Translabyrinthine Approach for Acoustic Neuroma

John Diaz Day, M.D.
Department of Neurosurgery, Drexel University College of Medicine, Philadelphia, Pennsylvania, and Allegheny General Hospital, Pittsburgh, Pennsylvania

Douglas A. Chen, M.D.
Department of Otolaryngology, Drexel University College of Medicine, Philadelphia, Pennsylvania, and University of Pittsburgh, Pittsburgh, Pennsylvania

Moises Arriaga, M.D.
Departments of Otorhinolaryngology and Neurosurgery, Drexel University College of Medicine, Philadelphia, Pennsylvania

Reprint requests:
John Diaz Day, M.D., Rocky Mountain Neurosurgical Alliance, P.C., 701 E. Hampden, Suite 510, Englewood, CO 80110-2776.

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ONLINE DIGITAL VIDEO

THE TRANSLABYRINTHINE APPROACH has been popularized during the past 30 years for the surgical treatment of acoustic neuromas. It serves as an alternative to the retrosigmoid approach in patients when hearing preservation is not a primary consideration. Patients with a tumor of any size may be treated by the translabyrinthine approach. The corridor of access to the cerebellopontine angle is shifted anteriorly in contrast to the retrosigmoid approach, resulting in minimized retraction of the cerebellum. Successful use of the approach relies on a number of technical nuances that are outlined in this article.

KEY WORDS: Acoustic neuroma, Surgery, Translabyrinthine approach, Vestibular schwannoma

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The translabyrinthine approach has been used for a number of years in the treatment of neoplasms of the cerebellopontine angle. The approach is commonly used in neurosurgical practice for the removal of acoustic neuromas and in combination with other approaches for cranial base tumors. This strategy is most often used as a team endeavor, combining the temporal bone drilling skills of an otologist with the intracranial microsurgical skills of the neurosurgeon. It is important for each surgeon, however, to be familiar with all aspects of the operation. Understanding the nuances of the bone removal aspect of the surgery is important for the neurosurgeon to ensure that it is adequate before tumor resection. Likewise, it is important for the otologist to be familiar with the difficulties encountered in tumor dissection when exposure is inadequate so as to best expose the region. A number of advantages realized by use of this approach, in addition to the nuances of surgical technique that result in optimizing outcome, are detailed here.

PATIENT SELECTION

The translabyrinthine approach is not an appropriate strategy in all patients with cerebellopontine angle tumors. Preoperative imaging and audiometry provide critical pieces of information in selecting the approach. Patients with a tumor of any size and with Gardner-Robertson Class III or IV hearing should be considered candidates for this approach. In general, only patients with large tumors (>2.5 cm) and hearing in Class I or II should be recommended for the translabyrinthine approach, owing to the very low possibility of hearing conservation with such a large tumor. In patients with smaller tumors and Class I or II hearing, an attempt at hearing preservation is reasonable. Patients with Class I or II hearing with small and medium-size tumors are considered candidates for a hearing preservation approach: either a retrosigmoid or middle fossa approach. Rarely, the auditory brainstem evoked response may be useful information. However, most patients who are candidates for the translabyrinthine approach already have significant or profound hearing loss, making this test not particularly useful.

Preoperative magnetic resonance imaging provides the most important information in approach selection. The main differential in the diagnosis for a cerebellopontine angle lesion is meningioma. Most patients with meningiomas of the cerebellopontine angle will have serviceable hearing and are more likely to present with imbalance. The chance of alleviating deficits such as imbalance or swallowing difficulty is quite high in the case of a meningioma. Therefore, the compulsory hearing loss from a translabyrinthine strategy is unjustified. An appearance of tumor consistent with meningioma including a dural tail makes other approaches preferable.

SURGICAL TECHNIQUE
(*see video at web site*)

Preparation and Positioning

In contrast to the majority of intracranial operations, rigid fixation of the head is not a requirement. However, the patient's body habitus may dictate placing the patient in the lateral position with rigid fixation of the head.

Patients are positioned supine with the head turned opposite the side of the lesion. It is helpful to place the patient obliquely on the table, shoulder near the surgeon, hips toward the opposite side. This results in opening the angle between the shoulder and occiput.

Mastoidectomy and Labyrinthectomy

Identification of certain landmarks is key to providing adequate exposure in the cerebellopontine angle. A common complaint of neurosurgeons with this exposure is that it is too limited for addressing larger tumors. However, when bone removal is adequate at superficial levels, the corridor of access is more than adequate for large lesions (*see video at web site*).

Superficial landmarks on the surface are located before planning and making the scalp incision. The root of the zygoma at the upper aspect of the external auditory meatus (EAM), the inion, the mastoid tip, and the backside of the body of the mastoid are palpated and marked. A semilunar incision is marked with the top at the level of the pinna. The anterosuperior limit is at the EAM. The incision curves gently posteriorly such that it extends approximately 1 cm behind the body of the mastoid. The inferior aspect of the incision ends at the mastoid tip.

Soft tissues are elevated in layers. The scalp is elevated deep to the galeal layer and raised anteriorly until the impression of the posterior border of the EAM is located. There are several methods of incising the musculofascial layer; however, a T-shaped incision will work best in terms of closure at the end of the surgery. The commonly used triangular musculofascial flap tends to shrink and is usually more difficult to close in a water-tight manner. It is best to incise this layer sharply, avoiding cautery, which tends to shrink the flaps and make closure more difficult. The musculofascial flaps are then elevated from the mastoid and suboccipital surface and retracted with low-profile hooks.

The important bony landmarks that are identified at this point are the spine of Henle, the EAM, the backside of the body of the mastoid (this is the ridge at the posterior margin of the mastoid bone), the supramastoid crest (this is a subtle ridge at the origin of the temporalis muscle and fascia), and the mastoid tip. The initial bone removal of a translabyrinthine craniotomy consists of a mastoidectomy. Drilling is started over the top of the EAM with a large cutting burr. A large suction-irrigator is useful for continually removing the large volume of bone dust created and makes bone removal efficient. Bone cuts are made along the supramastoid crest to a point just beyond the backside of the body of the mastoid and along the posterior margin of the EAM to the mastoid tip. The cortical mastoid bone can then be quickly removed to expose the underlying air cells. The spine of Henle marks the bone area overlying the mastoid antrum, which lies approximately 15 mm deep to the surface. With the antrum open, the bony lateral semicircular canal is seen (*see video at web site*).

It is very important to remove an adequate amount of bone at the margins of the mastoidectomy. Superior, middle fossa dura must be devoid of bone, and bone must be removed such that there is no remaining ledge. Bone must be removed until the dura at the lateral surface is exposed (*Fig. 1*). Posteriorly, an approximately 1-cm width of retrosigmoid dura is exposed. Inferior to the posterior semicircular canal, the superior aspect of the jugular bulb must be skeletonized, which is the inferior limit of the approach. Anteriorly, bone at the posterior aspect of the external auditory canal is removed such that only a 1-mm wall of bone remains. The vertical segment of the facial nerve in the fallopian canal is skeletonized, forming the anterior border of the exposure with the back wall of the external auditory canal. With bone removed in this way, the potential limitations in exposure from the surface are removed (*see video at web site*).

The labyrinthectomy is then performed. The most important technical points in providing optimum exposure relate to the skeletonization of the internal auditory canal (IAC). At the superior aspect, it is critically important to remove bone above the IAC and expose the vertical crest (also known as "Bill's bar") to help locate the facial nerve at the fundus of the canal. The inferior aspect of the IAC must be removed, with the medial landmark being the cochlear aqueduct. Exposure of the cochlear aqueduct will result in egress of cerebrospinal fluid (CSF). This signals that adequate bone has been removed in the medial direction, inferior to the IAC (*see video at web site*).

Tumor Dissection

Before opening the dura, it is important in the case of very large tumors to stimulate through the dura before any coagulation of bleeding points to rule out an unusual posterolateral location of the facial nerve. The dura is stimulated at a current of 0.1 to 0.3 mA. If there is no activity on the facial nerve monitor as a consequence, the dura is opened, and bleeding points are coagulated. It is helpful in cases of larger tumors to

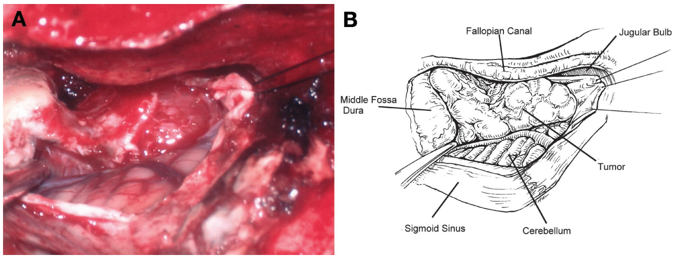

FIGURE 1. *Intraoperative photograph (A) and drawing (B). Initial view through right-side approach after dura is opened, revealing tumor and the cerebellum. Dura over the IAC remains intact.*

open the dura in the form of a "T" or an "H," tacking the dural flaps away with suture (*Fig. 1*). With the incision, an attempt is made to avoid opening the arachnoid with the dura mater.

It is important to identify and preserve the arachnoid fold over the lateral aspect of the tumor surface at the initial stage of dissection. Separating this arachnoid away from the tumor capsule helps identify the appropriate plane to best separate surrounding structures from the tumor capsule (*Fig. 2*). Over the cerebellar hemisphere anteriorly, preservation of the arachnoid helps to separate large tributaries to the petrosal vein complex that are usually present. As cerebellum is separated away, soft cottonoids are placed to preserve the opened plane and protect the structures. Use of cottonoids in this manner prevents readherence of the arachnoid to the tumor capsule, which would necessitate redissection.

Tumor dissection proceeds in a four-directional manner to maintain efficiency. The initial direction of dissection is posterior to separate away a limited portion of cerebellar hemisphere. The inferior direction is next. Here, it is very helpful to preserve the arachnoid plane, because it will result in easy separation of the lower cranial nerves from the tumor. Importantly, arachnoid inferior to the lower cranial nerves is opened to allow CSF to drain from the cisterna magna, resulting in cerebellar relaxation. This maneuver, coupled with tumor debulking, obviates the need for retractors in this procedure, even in cases of very large tumors. The superior direction is then addressed. The arachnoid plane is separated from the tumor capsule, which results in protection of the trigeminal nerve and petrosal vein. Again, as the plane is established, soft cottonoids are placed to preserve the dissection plane. An important concept in this dissection strategy is sequential dissection in the different directions down to a consistent level medially. With very large tumors, this sequential directional dissection is intermingled with debulking to reach sequential depths in the dissection (*see video at web site*).

Tumor debulking is necessary as the capsule is dissected away from the surrounding structures at sequential depths. It is advisable to always first stimulate over the area of capsule to be coagulated, opened, and debulked to ensure the absence of an aberrant facial nerve course. A number of debulking methods have been described; however, some are less efficient than others. The most efficient debulking technique is to resect pieces of tumor with a pituitary rongeur type of instrument while suctioning the pieces away with a large suction instrument (*Fig. 3*). This method rapidly removes the central portion of the tumor and can be done quite gently. Large pieces of tumor may also be cut away with microscissors. The important point with regard to tumor debulking is that this maneuver should be performed rapidly in the dissection. Experience with these cases fosters an enhanced three-dimensional sense of how far across the tumor the surgeon has dissected, which facilitates the speed with which this portion of the dissection is performed.

With sufficient tumor debulked and removed, the cerebellopontine and cerebellomedullary sulci are exposed, marking the first critical juncture in the dissection (*Figs. 4* and *5*). Inferiorly, the origin of the VIIIth cranial nerve is exposed (*Fig. 6*). The facial nerve origin at the brainstem is located just inferior and medial or medial to this point. The VIIIth nerve is divided and elevated to fully expose the facial nerve origin. Tumor is then separated from the facial nerve, working in the medial to lateral direction (*Fig. 7*). The technique that results in the least amount of manipulation and stretch of the facial nerve is to perform the dissection sharply. The tumor capsule is gently retracted from the nerve with the variable controlled suction tip, and the connections between capsule and nerve are divided sharply with microscissors or a small blade. In general, capsule can be dissected from nerve to the region near the porus acusticus.

The tumor that essentially remains at this point is that located near the porus acusticus and in the IAC. Here, the benefits of the translabyrinthine approach with regard to facial nerve dissection are realized. At the fundus, the facial nerve is located deep to the superior vestibular nerve, which is divided. This maneuver establishes the plane of dissection between the facial nerve and tumor capsule. The cochlear and inferior vestibular nerves are also divided laterally at the fundus. The tumor can then be gently retracted posteriorly with the suction while the connections between facial nerve and tumor capsule are divided sharply with microscissors or a small blade (*see video at web site*). Blunt dissection here is not recommended, because it tends to stretch and pull the facial nerve.

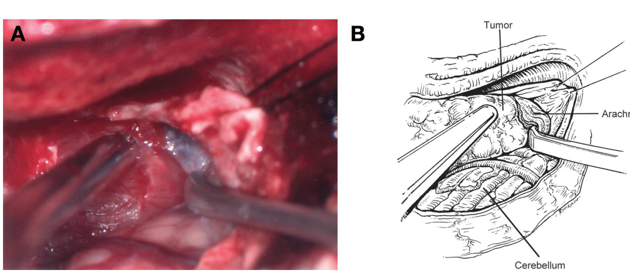

FIGURE 2. *Intraoperative photograph (A) and drawing (B). View of the double arachnoid membrane being separated from tumor capsule at the inferior aspect of the tumor, thus separating the lower cranial nerves from the inferior pole of the tumor.*

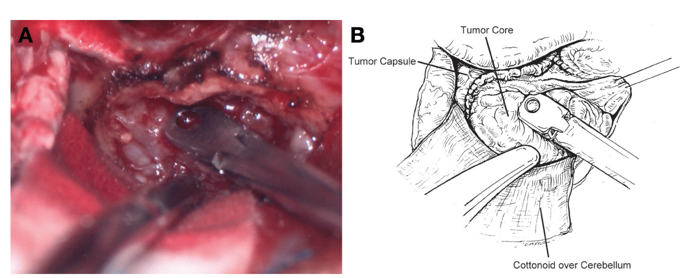

FIGURE 3. *Intraoperative photograph (A) and drawing (B). Tumor capsule is coagulated and opened, and internal debulking is performed with suction and a pituitary rongeur.*

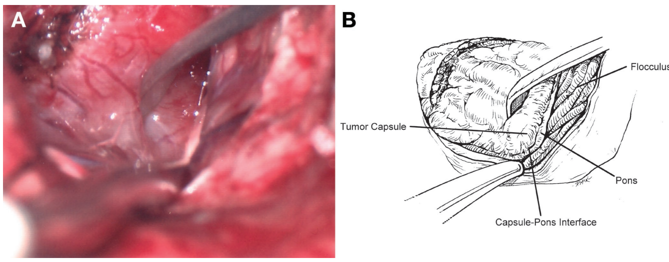

FIGURE 4. *Intraoperative photograph (A) and drawing (B). After debulking, tumor is further separated from the cerebellum and brainstem. The arachnoidal connections seen spanning the gap between capsule and pia are sharply divided.*

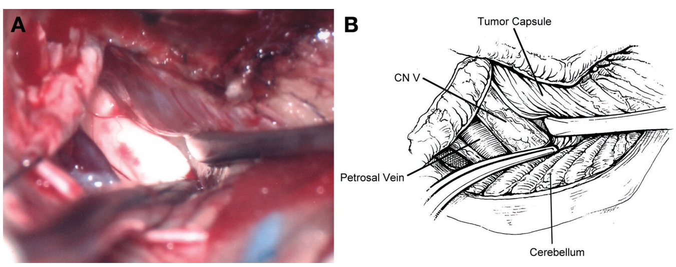

FIGURE 5. *Intraoperative photograph (A) and drawing (B). The superior pole of the tumor capsule is seen here separated from the trigeminal nerve and the petrosal vein. These structures are covered by a soft cottonoid after dissection for protection and to preserve the dissection plane.* CN, *cranial nerve.*

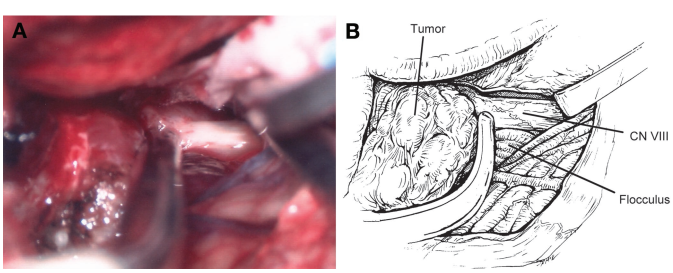

FIGURE 6. *Intraoperative photograph (A) and drawing (B). Inferiorly, the origin of the VIIIth cranial nerve (seen in the photograph) is exposed and divided, mobilizing the inferior pole of the tumor. The facial nerve origin at the brainstem is then visible.* CN, *cranial nerve.*

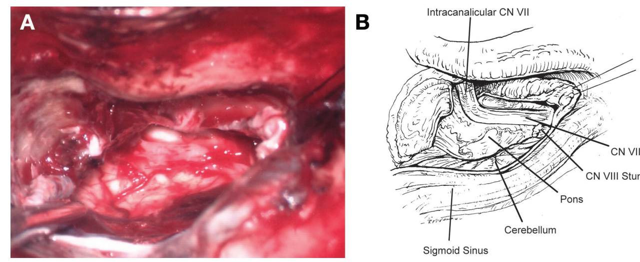

FIGURE 7. *Intraoperative photograph (A) and drawing (B). Final view after tumor removal showing the facial nerve from its brainstem origin to its intracanalicular course.* CN, *cranial nerve.*

As the region of the porus acusticus is approached, the facial nerve will tend to spread out over the capsule, especially in the case of larger tumors. The interface between tumor capsule and nerve must be preserved and kept in view under high magnification. At times, the facial nerve will essentially become a nearly transparent veil. The facial nerve stimulator becomes very helpful under these circumstances to determine the margins of the nerve. Again, sharp dissection should be used whenever possible to divide the fine connections between nerve and capsule, minimizing stretch on the extremely fragile nerve fibers. The goal during this phase is to perform the dissection with a minimum of signals reporting from the facial nerve monitor.

In some cases, the plane of dissection is lost because of tumor infiltration into the facial nerve. In this instance, it is best to leave a thin cap of tumor capsule against the involved segment of the nerve to preserve function. Such fine remnants are unlikely to grow because they have essentially little in the way of blood supply. Such remnants can in general be thinned with microscissors or an ultrasonic aspirator on very low power with no suction. The remnant is thinned until it stimulates with the facial nerve stimulator, indicating that the remnant possesses facial nerve fibers that are clearly not separable.

With tumor removed, hemostasis is obtained. In some cases, a small bleeding point may be present on the facial nerve. Such bleeding is controlled with a small piece of oxidized cellulose or microfibrillar collagen hemostat. No cautery is used in the vicinity of the facial nerve. Bleeding points on the pontine or cerebellar surface are treated similarly with oxidized cellulose, and the area is filled with warmed saline irrigation.

Reconstruction and Closure

Meticulous attention to closure technique is aimed at prevention of CSF leaks, probably the most common complication of the procedure. An important maneuver in this regard is closure of the eustachian tube orifice in the middle ear cavity. The facial recess is opened, and the incus is removed. The tendon of the tensor tympani muscle is then divided, which provides a good view of the eustachian tube orifice. The orifice is then occluded with small pieces of muscle and oxidized cellulose. The middle ear space is then also packed with pieces of muscle.

Our current closure technique has provided an extremely low incidence of CSF leak (<1% in the past 100 cases). Small strips of adipose tissue are harvested from the abdomen. After loose reapproximation of the dural flaps with suture, pieces of adipose tissue are placed in the depth of the mastoid defect up to the level of the middle ear space. Hydroxyapatite bone cement is then used to fill the remainder of the defect up to the level of the bone surface (*Fig. 8*). Care is taken to place cement into the mastoid antrum and facial recess. This technique cosmetically reconstructs the mastoid surface. The soft tissue flaps are then closed over a drain, and a pressure dressing is applied for 1 day.

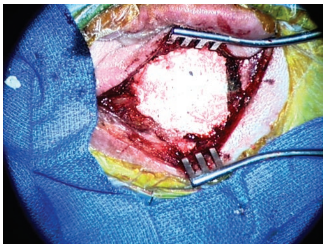

FIGURE 8. *Intraoperative photograph. The mastoid is reconstructed with an adipose graft in the depth and hydroxyapatite cement to cosmetically reconstruct the bone surface. The cement provides a natural contour to the mastoid area.*

CONCLUSIONS

The translabyrinthine approach is useful in the microsurgical removal of both large and small vestibular schwannomas. Successful performance of this technique relies on adherence to several key concepts. Mastoid bone removal must be wide, eliminating a restricted corridor of access at the surface. Skeletonization of the IAC should be performed such that more than 180 degrees of circumference is exposed, with the goal being closer to 270 degrees. The vertical and horizontal crests should be exposed, marking complete exposure of the IAC. Tumor resection is performed with particular attention paid to preservation of the arachnoid-tumor capsule interface, which helps protect the surrounding neural and vascular structures. The facial nerve is dissected from the tumor capsule in the lateral-to-medial direction in the IAC and usually vice versa in the cerebellopontine angle. Finally, CSF leakage, the primary complication with this technique, can be limited with attention to closure of the eustachian tube orifice and any opened air cells.

Acknowledgment

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COMMENTS

The translabyrinthine approach is an important part of the neurosurgical–neuro-otological armamentarium for acoustic neuromas. I use it primarily for tumors smaller than 2.5 cm together with poor hearing function. There is still a higher cerebrospinal fluid (CSF) leak rate with this approach than with the retrosigmoid approach, in which CSF rhinorrhea has been eliminated with the use of fat graft in the internal auditory canal and dural closure with fibrin glue.

Laligam N. Sekhar
Great Neck, New York

Day et al. nicely summarize the translabyrinthine approach for removal of vestibular schwannomas in patients with nonserviceable hearing and large tumors. The translabyrinthine approach is widely used for these indications. The retrosigmoid or suboccipital approach is also used by many surgeons. In such cases, the choice of approach for these large tumors, regardless of the patient's hearing status, is less important than the use of one approach consistently so that the surgeon's level of comfort increases with experience and complication rates correspondingly decrease.

We prefer to use frameless image guidance for large tumors to ensure that the brainstem is in no danger. Some may argue that image guidance is overkill. When considering a patient's livelihood or facial nerve outcome, however, such checks and balances will not increase the probability of complications and probably will limit them.

An adequate translabyrinthine exposure or even an extended translabyrinthine exposure is paramount for accessing large tumors involving the cerebellopontine angle. Adequate exposure provides the surgeon unobstructed access to the entire cerebellopontine angle both medial and inferior to the fundus of the internal auditory canal. The advantage of the translabyrinthine approach is immediate identification of the facial nerve and the ability to separate it from the superior vestibular nerve by way of Bill's bar. Identifying the facial nerve early rather than late in the operation has inherent benefits. The disadvantage of the translabyrinthine approach is that the risk of injury to the facial nerve may be increased during drilling. The larger the tumor, the more likely, of course, that the facial nerve will be thinned significantly, so much so that it can appear transparent. In our experience, the most vulnerable portion of the facial nerve is the junction of the most medial aspect of the internal auditory canal and the posterior petrous bone, where the facial nerve can easily be traumatized against the petrous bone itself.

We think that meticulous closure is essential to minimize the chance of CSF leakage. In particular, we would echo the authors' comment to close the orifice of the eustachian tube in the middle ear cavity. We obstruct the eustachian tube with Nu-Knit (Johnson & Johnson, Arlington, TX) and fill the middle ear space with strips of muscle harvested from the temporalis muscle. Furthermore, we frequently place a lumbar drain preoperatively and leave it in place 3 days after surgery to minimize the chance of CSF leakage.

To fill the mastoidectomy defect, we use strips of fat placed in a corkscrew-type manner and cover the defect over the mastoidectomy with a linear high-density polyethylene prefabricated implant (Medpor Biomaterial, Newnan, GA) cranioplasty that is prefabricated in the shape of the mastoid. We have abandoned the use of hydroxyapatite cement because in several cases it has been associated with erosion into the internal auditory canal. Furthermore, when the cement is setting, we noticed cracking and extrusion through the wound during closure.

Randall W. Porter
Mark J. Syms
C. Philip Daspit
Robert F. Spetzler
Phoenix, Arizona

The translabyrinthine technique is one of the oldest cranial base approaches. It fulfills the most important criteria of cranial base strategies in that it sacrifices bone in lieu of brain retraction. Neuro-otologists have made a major impact on the care and management of patients with acoustic neuromas dating back to the early 1960s. William House was arguably one of the first surgeons to adapt a microscope for use in the operating room. Despite the inroads made with stereotactic radiosurgery, I suspect that the most common approach used for the surgical management of acoustic neuromas in the United States is still the translabyrinthine approach. Thus, it behooves neurosurgeons who are interested in developing a team approach for this particular entity to become familiar with the translabyrinthine strategy. The authors rightfully emphasize the need for an exaggerated exposure in terms of the mastoid drilling. A typical mastoidectomy for chronic ear disease is woefully inadequate to use as an approach for the treatment of even small acoustic neuromas. What must be created is in effect a very shallow saucer of exposure, skeletonizing the sigmoid and the dura behind it as well as the middle fossa dura and the jugular bulb. It is only then that neurosurgeons at the early aspects of the learning curve can achieve any amount of comfort in maneuvering through this aperture in the cerebellopontine angle. The translabyrinthine and retrolabyrinthine exposures form an important component of other transpetrosal cranial base strategies and are thus an important component of the neurosurgeon's armamentarium.

Steven L. Giannotta
Los Angeles, California

***Anatomic plate and explanation from Casserius'* Tabulae Anatomicae.** *Superficial dissection showing the musculature and vasculature of the human head, along with renderings of the eye. (Courtesy, Rare Book Room, Norris Medical Library, Keck School of Medicine, University of Southern California, Los Angeles, California.)* *Also see pages 390, 464, and 499.*