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Retrosigmoid Approach for Acoustic Tumor Removal

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COMMENTARY

This is an update to the approach and technique as described in the original article that follows.

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The technique for this approach to the posterior cranial fossa continues to change and evolve, partially due to changing technology such as sophisticated monitoring techniques, and partially the result of on-going critical evaluation of complications and results of the surgery.

The main indication for the retrosigmoid approach remains the patient with useful hearing and an acoustic neuroma less than 15 mm extra canalicular. Occasionally, it is used in the case of a tumor, which is entirely intracanalicular, in which it is deemed wiser (eg, the older patient) not to perform a middle fossa approach. The translabyrinthine approach is used in virtually all patients with poor hearing and/or larger tumors, in which hearing preservation is not a reasonable goal.

The surgery is performed as follows:

Monitoring: EMG based VII, BAER, SSEP, transcranial facial MEP. Position, usually supine with head rotated away and semi-fixed with tape. Occasionally, lateral with head turned and rigidly fixed (for the ''fullback'' patient). The incision currently used is a ''gentle hockey-stick.'' An anteriorly-based skin and soft-tissue flap is turned, and then a pericranial anteriorly-based (Palva) flap is raised. Barbless fishhooks are used for retraction. Mannitol is administered intravenously. The mastoid is drilled and the sigmoid sinus skeletonized from the level of the transverse sinus to close to the jugular bulb, exposing the dura behind the sigmoid. A crescentic bone flap ($>/=2.5$ cm) is removed and preserved and the dura opened, creating an anterior-based C flap, and the CSF is decompressed. Retractors are not necessary but the cerebellum and any visible tumor are protected.

Dural flaps are raised on the posterior face of the petrous bone over the IAC, which is then drilled approximately 300 degrees around at the porus and less so laterally, out to $+/-9$ mm from the porus. The internal dura of the IAC is opened horizontally, the various nerves identified, a monitoring electrode is placed on the cochlear nerve and the tumor removed.

Closure: perimeatal cells, if any, are waxed, fat placed and glued in the bony defect, the petrous dural flaps are closed, as is the posterior fossa dura with the help of a temporalis fascia graft. The bone flap is replaced with titanium mini plates. The perilabyrinthine and retrofacial mastoid cells are waxed, and abdominal fat is glued in the mastoid so as not to inhibit incus motion. The Palva flap is closed and the scalp closed in layers.

The retrosigmoid approach to the posterior fossa is a modification of the traditional neurosurgical suboccipital craniotomy. The suboccipital craniotomy gives a wide view of the posterior fossa and has been the mainstay of access to this area by neurosurgeons since it was first described by Fraenkel and colleagues [1] in 1904 (Fig. 1). In fact, Woolsey had performed the first operation in 1903, to be followed very shortly by Krause in 1905 [2].

Cushing [3] then described his operation, consisting of a large, ''crossbow'' bilateral exposure of the posterior fossa, operating on the patient in the prone position. He advocated a subtotal removal. Dandy [4] then brought the operation

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ORIGINAL MEMORIS

CONTRIBUTION TO THE SURGERY OF NEURO-
FIBROMA OF THE ACOUSTIC NERVE.[1]

BY JOSEPH FRAENKAL, M.D., AND J. RAMSAY HUNT, M.D.,
OF NEW YORK

WITH REMARKS ON THE SURGICAL
PROCEDURE

BY GEORGE WOOLSEY, M.D., AND CHARLES A. ELSBERG, M.D.,
OF NEW YORK

THE rapid advances made during recent years in our Knowledge of the location of funtions in the cerebal cortex and the function and course of various conduction paths within the brain have rendered possible the localization of a large number of brain tumors.

In some instances, especially when situated in the Rolandic area or at the base of the brain implicating cranial nerves, the location of the neoplasm may be indicated with great exactness; more often, however, only an approximate idea of its situation is possible.

An estimation of the size and character of the growth is nearly always a mere matter of speculation, based on tumor

[1] Read before the New York Neurological Society, February 2, 1904.

Fig. 1. Fraenkel's original article.

into the more modern period, using a unilateral approach in 46 cases, with a mortality of only 10.8% (Fig. 2). Considering that the operation was done with primitive inhalation anesthesia, without the use of the operating microscope, adequate lighting, microsurgical instrumentation, or intraoperative monitoring, this was quite a remarkably low mortality rate. He was an advocate of total removal, accepting the almost inevitable loss of facial nerve function (44 of 46 cases). Interestingly Dandy reported that there was "good hearing" in 34 of his cases preoperatively.

Traditionally the suboccipital approach was performed in the seated position and consisted of a long straight incision extending well into the neck; elevation of the nuchal muscles from the posterior aspect and undersurface of the occipital bone; and removal of a large segment of the bone, extending laterally to the sigmoid sinus, medially to the midline, superiorly to the transverse sinus,

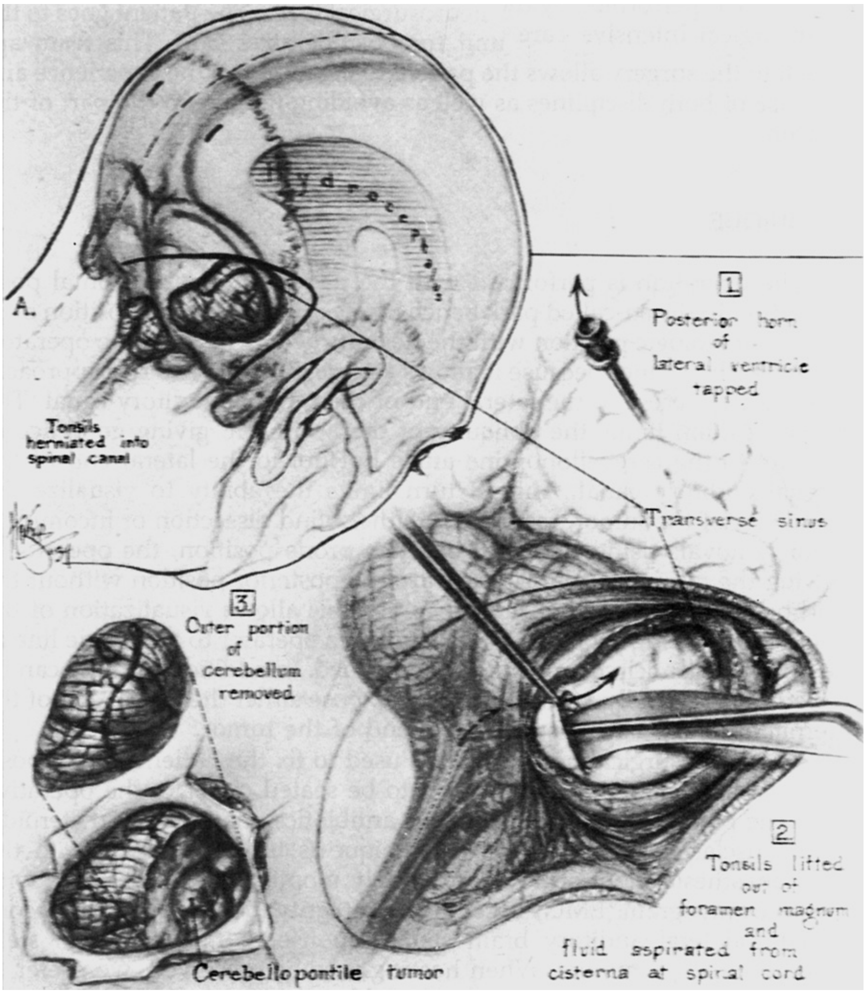

Fig. 2. Dandy's 1941 technique.

and inferiorly to the foramen magnum. Following opening of the dura, a segment of cerebellum was resected to gain access to the cerebellopontine angle, after which the tumor could be removed [5–8].

The suboccipital operation underwent many modifications, ultimately resulting in what has come to be called the *retrosigmoid-transmeatal operation* [9–13]. This approach involves a small curved or angulated incision, stopping well above the undersurface of the skull, no dissection of nuchal muscle from the bone, a limited removal of bone behind the sigmoid sinus, and no resection of the cerebellum. This is combined with exposure of the internal auditory canal by removing the posterior wall: hence the term *retrosigmoid-transmeatal*.

The surgical team consists of a neurosurgeon, neurotologist, anesthesiologist, and monitoring electrophysiologist, in addition to the usual nursing personnel. The neurosurgical team prepares the patient, makes the incision, performs the craniotomy, and exposes the tumor or the posterior face of the petrous bone as well as the VIIth and VIIIth cranial nerves in the cerebellopontine angle. If the tumor is large, the team debulks it and partially dissects it off the brain stem. Following this, the neurotologist opens the internal auditory canal and removes the remainder of the tumor.

Following tumor removal and plugging of the internal auditory canal, the closure is performed by the neurosurgical team. The patient goes to the neurosurgical intensive care unit for postoperative care. This team approach to the surgery allows the patient to benefit from the experience and expertise of both disciplines as well as avoiding fatigue on the part of the surgeon.

Technique

The operation is performed with the patient in the horizontal position, either in the so-called park bench (three quarters prone) position or in the supine otologic position with the head turned away from the operator. We prefer the former because it allows a more oblique posterior approach, giving better access to the lateral end of the internal auditory canal. The supine position limits the obliquity of the approach, giving good access medially to the cerebellopontine angle but not to the lateral end of the internal auditory canal. This in turn limits the ability to visualize the lateral end of the tumor, resulting in either blind dissection or incomplete tumor removal. Using the three quarters prone position, the operator is viewing the internal auditory canal from a posterior position without the head being rotated on the cervical spine. This allows visualization of the bone as the drilling proceeds and enables the operator to see a blue line as the posterior semicircular canal is approached. In addition, drilling can be carried as far laterally as is necessary to expose either the lateral end of the internal auditory canal or the lateral end of the tumor.

The neurosurgical head holder is used to fix the patient's head position as well as allowing the surgeon to be seated closer to the operative field. The patient receives intravenous antibiotics, mannitol, and steroids; a nonmuscle-relaxant anesthesia technique is used. In addition to the usual anesthesia monitoring, we routinely monitor the facial nerve with the electromyogram (EMG)-based nerve integrity monitor. We also record the contralateral auditory brain stem response to monitor brain stem integrity in larger tumors. When hearing is to be preserved, we prefer to monitor the VIIIth cranial nerve potential by placing an electrode directly on the surface of the VIIIth cranial nerve. If this is not feasible, ipsilateral auditory evoked responses are recorded. The incision consists of an L-shaped or C-shaped flap based anteriorly and centered at the approximate location of the transverse sinus (Fig. 3). The flap is retracted forward with barbless fishhooks. Soft tissues are elevated off the bone, and a craniotomy measuring approximately 3 to 5 cm in diameter is performed. The anterior border is the sigmoid sinus, whereas the superior border is the transverse sinus (Fig. 4). Often retrosigmoid mastoid air cells are entered, and these are filled with acrylic to seal them.

An anteriorly based dural flap is then incised and sutured forward, exposing the cerebellum. With the patient in the three quarters prone position, the head slightly elevated, and mannitol given intravenously, the cerebellum generally tends to fall away from the tumor once the

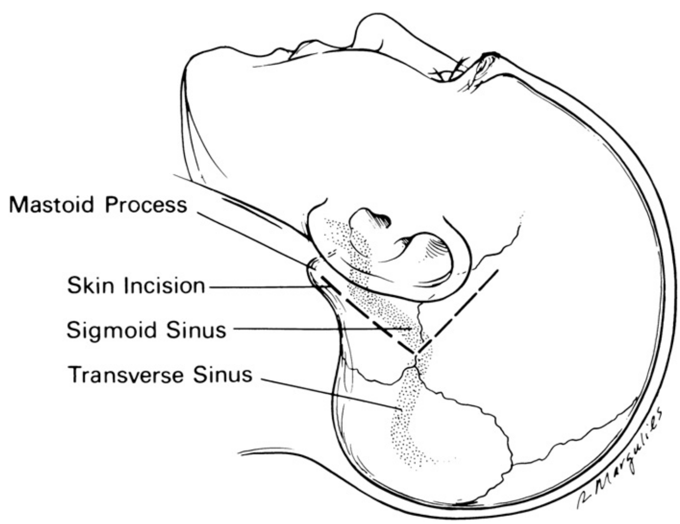

Fig. 3. Incision for retrosigmoid approach.

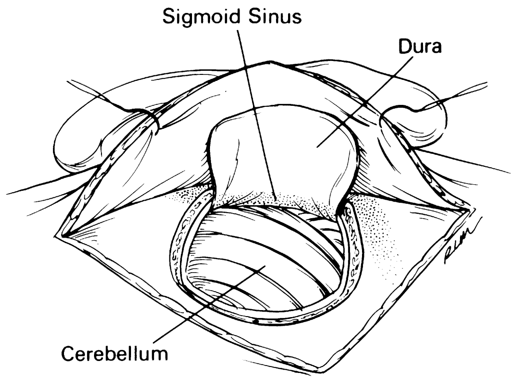

Fig. 4. Dural flap elevated.

subarachnoid space is opened. Usually the cerebellum need only be very lightly supported (Fig. 5A). This then allows opening into the cerebellopontine cistern, with release of the cerebrospinal fluid. The cerebellum is protected with Gelfoam (Upjohn, Kalamazoo, Michigan), a rubber dam, or Silastic sheeting (Fig. 5B). It need be retracted only for a larger tumor.

If the tumor is bulky, it may decompressed with the use of an ultrasonic aspirator at this point. We no longer use the carbon dioxide laser to debulk the tumor because the ultrasonic aspirator is much more rapid, causes no heating or charring of the tissue, does not require any bulky addition to the operating microscope, and avoids the potential danger of accidental burns inherent in all laser surgery. The rapidity of tumor removal can be varied by adjusting the power of the ultrasonic output as well as the suction. Care is taken to remain well within the capsule of the tumor to avoid injury to the facial nerve and brain stem. The ultrasonic aspirator need not be used when dealing with tumors that are less than 15 mm in diameter as measured from the porus. Obviously in the case of intracanalicular tumors, cerebellar retraction is minimal, and the tumor can usually be excised in one piece.

If necessary, the tumor is dissected off the cerebellum as well as the brain stem, depending on the size of the tumor. The facial nerve can be identified at or near the brain stem at this point, and if hearing preservation is the goal, an electrode can be placed on the cochlear nerve as well (Fig. 6A). When attempting hearing preservation, it is important to limit electrocautery as much as possible, depending on gentle blunt dissection to tease blood vessels away from the tumor and the VIIIth cranial nerve, while using Gelfoam to stop light venous oozing.

The dura over the posterior face of the petrous bone is coagulated using monopolar current and then excised after curettage. Alternately a laterally based dural flap can be raised [14]. Bleeding is controlled with the cautery. A cutting bur is used to outline the approximate location of the internal auditory canal, following which diamond burs are used for the final drill out. The magnetic resonance image (MRI) is used as a guide to the length of tumor extension into the internal auditory canal, and every attempt is made not to open into the posterior semicircular canal or vestibule, since this would probably result in the total loss of hearing. The endolymphatic sac and duct can also be used as landmarks: it is imperative

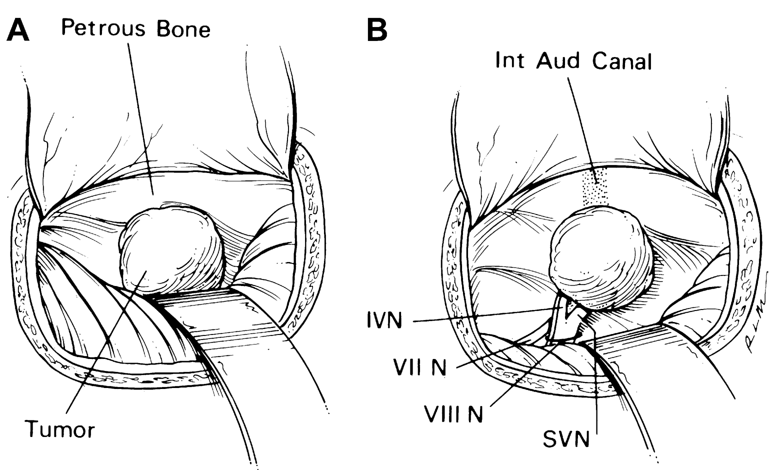

Fig. 5. (*A*) Tumor exposed; (*B*) cerebellum retracted.

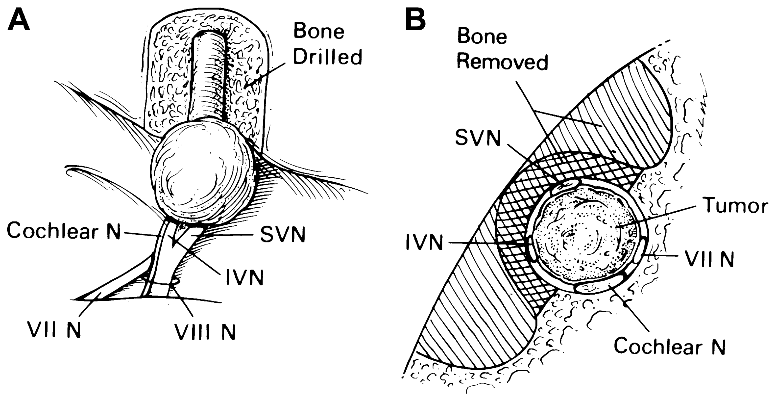

Fig. 6. (*A*) Bone drilled and nerves identified; (*B*) bone removed.

to remain medial and anterior to the duct to avoid entering the labyrinth [15,16]. When hearing is not to be preserved, either because of the low level of hearing or the size of tumor, as much bone as is required can be removed with impunity.

In attempting hearing preservation, up to 7 mm of the posterior internal auditory canal wall can generally be removed without endangering the posterior semicircular canal, but close observation is necessary to recognize a blue line as the labyrinth is approached. As drilling proceeds laterally, it is usually possible to recognize the lateral end of the tumor, even through the intact dura. The dura bulges over the tumor and transmits a fleshy red or yellow color. The internal auditory canal lateral to the tumor has flat dura, which generally appears blue or white. If the surgeon is unsure of whether the lateral end of tumor has been reached, the dura can be slit to inspect the canal. Further bone can then be removed if necessary.

It is important not only to thin the bone over the posterior aspect of the internal auditory canal, but also to drill well superior and inferior to the canal to expose least 180 degrees if not 270 degrees of the circumference of the canal, leaving only the anterior wall intact (Fig. 6B). This allows much easier and less traumatic dissection of the tumor off the nerves to be preserved. Care must be taken inferiorly if the jugular bulb is high-riding.

During this drill out, the subarachnoid space above and below the tumor should be protected with Gelfoam or Cottonoid to prevent bony debris from entering the subarachnoid space to an unnecessary extent [15]. If extensive, this material might lead to aseptic meningitis during the postoperative period or hydrocephalus at a later date. Suction irrigation also helps to limit the amount of bony debris and blood clot in the posterior fossa.

Once the bony removal has been completed, the dura of the internal auditory canal is slit with a fine sharp knife, ideally creating superior and inferior dural flaps by making a T-shaped incision in the dura (see Fig. 6). If the lateral end of the tumor cannot be visualized or readily delivered into the wound with an elevator, further bone should be removed. Dissection of the lateral end of the tumor should reveal the origin from the superior or inferior vestibular nerve, whereas retraction of these allows visualization of the facial and cochlear nerves (Fig. 7A).

After cutting of the vestibular nerves laterally, a plane is established between the tumor and the facial nerve superiorly and the cochlear nerve inferiorly (Fig. 7B). Dissection can then proceed either from lateral to medial or medial to lateral. There is a theoretical advantage to dissection from medial to lateral because it may not avulse fine blood vessels from the lateral end of the internal auditory canal and therefore the cochlea, but this has never been critically investigated. We have used both techniques and cannot perceive a difference in our hearing preservation results.

Attention is then paid to the medial end of the tumor, where the. superior and inferior vestibular nerves are very often splayed apart by the smaller tumor. These nerves may be cut at this point to allow dissection of the tumor from medial to lateral, but when attempting hearing preservation, it is safer to use blunt rather than sharp dissection because the blood supply to the inner ear may be inadvertently sacrificed by cutting the vestibular

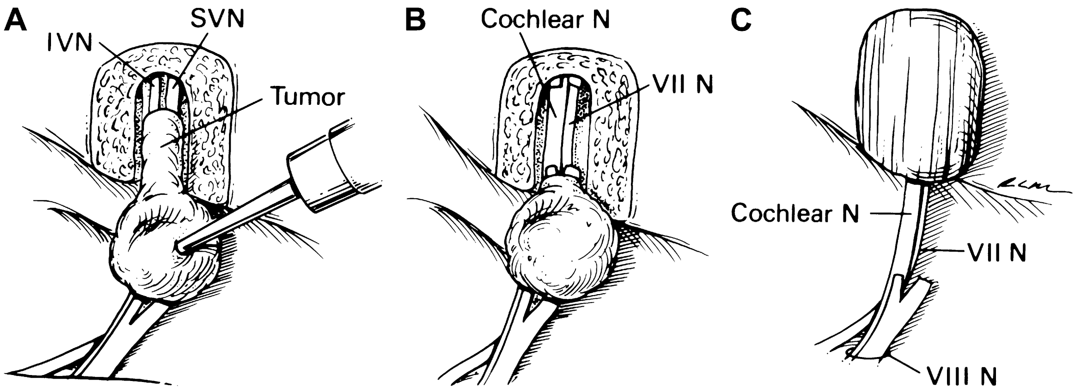

Fig. 7. (*A*) Cross section internal auditory canal (IAC); (*B*) SVN and IVN cut; (*C*) tumor out, IAC plugged.

nerves [7]. In large tumors, it is probably better to use sharp dissection rather than blunt to separate the tumor from both the facial and the cochlear nerves as long as no visible vessels are cut. This avoids further stretching of the already attenuated facial nerve [15].

A plane is developed between the tumor and the cochlear nerve, and dissection proceeds to remove the entire tumor with preservation of both the facial and the cochlear nerves or the facial nerve only (Fig. 7C).

When the operation is performed for hearing preservation, the primary goals are still total removal of the tumor with preservation of facial nerve function. Less than total removal should not be performed to preserve hearing but may be necessary occasionally to preserve facial nerve function. This is usually not the case because the facial nerve is seldom splayed out or distorted by tumors less than 2 cm in diameter. Occasionally a small scrap of tumor or capsule may be left attached to the facial nerve either just medial to the porus, where the nerve takes a sharp jog anteriorly, or at the brain stem, where the nerve is flattened by a large tumor.

In dealing with a larger neuroma, the ultrasonic aspirator is used to debulk the interior of the mass as it occupies the angle, then to remove the tumor as it is dissected off the brain stem, facial nerve, and out of the internal auditory canal (see Fig. 7A). With larger tumors or poor hearing, bipolar cautery is an important aid, but its use should be limited when hearing preservation is one of the goals of surgery. In general, it is safer to cauterize blood vessels rather than stretch them to the point where they might tear and retract. This is particularly important when dealing with a large petrosal vein, which is usually found at the superior aspect of the tumor and, if torn, can give rise to extremely troublesome bleeding as it retracts toward the tentorium.

Intraoperative auditory monitoring consists primarily of direct cochlear nerve recording. This is greatly preferable to using the auditory brain stem response because the latter requires extensive sampling and entails a very considerable time delay before any changes are noted [5,17,18]. It has been our experience that intraoperative auditory brain stem response monitoring has not increased our ability to preserve hearing [19]. Currently many surgeons use direct cochlear nerve monitoring, which is "real time" and allows the surgeon to stop dissection immediately when the amplitude or latency of the first wave diminishes [20]. At this point, there is not sufficient experience to be able to state definitely that this will permit us to preserve hearing in a higher percentage of cases than was previously possible, but data are being accumulated.

Following removal of tumor, the wound is copiously irrigated and bony debris and blood clot removed. Further hemostasis is obtained with bipolar cautery.

Any visible petrosal air cells that have been opened during the drill out of the internal auditory canal are then coated with bone wax, and a large piece of muscle taken from the edge of the wound is glued into the bony defect using fibrin glue made from the patient's own cryoprecipitate (see Fig. 7C).

The operation is then turned back over to the neurosurgical team, which removes the self-retaining retractor, controls any oozing from the cerebellum, performs a watertight closure of the dura, inserts a metal screen or the original bone-plug into the craniectomy, and closes the incision in layers. The patient continues on perioperative antibiotics and steroids.

Pros and cons of the retrosigmoid approach

The retrosigmoid approach is the most versatile operation for acoustic neuroma surgery [10,11,13,14,21]. It can be used for any size tumor, from intracanalicular to 4 cm or more from the porus. In dealing with a larger tumor, the skin incision may be lengthened to allow a lower craniectomy, and the superior-inferior diameter of the craniectomy may be extended to 5 cm or more.

The wide exposure of the posterior fossa gives excellent visualization of the tumor bed and the cranial nerves ranging from V above to IX, X, and XI below. Posterior fossa vessels are also well visualized. The prone position as well as slight elevation of the head allow for the cerebellum to fall away from the field and they do away with the need for excision or even hard retraction. Intravenous mannitol and dexamethasone cause shrinkage of the brain and prevent postoperative swelling.

Criticism of the posterior fossa approach in the past has been aimed mainly at the seated position, the need for flexion of the head on the cervical spine, the long nuchal incision, and the alleged difficulty in identifying the facial nerve. The seated position is uncomfortable for the surgeon and exposes the patient to the danger of air embolism. For these reasons, we decided to abandon the use of the seated position in favor of the three quarters prone horizontal position, with the head tilted slightly up. We occasionally operate in the seated position when dealing with a heavyset patient with a short neck and large tumor. The most common site for intraoperative air embolus formation in the seated position is the transverse sinus. Because this forms the superior margin of the craniectomy, it is relatively easy to nick the sinus and allow air to enter the venous bloodstream. Other sites of potential leak are the sigmoid sinus, large veins in the neck, and venous lakes within the bone of the skull itself. To avoid these leaks, meticulous care is used in coagulating visible blood vessels, waxing bone, and using ointment-impregnated gauze around the sites of head-holding pins. As already noted, despite these precautions, air emboli sometimes occur, are detected by the Doppler monitor, and require prompt action to correct them. The advantages of the seated position are that blood, cerebrospinal fluid, and bony debris tend to flow out of the wound rather than remain in the subarachnoid space and that the surgeon has a panoramic view of the entire posterior fossa. It also allows visualization of both ends of the VIIth cranial nerve at approximately the same plane, as well as visualization of both the brain stem and the lateral end of the internal auditory canal by merely rotating the microscope about its long axis. Visualization of the lateral end of the internal auditory canal is easily accomplished, with less bony removal than in any other position. Surgeons have attempted to address these pros and cons of the traditional suboccipital approach in several ways, leading to the evolution of the retrosigmoid technique.

The shorter-angled incision eliminates trauma to the nuchal muscles, leads to less blood loss, and has virtually eliminated postoperative neck pain and headache. Postoperative nuchal pain and headache have variously been ascribed to the presence of bone debris in the subarachnoid space and the suboccipital incision itself. We find that the latter is more likely to be the case. There have been a small number of patients who complain of severe pain following their suboccipital surgery, some of whom required release of a trapped occipital nerve, others rehabilitation, and still others protracted use of analgesics or nonsteroidal anti-inflammatory drugs. With the shorter, curved incision, we have not seen any protracted postoperative pain.

The size of the craniectomy can be varied between 3 cm for intracanalicular or small tumors to more than 5 cm for a large tumor, without substantially altering the external incision.

Facial nerve monitoring has been shown to lessen significantly the risk of damage in posterior fossa monitoring and has become the standard among otologists. Both pressure transducer and EMG-based systems have been used, with the latter having gained wider acceptance [12,22].

Facial monitoring has significantly reduced the incidence of severe facial nerve weakness in our experience, from 14.5% to 3.6%, and is expected to yield a higher percentage of patients with normal facial function (currently 80%) postoperatively as our series grows [12]. In the case of a small tumor, with the facial nerve anatomy not significantly distorted, the monitor should not affect results at all, but in dealing with larger tumors, in which the facial nerve is distorted and displaced, the monitor is invaluable in identifying the nerve, tracing its course, and preserving nerve integrity.

Although there has been some debate on the theoretical aspects of hearing preservation surgery, having to do with the possibility of incomplete tumor removal [23–25], the chance of tumor recurrence [26,27], and the fear of increasing complications as being the "cost" of hearing preservation surgery [28], to date these fears have not proved to be justified. The hearing goal should be to preserve hearing at or near the preoperative level. An occasional patient may note an improvement [9,29–31].

Although the retrosigmoid approach may be used for tumors of all sizes, regardless of hearing, it is not our custom to do so. There is a growing belief that the choice of approach should be dictated by size of tumor, level of hearing, patient's age and health, and experience and expertise of the surgical team. The middle fossa approach offers an equal likelihood of hearing preservation surgery for the intracanalicular and small extracanalicular tumor, with the advantages of a more limited craniotomy [21,27,32,33]. When it is not indicated to do the middle fossa approach in the older patient, or in the case of a larger tumor, the retrosigmoid approach is to be preferred.

When hearing is poor, the translabyrinthine approach is preferred, although we are more comfortable in using the retrosigmoid approach for tumors that are 3 cm or more from the porus. In a series of 445 cases, 277 were accomplished via the suboccipital-retrosigmoid approach and 173 via the translabyrinthine. Early in our series, six patients had two-stage operations (Table 1). In this series of 445 cases, 202 (45%) were tumors that were 2 cm or less from the porus, whereas 73 (16%) were intracanalicular tumors or protruded 1 cm or less from the porus, and 170 (39%) were larger than 2 cm (Table 2). Of these 445 patients, 183 (41%) had good hearing, as defined by a pure tone average of 50 dB or less, and speech discrimination of 50% or more, whereas 108 (24%) had excellent hearing, as defined by a pure tone average of 30 dB or less, and a speech discrimination score of 80% or more (Table 3).

Table 1
Approach in 445 cases

Suboccipital/retrosigmoid	277
Translabyrinthine	173
Middle fossa (2-Stage surgery)	1 (6)

Table 2
Tumor size

170 $\geq$ 2 cm EC	39%
202 $\leq$ 2 cm EC	45%
73 1C < 1 cm EC	16%

EC, extracanalicular; IC, intracanalicular.

Because we were dealing with a relatively high percentage of patients with small tumors or good hearing, we chose the retrosigmoid or suboccipital approach more often than the translabyrinthine. In general, the mean tumor size was greater in the suboccipital group than the translabyrinthine.

Results

Normal facial nerve function should be the expectation in all but the largest tumors [34,35]. Facial nerve function was completely intact (House type I) in 80% of our group as a whole, whereas there was an incidence of facial paralysis of 3.6% in the monitored group, compared with 14.5% in the unmonitored. There were no fatalities in the translabyrinthine group, but three postoperative mortalities in the suboccipital group. All of these occurred before 1985, with none since then. Mortality from all acoustic neuroma surgery should not exceed 1% to 2%. Hearing preservation surgery was performed in the suboccipital-retrosigmoid approach in 96 cases, of which hearing was preserved in 43 cases (43.8%). Presently it seems not possible to preserve hearing more than 50% of the time, regardless of tumor size, although there are occasional reports of better results in small series of perhaps selected cases [14,15,17,19,20,26,27,30–32,36–42]. This failure to preserve hearing in more than half the cases, regardless of whether the surgery is performed via the posterior or middle cranial fossa approach, remains an enigma to the surgeon. A difficulty in comparing results of hearing preservation surgery is the variation in definitions of success, ranging from 50% speech discrimination down to 15% [36,39]. In theory, one would think that earlier diagnosis of small tumors, improved surgical

Table 3
Level of hearing

183 (41%)	PTA $\leq$ 50 dB, SDS $\geq$ 50%
108 (24%)	PTA $\leq$ 30 dB, SDS $\geq$ 80%

PTA, pure tone average; SDS, speech discrimination score.

techniques, greater experience, and ability to monitor hearing intraoperatively would all contribute to a greater yield of hearing preservation surgery. Unfortunately this has not been the experience. An example of this is the fact that in our series, we attempted to preserve hearing in 42 patients from 1974 to 1988 and were successful in 21 cases, for a yield of exactly 50%. In 1989 and 1990, with the advantages of gadolinium-enhanced MRI scanning and intraoperative monitoring, we were successful in only 22 of 54 cases, for a yield of 41%.

Multiple factors probably come into play to explain these disappointing data. Although, in general, smaller tumors will present with better hearing, this is not at all necessarily the case (Table 4). A small tumor may be densely adherent to the cochlear nerve (this may be particularly true of inferior vestibular nerve tumors), or the blood supply to the inner ear may traverse the body of a small tumor; intracanalicular tumors may extend sufficiently laterally to require opening into the inner ear and therefore destruction of hearing; and finally far field monitoring such as the auditory brain stem response is much too slow to reveal damage to the inner ear, blood supply, or the cochlear nerve in time for the surgeon to react. In addition, the fact that many surgeons are operating on patients with poorer hearing probably also is at least in part responsible for these discouraging results. Despite this, it is our strong belief that, in the absence of any increased risk to the patient, attempts at hearing preservation are justified if the hearing is potentially useful to the patient.

Cerebrospinal fluid leaks have been bothersome occurrences, following both retrosigmoid and translabyrinthine approaches [28]. Our overall incidence has been approximately 12%. Our routine is to use spinal drainage for 3 to 5 days at the first diagnosis of a leak and to obliterate the mastoid in the case of the leak that follows a retrosigmoid operation or to repack the mastoid following a translabyrinthine leak. This surgery has been required in 4% of our 455 cases.

Table 4
Hearing level by tumor size

Small tumor (<2 cm), poor hearing	61.9%
Larger tumor (>2 cm), good hearing	20.3%
Larger (>2 cm) tumor, excellent hearing	46.4%
Small (<2 cm) tumor, poor hearing	32.3%

Since we have been using fibrin glue to attach the muscle in the retrosigmoid transmeatal drill out as well as the fascia graft and fat in the translabyrinthine approach, our incidence has decreased to 5%.

The retrosigmoid-transmeatal approach to the posterior fossa is a very versatile one and can be used for tumors of every size regardless of hearing. The technique has evolved from the classic suboccipital approach, thereby lessening the potential danger to the patient while allowing good access to the tumor and possible hearing preservation and decreasing the incidence of postoperative pain.

We use this approach in the majority of cases but advocate both the translabyrinthine and the middle fossa approaches for patients whose level of hearing and tumor size make these approaches reasonable choices. We firmly believe that there is more than one approach to the posterior fossa and that the level of hearing, the tumor size, and the patient's general health, occupation, and age should dictate the choice [9,10,21].

Summary

The retrosigmoid technique has evolved from the traditional suboccipital operation and, when combined with removal of the posterior wall of the internal auditory canal, affords a wide exposure of the cerebellopontine angle. This approach may be used for acoustic neuromas of all sizes, from intracanalicular to more than 4 cm from the porus acusticus. Hearing preservation may be attempted and is generally successful in a substantial minority of cases. The facial nerve is readily visualized at the lateral end of the internal auditory canal and is at no greater risk than in the translabyrinthine operation. We use this approach for all hearing preservation surgery as well as for tumors of more than 3 cm, regardless of hearing.

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