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Middle Fossa Approach for Acoustic Tumor Removal

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The middle fossa approach for vestibular nerve section was reported as early as 1904; however, hammer and chisel were used for surgery at that time, which put the facial nerve at risk [1]. The middle fossa approach did not have widespread application until refined by the senior author (WFH) in 1961, when it was used for decompression of the internal auditory canal in cases of extensive otosclerosis [2]. That therapy was later abandoned, but it became evident that this approach was suitable for removal of acoustic tumors. Initially the middle fossa approach was used for tumors of all sizes. Further experience demonstrated, however, that it was most suitable for small tumors [3–5] and that preservation of hearing and facial nerve function was possible in a significant proportion of operated patients [6]. The middle fossa approach was used infrequently until the development of gadolinium-enhanced magnetic resonance imaging (MRI). With this development, a larger number of acoustic tumors are diagnosed when they are small and before hearing has been significantly affected, making an attempt at hearing preservation desirable.

The primary indications for the middle fossa approach are a small acoustic tumor, with less than 5 mm extension into the cerebellopontine angle, and good preoperative hearing. For hearing conservation surgery, we use the arbitrary audiometric criteria of speech reception threshold better than 30 dB and speech discrimination score better than 70%, although these indications must be individualized to the needs of the patient [7]. Some advocate attempted hearing preservation in the removal of small acoustic tumors if any measurable preoperative hearing exists [8].

The middle fossa approach provides complete exposure of the contents of the internal auditory canal, allowing removal of laterally placed tumors without the need for blind dissection [9]. This exposure ensures total removal and is well suited for the removal of very small acoustic tumors [10]. The facial nerve can be located in its bony canal, allowing positive identification in a location not involved by tumor.

The middle fossa approach is technically difficult because of the lack of robust landmarks and the limited exposure. Bleeding in the posterior fossa can be difficult to control because of the limited access. Because of its location in the superior aspect of the internal auditory canal, the facial nerve is subjected to more manipulation than in the other approaches [11,12]. In the past, facial nerve results in middle fossa cases have not been as good as those using the translabyrinthine approach for similar-sized tumors [13]. The routine use of the facial nerve monitor, however, has helped to improve these results. Patients older than 60 years do not tolerate the middle fossa approach as well as younger patients because of the fragility of the dura and retraction of the temporal lobe.

Several authors use an extended middle fossa approach for large tumors [14–16]. The tentorium is divided to give wider access to the posterior fossa. Some also perform a labyrinthectomy to enlarge the exposure when hearing preservation is not attempted [17–19].

Perioperative Management

We do not usually use preoperative or postoperative antibiotics, but despite this, the

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incidence of postoperative meningitis is very low. Because of the long-distance referral nature of our practices, we prefer that if a patient is to develop postoperative meningitis, it happen while still in southern California, instead of a partially treated meningitis occurring at home.

Intraoperative furosemide and mannitol are given to allow easier temporal lobe retraction. The junior author (CS) also routinely uses a single dose of dexamethasone (Decadron) intravenously at the beginning of surgery. It is his clinical impression that the incidence of delayed facial paralysis is reduced by this measure. This single dose of steroid does not seem to affect wound healing adversely. Long-acting muscle relaxants are avoided during surgery so as not to interfere with facial nerve monitoring.

Surgical anatomy

The surgical anatomy of the temporal bone from the middle fossa approach is compact but complex (Fig. 1). Landmarks are not as apparent as with other approaches through the temporal bone, so laboratory dissection is useful for the surgeon to become familiar with the anatomy from above.

Anteriorly the limit of the dissection is the middle meningeal artery, which is lateral to the greater superficial petrosal nerve. The arcuate eminence marks the position of the superior semicircular canal and may be readily apparent in some patients but obscure in others. Kartush and colleagues [20] have cautioned that the relationship between the arcuate eminence and the superior semicircular canal may be variable in some patients, but the superior canal tends to be perpendicular to the petrous ridge. Medially the superior petrosal sinus runs along the petrous ridge.

Surgical tolerances are tight in the area of the lateral internal auditory canal. The labyrinthine portion of the facial nerve lies immediately posterior to the basal turn of the cochlea. Bill's bar separates the facial and superior vestibular nerves. Slightly posterior and lateral to this area are the vestibule and ampullated end of the superior semicircular canal.

Identification of the geniculate ganglion can be accomplished by tracing the greater superficial petrosal nerve posteriorly to it. If the tegmen is unroofed, the geniculate is found to be slightly anterior to the head of the malleus.

The internal auditory canal lies approximately on the same axis as the external auditory canal; this relationship is useful in orienting the surgical field [14]. The more medial one progresses along the internal auditory canal, the more space exists

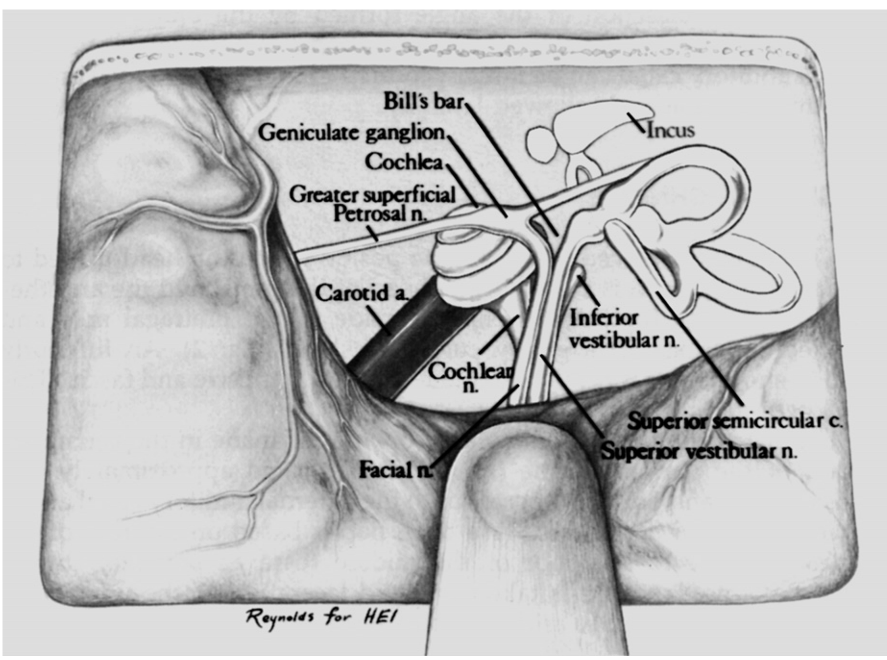

Fig. 1. Surgical anatomy of the temporal bone as viewed from the middle fossa approach. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

around it, [21] allowing for safe dissection in this area.

Several methods can be used to locate the internal auditory canal, which are reviewed in detail elsewhere [14,20]. We prefer to follow the facial nerve in a retrograde fashion to the internal auditory canal (see later). In some cases, after the geniculate ganglion has been identified, the junior author (CS) employs the technique of Garcia-Ibanez, [22] which involves drilling on the bisection of the angle formed by the blue line of the superior semicircular canal and greater superficial petrosal nerve. The internal auditory canal can be initially located in the "safe" medial area of the temporal bone and followed laterally.

Surgical technique

The patient is placed in the supine position with the head turned to the side. The surgeon is seated at the head of the table, and the anesthesiologist is at the foot. An incision is made in the pretragal area and extended superiorly in a gently curving fashion (Fig. 2). An inferiorly based U-shaped flap is fashioned of the temporalis muscle and fascia. This flap is reflected inferiorly.

Using a cutting bur, a craniotomy opening is made in the squamous portion of the temporal bone (Fig. 3). It is located approximately two thirds anterior and one third posterior to the external auditory canal and is approximately 2.5 cm square. This bone flap is based on the root of the zygoma as close to the floor of the middle fossa as possible. During creation of this flap, care is taken to avoid laceration of the underlying dura. The bone flap is set aside for later replacement.

The dura is elevated from the floor of the middle fossa. The initial landmark is the middle meningeal artery, which marks the anterior extent of the dissection. Frequently venous bleeding is encountered from this area and can be controlled with oxidized cellulose (Surgicel). Dissection of the dura proceeds in a posterior to anterior fashion. In approximately 5% of cases, the geniculate ganglion of the facial nerve is dehiscent, but injury can be avoided with dural elevation in this manner. The petrous ridge is identified with care not to injure the superior petrosal sinus. The arcuate eminence and greater superficial petrosal nerve are identified. These are the major landmarks to the subsequent intratemporal dissection. Once the dura has been elevated, typically with a suction irrigator and a blunt dural elevator, the House-Urban retractor is placed to support the temporal lobe. To maintain a secure position, the teeth of the retaining retractor should be locked against the

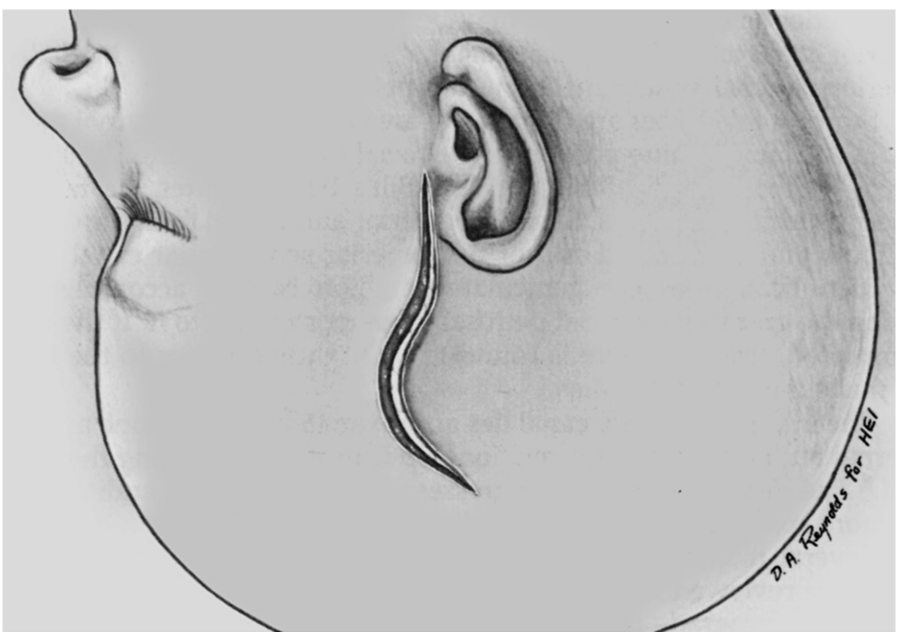

Fig. 2. Incision begins in the pretragal area and extends 7 to 8 cm superiorly in a gently curving fashion. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

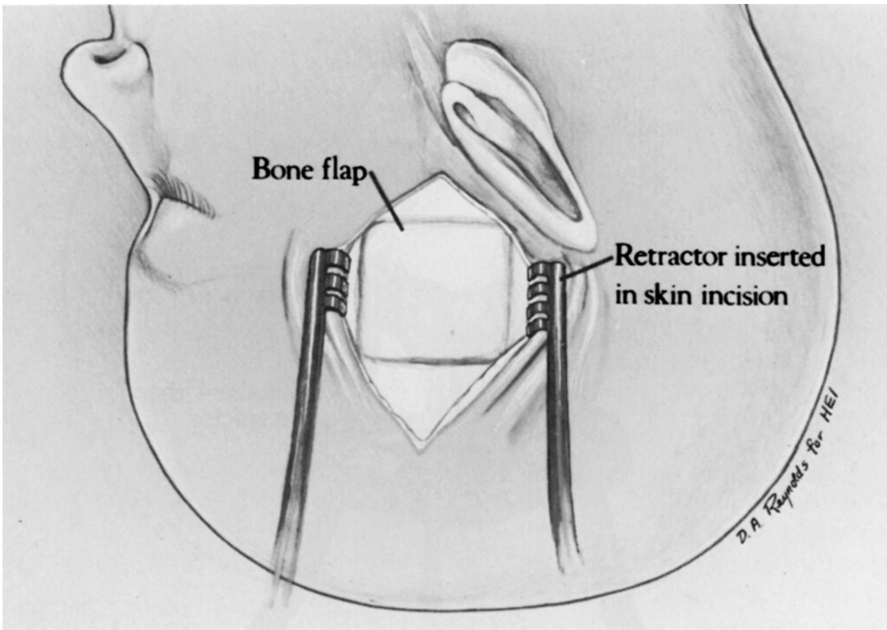

Fig. 3. Two thirds of the craniotomy window is located anterior to the external auditory canal. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

bony margins of the craniotomy window (Fig. 4). Using a large diamond bur and continuous suction irrigation, the blue line of the semicircular canal is identified at the arcuate eminence. This structure makes an approximately 45 to 60 degree angle with the internal auditory canal.

The greater superficial petrosal nerve is located medial to the middle meningeal artery (Fig. 5) then followed posteriorly to the geniculate ganglion (Fig. 6). The labyrinthine portion of the facial nerve is identified medial to the ganglion. Care must be taken to avoid the cochlea, which lies only a few millimeters anterior to the labyrinthine portion of the facial nerve.

Bone is removed from the superior surface of the internal auditory canal down to the porus acusticus. The lateral end of the internal auditory canal is dissected with identification of Bill's bar and the superior vestibular nerve (Fig. 7). Medially 180 degrees of bone can be removed from its circumference (Fig. 8). This exposure must narrow laterally because of the location of the inner ear.

The dura of the internal auditory canal is divided along the posterior aspect (Fig. 9). The facial nerve is clearly identified in the anterior portion of the internal auditory canal.

The superior vestibular nerve is cut at its lateral end, and the vestibulofacial anastomotic fibers are divided. The tumor is separated from the facial and cochlear nerves (Fig. 10). Using a right angle hook, the inferior vestibular nerve is divided, and the tumor is gently freed from the lateral end of the internal auditory canal. The tumor is separated from the cochlear and facial nerves and removed (Fig. 11). To preserve hearing, it is essential to preserve the internal auditory artery. The vessel typically runs between the facial and cochlear nerves but may not be visible during the dissection.

After irrigation of the tumor bed and establishment of hemostasis, abdominal fat is used to close the defect in the internal auditory canal. The House-Urban retractor is removed and the temporal lobe is allowed to reexpand.

The wound is closed with absorbable subcutaneous sutures over a Penrose drain if indicated. This drain is typically removed on the 1st postoperative day. A mastoid-type pressure dressing is maintained for 4 days postoperatively.

Postoperative care

The patient is observed in the intensive care unit for the initial 2 postoperative days and typically has a hospitalization of 6 to 7 days. Once leaving the intensive care unit, ambulation is

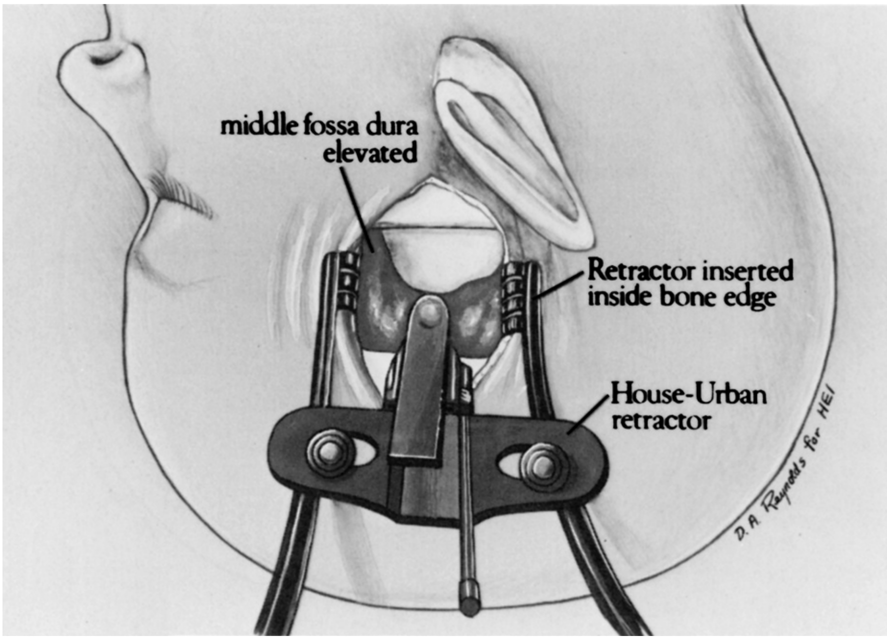

Fig. 4. Temporal lobe is supported by House-Urban retractor. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

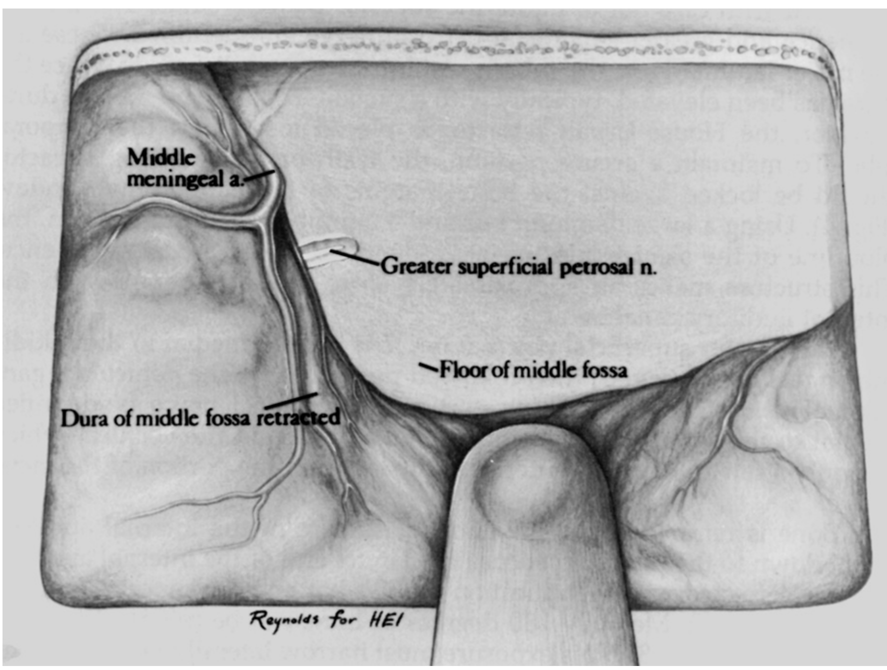

Fig. 5. The greater superficial petrosal nerve is identified medial to the middle meningeal artery. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

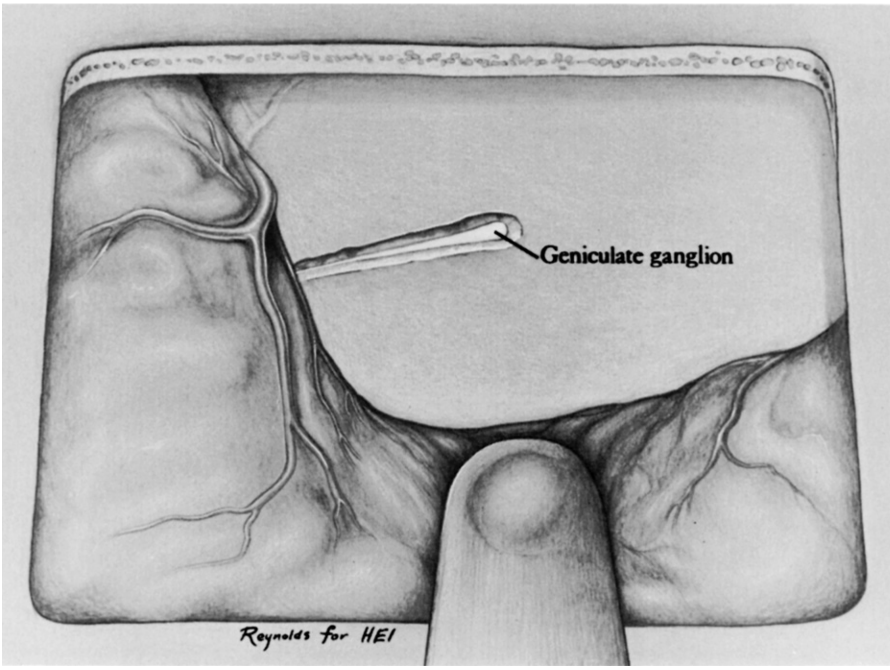

Fig. 6. The geniculate ganglion is found by following the superficial petrosal nerve posteriorly. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

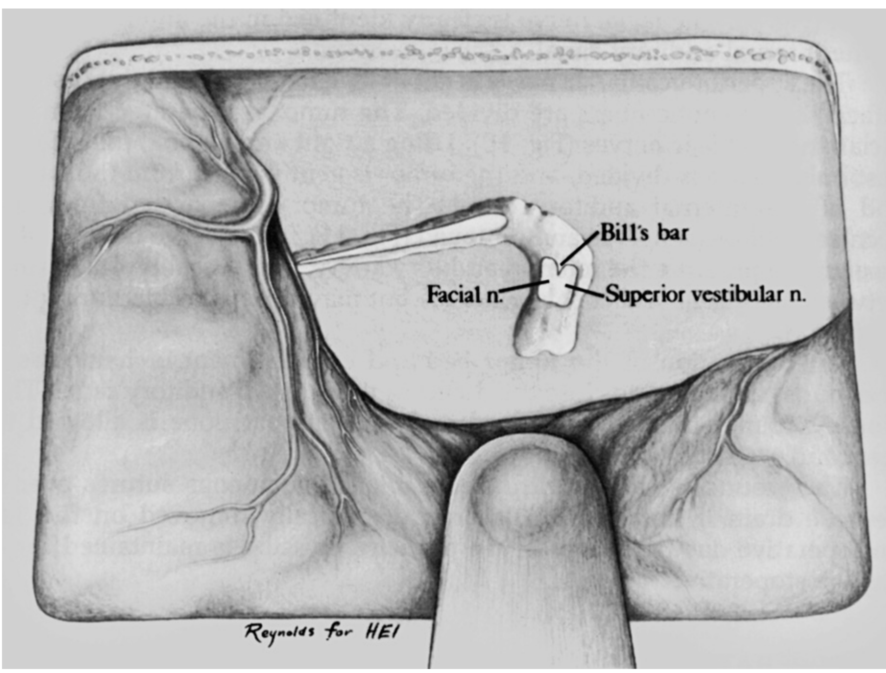

Fig. 7. Bill's bar separates the facial from the superior vestibular nerve at the lateral end of the internal auditory canal. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

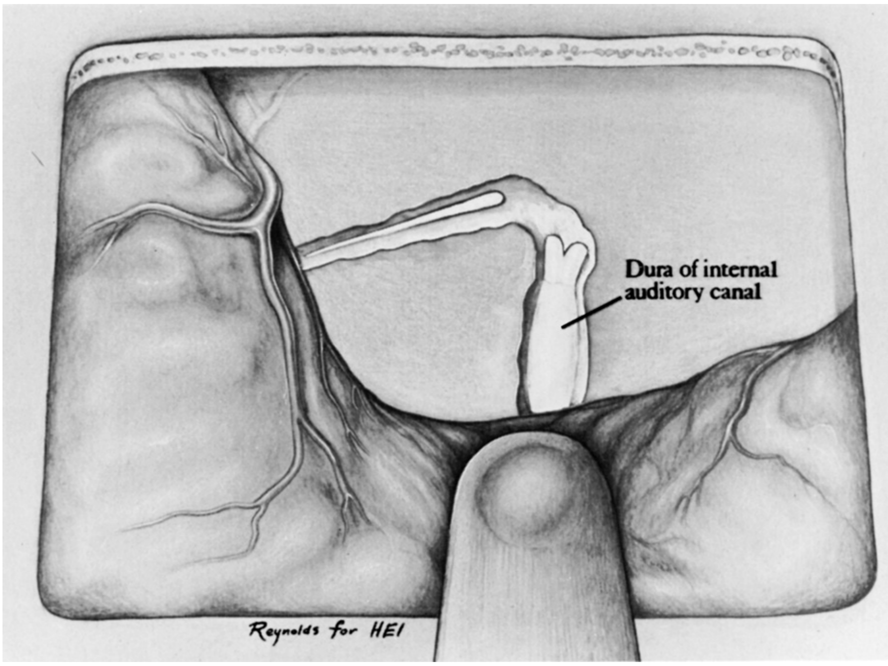

Fig. 8. The internal auditory canal is skeletonized through the entire length. Bone is removed around the porus acusticus, uncovering dura of the posterior fossa. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

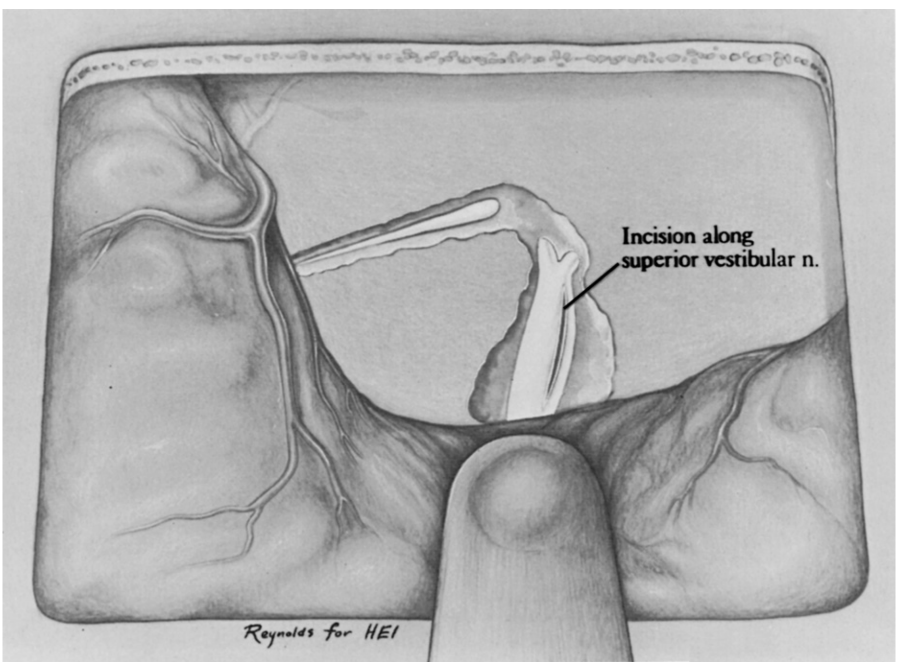

Fig. 9. The dura of the internal auditory canal is incised along the posterior aspect. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

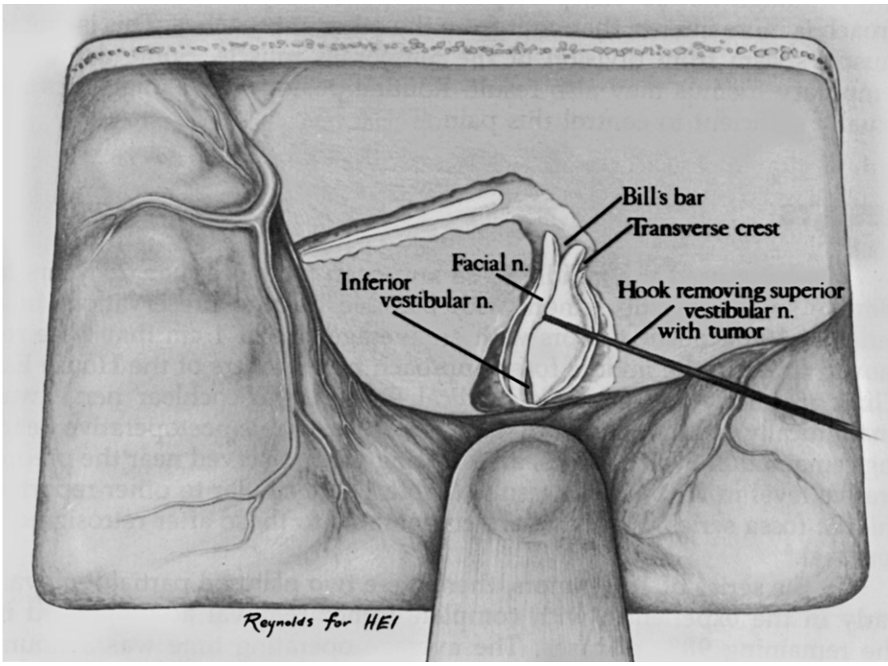

Fig. 10. The intracanalicular acoustic tumor is dissected from the facial and cochlear nerves. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

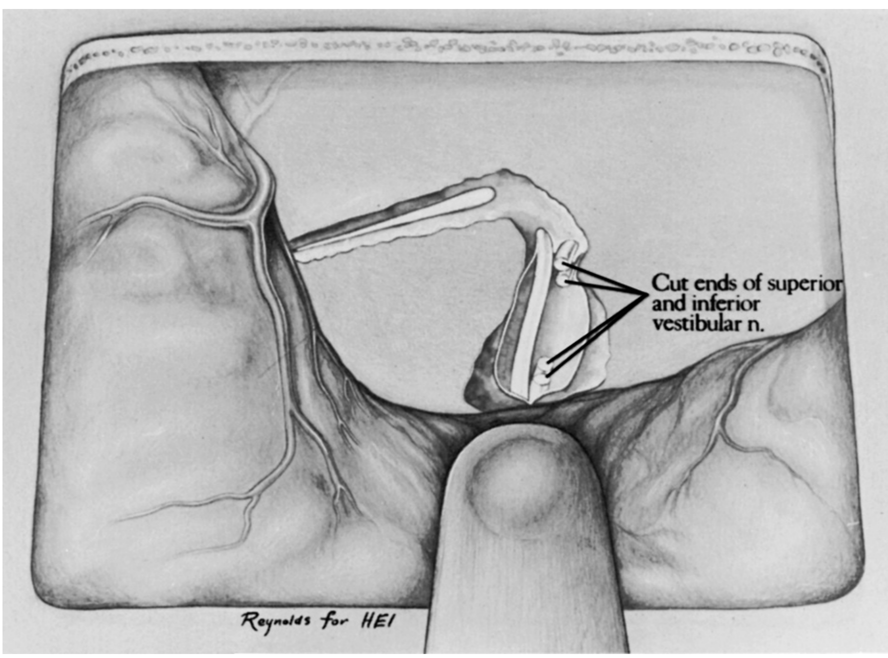

Fig. 11. Divided vestibular nerves are visible after tumor removal. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

Table 1
Postoperative facial nerve and hearing results

Series	n	Measurable postoperative hearing (%)	Anatomic facial nerve preservation (%)	Postoperative facial nerve function (house grade I or II) (%)
Shelton, et al [13]	106	59	100	89
Gantz, et al [8]	42	50	98	86
Glasscock, et al [23]	32	31	100	Na
Sanna, et al [24]	20	50	95	Na

Abbreviation: Na, not available.

encouraged. We believe early ambulation is important for rapid vestibular compensation.

Although not severe, postoperative pain after the middle fossa approach is more intense than that from the other approaches. This is due to muscle spasm from division of the temporalis muscle. Some degree of temporary trismus may also result. Routine postoperative analgesics are usually sufficient to control this pain.

Results

We have used the middle fossa approach for more than 25 years to remove small acoustic tumors with possible hearing preservation. In a series of 106 acoustic tumors with an average size of 1 cm that were removed through the middle fossa approach by members of the House Ear Clinic (formerly the Otologic Medical Group), the cochlear nerve was anatomically preserved in 89% of cases [13]. Measurable postoperative hearing remained in 59% of cases, and hearing was preserved near the preoperative level in 35%. These results (Table 1) are similar to other reported middle fossa series [8,23–26] and are comparable to those after retrosigmoid removal [27].

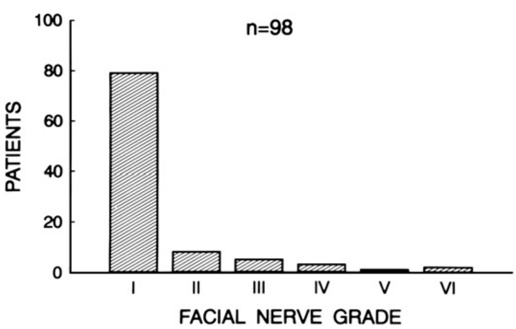

Fig. 12. Distribution of postoperative facial nerve function at 1 year or greater. Normal or near normal function occurred in 89% of patients. (*Reprinted by* permission of the House Ear Institute, Los Angeles.)

In the series of 106 tumors, there were two planned partial removals early in the experience, with complete tumor removal accomplished in the remaining 98% of cases. The average operating time was 3 hours, 12 minutes, with a range of $1\frac{1}{2}$ to 6 hours.

The facial nerve was anatomically preserved in all cases. Of the 98 patients with 1-year follow-up, 89% had House grade I or II function (Fig. 12).

Complications occurred in 18% of the patients. Two patients with cerebrospinal fluid leaks required surgical closure. No patients had postoperative seizures or hydrocephalus. Six patients had meningitis that responded to antibiotic therapy.

Serious complications were rare. There were two postoperative deaths, both in the 1960s, early in our experience. The middle fossa approach was used then for tumors that were larger than we would now consider appropriate. One patient died after a posterior fossa bleed, the other from anterior-inferior cerebellar artery thrombosis.

Postoperative seizures have been reported only in two patients from one series [23]. Electroencephalogram studies in both of these patients were consistent with an ipsilateral temporal lobe source for the epileptic activity, which was believed to be due to temporal lobe retraction.

Summary

The middle fossa approach is well suited for the removal of small acoustic tumors with possible hearing preservation. The most appropriate candidates have tumors with less than 5 mm extension into the cerebellopontine angle and good preoperative hearing (speech reception threshold $\leq$30 dB, speech discrimination score $\geq$70%). Measurable postoperative hearing can be preserved in 31% to 59% of patients, and normal or near normal facial function occurs in 86% to 89%. Serious postoperative complications are rare with this approach.

With the advent of gadolinium-enhanced MRI, it is now possible to diagnose acoustic tumors reliably when small and before hearing has been significantly affected. The middle fossa approach provides excellent access for the removal of these small tumors.

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