Stereotactic Approach to Skull-Base Lesions

Abstract— With improved knowledge of the anatomy and increased collaboration between the neurosurgeon and the otolaryngologist, successful surgical resection of skull-based tumors is being achieved with reduced mortality and morbidity. In spite of this, there remains a group of patients in whom an alternate surgical approach of stereotaxis may be indicated. This group of patients includes those in whom only biopsy is required, or those in whom brachytherapy using high-intensity ^{125}I is planned because the patients' general condition is not good enough to undergo open surgical resection of the tumor or the tumor is unresectable or the patient refuses open surgery. This article presents a preliminary report on stereotactic approach to skull base lesions with special emphasis on the technique. (*Skull Base Surgery, Volume 1, Number 4, 1991, p. 235*)

With improved knowledge of the anatomy and increased collaboration between the neurosurgeon and the otolaryngologist, successful surgical resection of skull-based tumors is being achieved with reduced mortality and morbidity.¹⁻⁸ In spite of this, there remains a group of patients in whom an alternate surgical approach of stereotaxis may be indicated. This group of patients includes those in whom only biopsy is required, or those in whom brachytherapy using high-intensity ^{125}I is planned because the patients' general condition is not good enough to undergo open surgical resection of the tumor or the tumor is unresectable or the patient refuses open surgery.

This article presents a preliminary report on stereotactic approach to skull base lesions with special emphasis on the technique.

MATERIALS AND METHODS

Twenty-eight stereotactic procedures were performed over a period of 3 years. Eleven procedures were for biopsy and 17 for brachytherapy. Six patients were common to both groups. The age of patients was between 25 and 80 years. The indications for the procedures have already been stated in the introduction.

Preoperative evaluation included contrast-enhanced axial computed tomography (CT) scans and axial, sagittal, and coronal magnetic resonance imaging (MRI). These scans were used in choosing the targets and planning the trajectory to the targets. Critical vascular and neural structures were visualized in three different planes on MRI, and trajectories were chosen that would avoid critical structures and would travel through the least amount of brain.

The procedure was performed under local anesthesia using the Patil Stereotactic System (Terhorst Manufacturing, Minot, ND). The details of the method of use of this system have already been described in previous publications.⁹ The entire procedure was performed on the CT table and intraoperative scans were obtained to confirm the accuracy of the procedure. Entry through the skull was made using a Steinmann pin and an air drill. The Steinmann pin was guided through the probe holder of the stereotactic frame.

Floor of the Anterior Cranial Fossa

Lesions at the floor of the anterior fossa were approached through the anterior part of the frontal lobe with

the patient supine. The entry point in the skull was 4 to 5 cm lateral from the midline.

Floor of the Middle Cranial Fossa and the Cavernous Sinus

This area was approached through the temporal lobe with the patient supine and the head turned to the opposite side of the lesion. The entry point in the skull was through the squama of the temporal bone (Fig. 1).

Cerebellopontine Angle, Jugular Foramen, and Petrous Ridge

These areas were approached through the cerebellum (Fig. 2) with the patient positioned either prone or in the lateral position. Entry into the skull was retromastoid.

Clivus Area

This was approached in the same manner as the cerebellopontine angle lesion, if the clival mass was laterally located and was large enough to displace the brainstem. A midline clivus lesion without mass effect was approached transphenoidally through the nose (Fig. 3).

A lesion in the vertebral body of second cervical vertebrae was approached transorally. A lesion in the greater wing of the sphenoid was reached using an entry point directly over the external surface of this bone. A lesion in the base of the petrous bone was reached by using entry point over the mastoid.

Figure 1. Computed tomography scan shows the biopsy needle positioned at the petrous apex.

Figure 2. Computed tomography scan shows the tip of the biopsy needle (arrow) in the jugular foramen.

Patients with lesions that extended from the cerebellopontine angle to the parasellar area, and needed radiation seeds placed in both these areas, were positioned on the side; and the two areas were approached through the cerebellum and the temporal lobe, respectively.

Biopsies were performed using a 14 or 16 gauge stainless-steel needle (with a hub length equal to the radius of the stereotactic frame's arc). Tissue for biopsy was sucked into the needle by applying 6 to 8 ml of negative pressure using a 12 ml syringe. During biopsy of lesions that were located completely within bony structures, entry into the bone was obtained by a twist drill that was guided through the probe holder of the stereotactic frame. The length of the drill bit was adjusted so that it was a few millimeters less than the radius of the stereotactic frame's arc. Drilling was continued until the probe holder prevented it from further advancement. The drill bit was then removed, and the biopsy needle was inserted through the probe holder. The last few millimeters of the undrilled portion was entered by gently tapping the needle, without the stylet, with a mallet until the probe holder prevented it from further advancement. After confirming the accuracy of the needle tip placement, 8 to 10 ml of negative pressure was applied through the needle using a 12 ml syringe and the needle was withdrawn. The contents of the syringe and the barrel of the needle were flushed into a bottle containing formalin, using a few milliliters of normal saline.

Brachytherapy of the tumors was performed by stereotactically placing the tip of a 16 gauge needle through a twist drill hole at the intended site in the tumor. After

Figure 3. Transnasal approach to the clivus guided by the stereotactic system. A: Lateral scout view obtained from the scanner shows the tip of the biopsy probe (arrow) almost at the clivus. B: Computed tomography scan showing the tip (arrow) of the biopsy needle at the clivus.

confirming the location of the needle tip at the intended site on an intraoperative CT scan, the high activity permanent ^{125}I seeds (8 to 17 mc/seed) were placed in the barrel of the needle and pushed to the target by means of a blunt stylet. The activity, the number of seeds (between 1 and 3), and the site of placement of the seed were chosen so that the high-dose radiation (approximately 200 Gy) is confined to the tumor volume.

In the six patients who underwent both procedures, the two procedures were performed at the same sitting. The biopsy was obtained first, and after the frozen section study was reported, radioactive seeds were deposited.

RESULTS

Tables 1 and 2 shows the cases that underwent biopsy based on the site and diagnosis. Pathologic tissue was obtained in nine cases. No morbidity or mortality resulted from the biopsy procedure.

Tables 3 and 4 show the breakdown of the cases that underwent brachytherapy based on location and diagnosis. The longest follow-up is for 3 years, three patients have longer than 2 years follow-up, and the median for follow-up is 16 months. All of the 15 cases that have longer than 1 month of follow-up have shown regression of the tumors on postoperative scans. Twelve patients have

Table 1. Biopsy Site for Patients Undergoing Stereotaxis

<i>Biopsy Site</i>	<i>No. Cases</i>
Cerebellopontine angle	4
Jugular foramen	1
Clivus	1
Petrous apex	1
C2 vertebral body	1
Planum sphenoidale	1
Greater wing of the sphenoid	1
Base of petrous bone	1
Total	11

Table 2. Diagnoses of Patients Undergoing Stereotaxis

<i>Diagnosis</i>	<i>No. Cases</i>
Meningioma	5
Metastatic tumor	3
Necrotic tissue	1
Normal tissue	1
Inadequate tissue for diagnosis	1
Total	11

Table 3. Brachytherapy Site in Patients Undergoing Stereotaxis

<i>Brachytherapy Site</i>	<i>No. Cases</i>
Floor of anterior cranial fossa	1
Floor of the anterior cranial fossa plus anterior segment of cavernous sinus	1
Cavernous sinus	7
Cerebellopontine angle, clivus, and cavernous sinus (posterior segment)	3
Cerebellopontine angle	3
Petrous ridge	1
Jugular foramen	1
Total	17

Table 4. Diagnosis of Lesions That Received Brachytherapy

<i>Diagnosis</i>	<i>No. Cases</i>
Meningioma	13
Metastatic tumors	3
Chondrosarcoma	1
Total	17

shown between 80 and 100% regression of the tumors (Figs. 4, 5). No mortality resulted from the brachytherapy procedure. One patient with metastatic lesion in the cavernous sinus showed progression of fifth cranial nerve lesion in spite of CT evidence of tumor regression. Another patient with metastatic lesion in the cavernous sinus

showed transient third cranial nerve involvement 2 months after placement of radioactive seed.

The mean hospital stay for all of above procedures was 1 day.

DISCUSSION

Stereotactic surgery of skull base lesions presents two special problems. The first problem is planning of safe trajectory because these lesions have close association with critical vascular and neural structures. Fortunately, the ability to obtain CT and MR images in different planes allows the surgeon to visualize the structures that surround the target and the trajectory. This enables the surgeon to plan safe trajectories. Furthermore, since high-intensity radioactive seeds were used, only a limited number of trajectories were required.

The second problem was the presence of some of the lesions within bony structures, making the biopsy procedure difficult. In order to reach such targets, an extra-cerebral trajectory was chosen and the target was reached by drilling into the bone using the stereotactic probe holder for guidance. The latter, in addition to serving as a guide for the purpose of drilling, also acted as a stop, preventing the drilling bit from entering structures beyond the lesion.

Because the radiation seeds used for brachytherapy deliver radiation at a very slow rate over a period of several months, very high-dose radiation could be delivered with-

Figure 4. A: Computed tomography scan with contrast enhancement shows a meningioma at the clivus. B: Almost complete regression of the tumor 6 months after placement of ^{125}I seeds (a radioactive seed is seen in the area of the tumor).

Figure 5. A: Contrast enhanced computed tomography (CT) scan showing a meningioma in the cerebellopontine angle. Note the displacement of the fourth ventricle to the opposite side. B: CT scan with contrast enhancement obtained at 33 months after implantation of the ^{125}I seeds shows complete regression of the tumor. Artefact seen in the cerebellopontine angle is from the radioactive seeds.

out the danger of damage to surrounding structures.^{10,11} Furthermore, since the procedures were performed with intraoperative CT monitoring, accurate seed placement could be achieved in every case, which also helped to prevent damage to the surrounding structures.

In summary, stereotactic procedures can be used as an alternative to open surgical procedures in skull base lesions when an open surgical procedure is not desired because of the age or general health of the patient or when the tumor is not totally resectable or when only a biopsy is needed. Early results indicate that this technique can be safely and effectively performed and requires only a minimal hospital stay.

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