Suboccipital Surgery for Acoustic Neurinomas:
Advantages and Disadvantages*

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This review is based on 76 patients with acoustic neurinomas operated upon between 1950 and 1965. Of these, 72 had a single (unilateral) tumor and 4 had multiple tumors, 3 being bilateral.

Suboccipital surgery has been the classical method of removing acoustic nerve tumors since 1917 when Cushing published his well known monograph on the subject.

Cushing preferred subtotal, intracapsular removals whereas Dandy subsequently indicated that total removals were preferable. Following Dandy's lead, more and more total removals have been successfully accomplished, partly because of improvements in surgical technique and anesthesiology, and partly because of earlier detection of these tumors before they have become dangerously large.

In recent years, House has perfected a microsurgical translabyrinthine or middle fossa operation by which total removal of small intracanaliculuar tumors can be accomplished with little or no risk of facial palsy and a remarkably low mortality. It is of interest that a translabyrinthine approach was first used by Panse and others as early as 1904, often with success. However, this approach is not satisfactory for the adequate removal of large tumors, which require craniotomy. Craniotomy also permits opening of the internal auditory canal (intracranially) for total tumor removal. A dissecting microscope is helpful in identifying and sparing the facial nerve.

Diagnosis

Symptoms. Progressive deafness in one ear was the most common initial symptom of acoustic neurinomas in this series of 76 cases.

Tinnitus was the next most common symptom, often occurring several months or years after the onset of deafness, while vertigo, sometimes suggestive of Ménière's disease, was a presenting symptom in only 3 patients. Symptoms suggesting trigeminal neuralgia were present in another 3 patients.

Later symptoms, indicative of a large expanding tumor, included imbalance and numbness or paresthesias of part or all of the face and even the opposite side of the body. Headaches, nausea and vomiting, impaired vision, and occasionally coma, occurred in some patients as the result of increased intracranial pressure.

On neurological examination the most common sign was, of course, partial or complete deafness in the affected ear. Some patients with a relatively small tumor had no other sign. Reduction of ipsilateral corneal sensitivity, the second most frequent abnormality, was usually present when the tumor was so large that it compressed the brain stem and/or the posterior root of the trigeminal nerve. However, it was sometimes associated with relatively small tumors.

Nystagmus and ipsilateral ataxia were usually associated with large or moderately large tumors. Facial weakness, although rare, may only be suggested by paralysis of the platysma. House and his colleagues, moreover, drew attention to reflex and parasympathetic changes indicative of early facial nerve dysfunction.

Large tumors generally gave rise to additional signs such as pronounced facial nerve involvement, including impairment of taste on the anterior two-thirds of the tongue, ipsilateral sensory impairment of the face and/or pharynx, and perhaps paresis of the spinal accessory nerve. In such cases the tragus of the affected ear was often insensitive to pinprick, possibly as the result of dysfunction of the nervus intermedius or vagus nerve.

In addition, large tumors, compressing the

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cerebellum and brain stem, frequently gave rise to pronounced ipsilateral ataxia and contralateral hemihypesthesia and/or hemiparesis.

Increased intracranial pressure secondary to the tumor mass or blockage of cerebrospinal pathways usually resulted in papilledema or retinal hemorrhages leading to blurred vision, and diplopia due to sixth nerve paresis. Finally, nausea and vomiting might become so severe that a gastrointestinal lesion, rather than a brain tumor was suspected. This happened in 3 cases. One had undergone an exploratory laparotomy, and 2 were subjected to a complete barium study before lapsing into the coma that led to neurosurgical consultation and emergency surgery.

**Special Tests.** The accuracy of diagnostic tests has steadily improved. Examples are the recruitment,\(^5\) Békésy,\(^7,14\) and other special tests of auditory discrimination,\(^5\) as well as refinements of vestibular tests including electronystagmography.\(^6\) Special x-ray views, including tomography, arteriography, air,\(^10\) and more recently Pantopaque\(^6\) contrast studies have also led to more accurate and earlier diagnoses. As a result these tumors can now be detected before they have reached the large size they did in Cushing’s day, when they usually were not discovered until the patient was seriously ill because of increased intracranial pressure. Today, therefore, it is not unusual to make the diagnosis before the cerebrospinal fluid pressure or protein content have become elevated, as they usually are with large tumors, or before clear-cut findings appear on plain x-ray studies.

**Treatment**

Acoustic nerve tumors do not respond to x-ray or chemotherapy and can therefore be treated only by surgery. The sooner the diagnosis can be established and surgery performed the better. There have been no deaths in this series following removal of relatively small or moderate sized tumors in otherwise healthy patients. Mortality has been directly related to tumors of large size or serious systemic disease such as hypertensive cardiovascular disease. We firmly believe, therefore, that these tumors, like most brain tumors, should be operated upon as soon as the diagnosis is established. Delay only courts disaster.

Factors that must be evaluated include the age of the patient (Table 1); the neurological findings, including preoperative ataxia; systemic illness; and the size of the tumor.

**Age of Patient.** The operative mortality for patients less than 50 years of age following total (T) and radical (Ts) removals has been reduced in the last 10 years to 4 per cent, but remains close to 8 per cent for patients over 50 years old (Table 2).

**TABLE 1**

*Results of suboccipital surgery on acoustic tumors (single) (1950-1965)*

<table>
<thead>
<tr>
<th>Age</th>
<th>Operation</th>
<th>No. of Cases</th>
<th>Good</th>
<th>Poor</th>
<th>Operative Mortality</th>
<th>Late Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 50</td>
<td>T</td>
<td>24</td>
<td>18</td>
<td>3</td>
<td>2</td>
<td>1 (5 yrs.)</td>
</tr>
<tr>
<td>Over 50</td>
<td>T</td>
<td>10</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>34</td>
<td>25</td>
<td>4</td>
<td>4</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>(73%)</td>
<td>(11%)</td>
<td></td>
<td>(11%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 50</td>
<td>Ts+S</td>
<td>16</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>1 (4 yrs.)</td>
</tr>
<tr>
<td>Over 50</td>
<td>Ts+S</td>
<td>22</td>
<td>13</td>
<td>5</td>
<td>3</td>
<td>1 (8 yrs.)</td>
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<tr>
<td>Total</td>
<td></td>
<td>38</td>
<td>25</td>
<td>6</td>
<td>5</td>
<td>2 (5.2%)</td>
</tr>
<tr>
<td>(66%)</td>
<td>(15%)</td>
<td></td>
<td>(13%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total for all cases with single tumors</td>
<td>72</td>
<td>50 (70%)</td>
<td>10 (13.8%)</td>
<td>9* (12.5%)</td>
<td>3 (3.6%)</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 2
Suboccipital surgery on acoustic tumors, total and near total removal (1954-1965)

<table>
<thead>
<tr>
<th>Age</th>
<th>Operation</th>
<th>No. of Cases</th>
<th>Good</th>
<th>Poor</th>
<th>Operative Mortality</th>
<th>Re-operation for Recurrence</th>
<th>Late Mortality</th>
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</thead>
<tbody>
<tr>
<td>Under 50</td>
<td>T</td>
<td>19</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Under 50</td>
<td>Ts*</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>24</td>
<td>20 (84%)</td>
<td>3 (12%)</td>
<td>1 (4%)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Over 50</td>
<td>T</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Over 50</td>
<td>Ts</td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>12</td>
<td>11 (91%)</td>
<td>0 (8.3%)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total for all cases</td>
<td>36</td>
<td>31 (86%)</td>
<td>3† (8.8%)</td>
<td>2 (5.5%)</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

* Total save scrap on brain stem or 7th nerve.
† All patients were poor risk preoperatively.

For patients in both of these age groups, however, the mortality has been 14 per cent following subtotal intracapsular procedures (Table 3), which are often done because the patient's condition is poor.

Neurological Condition. Pronounced ataxia prior to surgery usually, but not always, led to postoperative ataxia. High intracranial pressure was another unfavorable prognostic sign, especially if it had led to marked impairment of vision or to a stuporous or comatose state.

Systemic Illness. Vascular hypertension of a marked degree, severe diabetes mellitus, advanced cerebral arteriosclerosis, or other chronic systemic illnesses were clearly related to most poor postoperative results. For this reason, we presently believe that patients afflicted with chronic systemic disease should not be submitted to total or radical tumor removal. Decompressive intracapsular removal for these patients is preferable, supplemented by further surgery later if there is recurrence of the tumor.

Size of Tumor. Postoperative morbidity and mortality are of course closely related to the size of the tumor. For example, there have been no deaths and very few complications when relatively small tumors have been removed, unless the patient had a serious systemic disease. On the other hand, most deaths and complications have occurred after the surgery of large tumors that seriously compressed the brain stem and led to advanced neurological deficits or greatly increased intracranial pressure.

TABLE 3
Suboccipital surgery on acoustic tumors, subtotal intracapsular removal (1954-1965)

<table>
<thead>
<tr>
<th>Age</th>
<th>No. of Cases</th>
<th>Good</th>
<th>Poor</th>
<th>Operative Mortality</th>
<th>Re-operation for Recurrence</th>
<th>Late Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 50</td>
<td>7</td>
<td>5 (71%)</td>
<td>0</td>
<td>1 (14%)</td>
<td>4</td>
<td>1 (4 yrs.)</td>
</tr>
<tr>
<td>Over 50</td>
<td>14</td>
<td>7 (50%)</td>
<td>5 (36%)</td>
<td>2 (14%)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>12 (57%)</td>
<td>5 (24%)</td>
<td>3 (14%)</td>
<td>7* (88%)</td>
<td>1 (5%)</td>
</tr>
</tbody>
</table>

* 2-4 yrs.
Ventricular Drainage

Preoperative. Whenever there is evidence of greatly increased intracranial pressure and the condition of the patient is therefore poor, we make it a practice to institute continuous ventricular drainage for 12-48 hours prior to surgery, using a rubber (Scott) catheter attached by sterile tubing to a bottle at head level. Permanent ventricular drainage by an implanted tube or valve does not seem necessary or advisable.

At Operation. It is always advisable to tap one of the lateral ventricles as soon as possible if there is any indication or even possibility of increased intracranial pressure. If the ventricular pressure is elevated, the drainage tube should be left open until the posterior fossa dura and arachnoid are to be opened.

Postoperative. If the condition of the patient is unsatisfactory without obvious reason, it is usually wise to resort promptly to a ventricular tap to determine whether or not the pressure is high and whether constant drainage is therefore necessary.

Whenever a large or otherwise difficult tumor has been removed thus establishing the risk of cerebellar edema, continuous ventricular drainage at head level is advisable as a precautionary measure. Antibiotics should then be used to prevent possible infection.

Operative Procedure

With only one exception, all operations were performed under intratracheal anesthesia, usually in the upright position and through a paramedian incision. The internal auditory canal was always opened for transeptal total or radical tumor removal when it seemed possible to save the facial nerve.

Anesthesia. After induction with intravenous sodium pentothal, intratracheal anesthesia with nitrous oxide and oxygen or Fluothane was used. Most patients were allowed to breathe spontaneously, because an automatic respirator may mask evidence of medullary dysfunction during tumor removal until too late. A monitoring electrocardiogram was used throughout all operations.

Local anesthesia alone was used in only one case. This was a 73-year-old woman with known coronary disease. An effective intracapsular decompression was performed in 1 hour and 10 minutes, and the patient was discharged 4 days later in excellent condition, relieved of ataxia.

Surgical Technique for Suboccipital Approach. The upright position was used in all but 2 cases. The latter were patients 65 and 70 years of age in whom it was feared that their marked cerebral arteriosclerosis plus the upright position might lead to permanent ischemic changes in the brain.

The legs of all patients were always wrapped with Ace bandages to minimize the risk of postural hypotension, and a small stethoscope was strapped over the heart to detect any evidence of air embolism in time to avert a catastrophe. In some cases pin fixation of the head was used, in others a simple head rest.

We used a paramedian incision\(^\text{10}\) between the mastoid process and the midline, high enough for a burr-hole that permitted ventricular tapping, and curved at its lower end towards the midline so that the posterior rim of the foramen magnum and the arch of the atlas could be exposed and removed if necessary. In some cases a small separate incision was made for ventricular tapping.

At the start of the operation ventricular decompression was accomplished by means of an indwelling Scott catheter which was then left open until the posterior fossa dura was ready for opening. This was done routinely whenever there was any indication or possibility of increased intracranial pressure. Before opening the dura, the catheter was corked to lessen the risk of abrupt ventricular decompression on release of CSF from below. Without this precaution rapid collapse of the cerebral hemispheres might tear a superior cerebral vein and lead to a subdural hematoma. In several patients ventricular drainage did not relieve the increased pressure within the posterior fossa, because the cerebrospinal fluid was completely blocked at the tentorial ring by a large tumor.

In exposing the foramen magnum, care should be taken to avoid injuring the extracranial segment of the vertebral artery, as we did in one early case, fortunately without ill effects.

In all patients with large tumors the posterior rim of the foramen magnum and the
arch of the atlas were removed as a precaution against postoperative cerebellar herniation that might compress the medulla. This was usually done even when there was no existing tonsillar herniation.

Once the dura was exposed up to the transverse sinus and as far laterally and medially as necessary, it was opened as a flap over the lateral half of the cerebellar hemisphere. Remaining margins of the dura were then tucked up out of the way by retaining sutures to provide the extra 2–3 mm. of exposure that is so often useful.

The arachnoid was then opened, at first only by a small nick, so that cerebrospinal fluid would not escape too rapidly.

The cerebellar hemisphere was then very gently retracted until the tumor or an adjacent cyst, and the 9th, 10th, and 11th cranial nerves were visualized. At this point we have found it wise to place a cottonoid strip between the tumor and the nerves, lest they be injured. Cardiac irregularity caused by freeing the vagus nerve may be prevented or corrected by intravenous atropine 0.4 mg. or by placing cottonoid soaked with 2 per cent novocain on the nerve to block it.

When the tumor was large, its exposure often required the intravenous administration of a hypertonic solution such as urea or Mannitol, or cerebellar uncapping, namely resection of the lateral one-fourth of the hemisphere. We prefer the latter, for this step, per se, does not seem to cause any postoperative ataxia. In our experience, hypertonic solutions have not proved as useful in posterior fossa surgery as they have for supratentorial operations. Moreover, their use can lead to collapse of the cerebral hemispheres sufficient to cause a subdural hematoma.

When the tumor has been exposed, the cerebellar hemisphere should be held in place by a self-retaining retractor, because a retractor held by an assistant may inadvertently shift and injure the brain stem.

At this stage the facial nerve was rarely seen, unless the tumor was comparatively small, because the nerve is usually situated anterior to the tumor. It therefore seemed advisable to open the tumor capsule and gently remove as much tumor tissue as possible in order to gain an adequate exposure. Soft, friable tumor tissue can often be removed piecemeal with a small suction tip or Cushing spoon, whereas tough, fibrous, or vascular tumor tissue may require a small electrocautery loop. The utmost care should be taken at all times to avoid any tugging or traction that could cause brain stem damage. Nor should electrocautery be used too near the brain stem. If small vessels must be cannized close to the stem, a 2-point cautery is far safer than a single contact instrument.

After the core of a large tumor has been removed, the posterior root of the trigeminal nerve usually becomes visible. Nodules of tumor that invaginate and block the tentorial ring should be removed. When this has been done, clear CSF flows readily downwards from above. The midbrain, oculomotor nerves, basilar artery and some of its branches then become visible. Identification of the facial nerve is now feasible. When it is difficult to identify, electrical stimulation through the remnants of the gutted tumor capsule often indicates its course and suggests its location. Most of these tumors, once gutted, can then be peeled off the facial nerve and brain stem by painstaking, gentle, stepwise dissection from above downwards, often with the aid of a dissecting microscope. Great vigilance is required to avoid injury to important vessels, such as the posterior inferior or anterior inferior cerebellar artery which may be partly adherent to the tumor capsule. If the tumor is large the facial nerve is often splayed out into badly stretched, separated delicate strands that cannot be preserved during total (T) tumor removal. Even if one succeeds in preserving most or all of such a thinned out nerve it rarely functions again. This, of course, is a major reason for operating on acoustic nerve tumors before they reach a dangerous size, since, when small, they can be totally removed without producing facial palsy.

The 8th nerve, a few millimeters from the brain stem, usually becomes enlarged as it flares out to merge with the tumor to which it has given origin. It must usually be divided between silver clips at this point.

If the tumor capsule is densely adherent, or its blood supply is intimately interwoven with that of the adjacent brain stem or facial nerve, that portion of the capsule, usually no more than a small scrap, should be left in situ. This type of removal is subsequently
referred to as a radical subtotal (Ts) removal, in contrast to an intracapsular subtotal (S) removal wherein a considerable portion of the capsule and some tumor tissue remains.

If the tumor is so large that the facial nerve could not be saved, we have always attacked the intracanalicular portion of the tumor by using thorough deep curettage and cauterization within the canal. There have been no recurrences when this has been done. For large tumors in elderly, arteriosclerotic or very ill patients, or in patients whose livelihood depends on preservation of facial function, we have used a more conservative method, consisting simply of intracapsular removal, at least as a first stage.

However, elimination of tumor from the internal auditory canal, can often be successfully accomplished if the tumor is not large. Removal obviously cannot be considered total unless this is done. To accomplish this the canal must be opened. This is usually a simple matter, because the roof of the canal is generally thin by virtue of tumor erosion. The canal can therefore be unroofed by peeling back the overlying dura and then removing the thin bone with small chisels or a thin cervical rongeur. Smaller tumors can be totally removed from within the canal by this procedure without facial palsy, ataxia, or recurrence. We first accomplished this in 1953 (Fig. 1).

If the facial nerve has been divided, its ends can sometimes be sutured or a nerve graft used (see Facial Nerve Function). Great care should be taken to seal off any openings in the bone with bone wax lest a CSF leak occur; this occurred in one early case of this type, but fortunately the patient recovered completely.

After completion of tumor surgery, and establishment of hemostasis with oxidized cotton or gelfoam if necessary, the wound is closed in layers. The dura is left partly open if the tumor is large and there is any threat of postoperative cerebellar edema. After total removal of smaller tumors, however, the dura is closed in water-tight fashion. For patients threatened with postoperative edema because their tumor was exceptionally large or because they were extremely ill prior to surgery, the intraventricular catheter is left in place and connected by sterile tubing to a sterile drainage bottle at head level (see Ventricular Drainage).

**Postoperative Care**

If the respiratory exchange is difficult, a tracheostomy should be done without delay. We have seen no harm and often great benefit from tracheostomy and cannot sufficiently stress its value. For patients unable to swallow, nasogastric tube feedings are advisable. Otherwise the postoperative management is quite similar to that for other types of brain surgery.

If facial palsy has occurred the lids of the affected eye are sutured at once or sealed with a butterfly dressing to prevent corneal injury. The drooping side of the face, in addition, is pulled up and supported with an

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**Fig. 1.** A. Unroofing internal auditory canal with small rongeur or chisel preparatory to total removal of tumor after its intracranial portion has been excised. B. Diagram showing intact facial nerve (VII) and adjacent cranial nerves after total removal. A dissecting microscope has proved helpful in dissecting the facial nerve.
Suboccipital Surgery for Acoustic Neurinomas

elastie band attached by safety pins to 2 dressings glued to the skin with collodion.\(^{10}\) Correction of facial paralysis will be discussed later under Facial Nerve Function.

**Complications**

A cerebrospinal fluid (CSF) leak may develop if mastoid air cells are opened during the suboccipital craniectomy or the internal auditory meatus is unroofed. To prevent this, bone edges should always be carefully and thoroughly waxed and any large openings sealed with a muscle stamp. CSF leakage occurred in 4 patients after total tumor removals.

In one patient, age 13 years, there was no obvious leakage, but it was presumed when meningitis occurred one month after operation. Complete and rapid recovery followed prompt antibiotic therapy. Another patient with no gross evidence of leakage developed meningitis 2 years after surgery but was not brought to the hospital until he was desperately ill. He died despite treatment. A third patient, in poor condition before as well as after surgery, was successfully re-explored and the leak stopped by a muscle flap.

Rhinorrhea in the fourth patient was noticed while he was still in the operating room; the wound was reopened and a large muscle stamp was placed over the lateral aspect of the bony opening with recovery.

**Air Embolism.** In the upright position lethal volumes of air may enter the venous system and reach the heart, unless the source is promptly sealed. This happened once during incision of the posterior cervical muscles and was indicated by a fall of blood pressure and sounds of air in the heart. The wound was immediately, firmly, and continuously compressed by gauze pads and the patient was quickly lowered from the upright position on to her side. After a few minutes, recovery was complete. The offending vein was then located and cauterized, and the operation successfully completely in a semi-lateral position. A large tumor was totally removed and the patient is perfectly well today.

An exactly similar train of circumstances followed air embolism when a small cerebellar-tentorial vein snapped and was not noticed until sudden hypotension occurred. The vein was cauterized at once, the patient lowered to her left side until her condition was satisfactory, and then the tumor was totally and successfully removed.

In a third patient 3 or 4 air bubbles were seen coursing through the transverse sinus. A torn small tentorial vein was again the cause. It was immediately cauterized and since no more air was seen in the sinus and the condition of the patient was satisfactory, the operation was carried to a successful conclusion.

These 3 cases illustrate the need for great care in looking for and sealing off all veins during surgery in the upright position, and for prompt postural correction. It is also apparent that when the patient's condition again becomes satisfactory, the operation can be continued.

**Facial Nerve Function**

If the 7th nerve cannot be saved during tumor removal, a direct intracranial anastomosis of the divided ends can sometimes be accomplished, as reported by Dott\(^{5}\) and by Drake.\(^{4}\) They also found that it is occasionally possible to suture a nerve graft to the proximal stump of the 7th nerve and subsequently anastomose the distal end of the graft to the 7th nerve extracranially. If these procedures cannot be done, a postoperative facial palsy can be corrected by an extracranial anastomosis of the facial to the spinal accessory or the hypoglossal nerve.

In our experience, anastomosis to the 12th nerve has proved the most effective. As Stookey pointed out,\(^{10}\) this is probably because the hypoglossal is phylogenetically, anatomically, and functionally more closely related to the 7th nerve than is the spinal accessory nerve. The surgical procedure is relatively simple; the main difficulty is finding the 7th nerve. However, the facial nerve can usually be identified by palpating the styloid process and then exposing it until the nerve is located. To preserve useful function and prevent complete hemiatrophy of the tongue (Fig. 2), the descendens hypoglossi should be sutured to the distal stump of the divided hypoglossal nerve.

The results of this procedure, reported in 1959,\(^{8}\) are summarized for this series in Table 4. Only one facial palsy followed total (T) removal of 5 moderate sized tumors whereas there were 25 facial palsies after total removal of 29 large tumors. There were...
Fig. 2. Photographs of 2 patients after total tumor removal and 7th–12th nerve anastomosis. (Reprinted with kind permission of Neurology).

5 facial palsies after radical subtotal (Ts) removal of 12 large tumors, 2 after radical surgery of 3 moderate sized tumors and only 3 facial palsies following 23 intracapsular removals.

Only 1 of 3 cases with 7th to 11th nerve anastomosis in this series was successful. In one patient, 7th–11th nerve anastomosis led to a very distressing tic-like facial and shoulder movement. We abandoned this type of repair years ago.

Facial nerve anastomosis should be done not later than 3 months after tumor surgery. A longer delay usually spells failure. However, if there is clinical or electrical evidence that the facial nerve has any function, nerve suture may be delayed until it is certain that no useful return of function is likely.

Plastic surgery, I feel, is a last resort as it usually requires repeated operations for readjustments, and rarely offers as good results as 7th to 12th nerve anastomoses. Several patients were content to forego any attempt at facial nerve repair.

Ataxia

As shown in Table 5, 30, or approximately 50 per cent, of the patients listed had no ataxia following tumor removal and most of the others had only a minimal and therefore not an incapacitating amount of this disability. Altogether 82 per cent were free or almost free from ataxia despite the fact that all but 8 of the tumors were large and that partial cerebellar resection or uncapping was performed in 46 of these cases.

Thirty-eight, or more than 50 per cent, of

TABLE 4
Facial nerve function

(a) Immediately following surgery

<table>
<thead>
<tr>
<th></th>
<th>No. of Cases</th>
<th>No Palsy</th>
<th>Paresis</th>
<th>Palsy</th>
</tr>
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<tbody>
<tr>
<td>Large tumor</td>
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<tr>
<td>Total removal (T)</td>
<td>29</td>
<td>2</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Radical removal (Ts)</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Subtotal intracapsular (S)</td>
<td>23</td>
<td>20</td>
<td>0</td>
<td>3</td>
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<tr>
<td>Moderate sized tumor</td>
<td></td>
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</tr>
<tr>
<td>Total removal (T)</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Radical removal (Ts)</td>
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<td>Subtotal intracapsular (S)</td>
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<td>0</td>
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<tr>
<td>Total</td>
<td>72</td>
<td>32</td>
<td>4</td>
<td>36</td>
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(b) Results of 7th–12th nerve anastomosis

<table>
<thead>
<tr>
<th></th>
<th>No. of Cases</th>
<th>Good</th>
<th>Poor</th>
<th>No Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 3 mos. after damage</td>
<td>14</td>
<td>12</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>More than 3 mos. after damage</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
these 61 surviving patients had at least some degree of ataxia prior to surgery. This improved after tumor removal in 26 cases.

Table 5 clearly shows that cerebellar resection can be performed without necessarily causing incoordination or making it worse. Moreover, ataxia was reduced in some cases following cerebellar resection for tumor removal. This indicates that cerebellar resection per se does not necessarily lead to ataxia. Two patients in this series actually are now active as professional pianists following total tumor removal; in each cerebellar uncapping was part of the procedure.

**Results**

*Multiple Tumors.* Of the 76 patients operated upon since 1950, there were 4 with multiple posterior fossa tumors.

Three had bilateral acoustic tumors and multiple neurofibromatosis. One of these also had a cervical cord ependymoma and a parasagittal meningioma. He survived for 5 years after intracapsular removal of a large right acoustic neurinoma and subtotal removal of the intra-axial spinal cord ependymoma during the same operative procedure. He returned to his law practice for over 3 years but finally succumbed to recurrence of the acoustic tumor, complicated by meningioma surgery and a large mediastinal tumor. The other two patients, with bilateral lesions after subtotal removal of large acoustic tumors, resumed their usual work for 4 and 6 years respectively, although handicapped by bilateral deafness.

The 4th patient in this group had an acoustic neurinoma and a contiguous but entirely separate neurinoma of the posterior root of the trigeminal nerve. Unfortunately he died 10 days after the total removal of both tumors.

*Single Acoustic Neurinomas (1950–1965).* Seventy-two patients with a single (unilateral) tumor have been operated on since 1950 (Table 1). Ninety per cent of these were large tumors, 3 to 5.5 cm. in maximal diameter, and 10 per cent were of moderate size, 1.5 to 2.5 cm. in diameter. None of the tumors in this group was less than 1.5 cm. in diameter.

Total removals were accomplished in nearly 50 per cent of the cases. There were 50 good results, in which the patient returned to his usual occupation without incapacitation. The 10 poor results and most of the 9 operative deaths occurred principally in patients who were already seriously ill or badly incapacitated prior to surgery. Most of them had large tumors. There were 3 late deaths caused by recurrence, reoperation, and the delayed effects of surgery, respectively; each had a subtotal intracapsular removal (Table 1).

*Single Tumors (1954–1965).* The results for the last 10 years have been evaluated separately because these data were requested by Dr. William House for presentation at his course in February, 1965. There were 57 cases in this group.

Total Removal (T). Following 24 total removals (T) there were 20 good results (84 per cent); 3 poor results (12 per cent); and 1 operative death (4 per cent). There have been no recurrences in this group (Table 2).

Radical Removal (Ts). Radical removal (Ts) was accomplished in an additional 12 patients. This means total removal except for a small scrap 3 mm. or so in size that could not safely be removed because it was densely adherent to the brain stem or facial nerve. Of these 12 there were 11 good results; no poor results and 1 operative death. Recurrence over 4 years later occurred in only 2 patients and reoperation was then performed13 with 1 late death (Table 2).

Subtotal Removal (S). Subtotal removal (S) means that a considerable portion of
tumor capsule was left because it was adherent to the brain stem, or because the patient was either elderly, seriously ill, or did not wish to risk a facial palsy. Of 21 cases so treated, there were only 12 good results, 5 poor results, 3 operative deaths, and 1 late death due to recurrence. The overall recurrence rate following subtotal removals was 33 per cent. Most of these cases were operated upon a 2nd or 3rd time, and for some, a total removal was possible at reoperation. 12 We could find no histological criteria by ordinary microscopy that indicated whether a tumor was likely to recur (Table 3).

Considering only the 57 patients with single tumors who were operated upon within the last 10 years (1954–1965), it is apparent from Tables 2 and 3 that total (T) and radical removals (Ts) offered the best results. In these 2 groups there were 36 cases (Table 2) with 31 good results (86 per cent), and only 1 recurrence.

Summary

We have reviewed our experiences with 76 acoustic neurinomas treated by suboccipital surgery. The best results from all points of view were obtained in those where either total or radical removal was employed.

In contrast, intracapsular removals led to a high recurrence rate and a much higher morbidity and operative and late mortality. The poorer results in this group are mostly a reflection of a larger tumor size and therefore a more precarious condition of the patient. They illustrate the need for earlier diagnosis and earlier surgical intervention and, of course, clearly indicate that recurrence is apt to occur unless a total or radical removal is accomplished.

We have also emphasized that the facial nerve can usually be spared during total removal of moderate sized tumors, through the device of meatal unroofing and have indicated the usefulness of 7th to 12th nerve anastomosis where necessary.

References


Addendum

Identification and preservation of the facial nerve can be greatly facilitated by Rand and Kurze’s technique of opening the internal auditory canal before proceeding with tumor removal. Preliminary intracapsular decompresion facilitates this part of the procedure. When the canal is unroofed the 7th and 8th nerves can usually be plainly seen, near the apex of the canal. The nubbin of tumor in the canal can then be easily peeled off the 7th nerve, and the nerve followed to the brain stem on removing the intracranial portion of the tumor. Although a dissecting microscope is not always necessary, it is helpful in sparing the 7th nerve.

While Rand and Kurze use a motor-driven drill to unroof the canal, we have found small chisels equally useful. Care must be taken to seal any openings into air cells with wax or muscle.

Seven additional tumors have now been removed, all with good results save for 1 facial palsy. This makes a total of 79 cases.