herophili, both transverse sinuses, the occipital pole, and the great vein of Galen and its tributaries. As they observed, the disadvantages of the supratentorial–infraoccipital approach include the need for occipital lobe retraction as well as wide exposure of the midline dural venous sinuses, with the inherent risk of blood loss, air embolism, and delayed sinus thrombosis.

The lateral occipitotemporal approach has not been previously described in the neurosurgical literature. Taking into consideration the limitations of previous techniques for gaining access to this region, we believe that this route offers several advantages. Because of its lateral occipitotemporal trajectory, it obviates the need for both resection and retraction of brain tissue and thereby avoids potential damage to vital neurovascular structures, which include the optic radiations, anterior and lateral temporal cortex, vein of Labbé, the occipital pole, and the midline dural sinuses. As noted by Smith and Spetzler,13 the surgical anatomy of the medial temporocerebellar junction is not familiar to most neurosurgeons, particularly as viewed from the posterolateral approach, and the surgical trajectory is long and narrow, limiting exploration. Therefore, some form of stereotactic guidance is essential, in either the supratentorial–infraoccipital or the lateral occipitotemporal approach, to maintain spatial and anatomical orientation. Smith and Spetzler13 observed that if a frameless stereotactic unit were not available, a standard frame-based stereotactic instrument could be used to place a catheter in the lesion to assure correct localization. We believe that our computer-assisted stereotactic volumetric approach not only can accurately localize these lesions but offers the additional advantage of facilitating complete removal of radiographically defined tumor volumes by delineating the margin between tumor tissue and the surrounding parenchyma.1,4,8

References

Lateral occipitosubtemporal stereotactic approach


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