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Acoustic Tumor Surgery and Tinnitus

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Abstract: A total of 311 patients with a unilateral acoustic neurinoma were operated on via the enlarged middle cranial fossa approach. A total tumor removal was achieved in 98% of cases. The mortality was 0.6%. Overall in acoustic neurinoma surgery, the percentage rates of meningitis (1.6%), cerebrospinal fluid fistula (1.6% requiring surgery), and neurological deficits were fairly low. The facial nerve could be preserved anatomically in 99%. A House I or House II classification was demonstrated in 91% of all tumors and in 98% of small- and medium-sized tumors. Preservation of the hearing function was possible in 49% of all patients (71% in small tumors). A positive effect on tinnitus usually occurred in 45% of cases. The enlarged middle cranial fossa approach allows function-preserving surgery of the cranial nerves (e.g., the facial and cochlear nerves) and cerebral structures, even including total removal of large acoustic neurinomas of up to 3–4 cm.

During recent years, a lot of controversy has arisen around the advantages and disadvantages of different approaches for the removal of acoustic neurinomas: the middle cranial fossa approach [1], translabyrinthine approach [2], transcochlear approach, retrolabyrinthine approach, transotic approach [3], retrosigmoid approach [4], suboccipital approach [5], and modifications of transtemporal approaches [6–8].

The enlarged middle cranial fossa surgery allows function-preserving surgery of the facial nerve, cochlear nerve, and cerebral structures, including total removal of large acoustic neurinomas of up to 3–4 cm. Thereby, even the tinnitus can be influenced positively.

MATERIAL AND METHODS

The author has experience operating on 311 patients with unilateral acoustic neurinomas via the enlarged middle cranial fossa approach (Table 1). Forty-eight tumors were classified as small, 133 as medium, and 130 as large. The average age of the patients was 49 years. The youngest person was 16 years old, and the oldest was 83 (mean age, 51–60 years). A slight predominance of women was noted, with no preference for anatomical side.

The enlarged middle cranial fossa approach, under general anesthesia, starts with a temporal skin incision forming a caudally pedicled flap over the sleeve, with the root of the zygomatic arch in its center. The temporal muscle is transected by a Y-shaped incision.

An osteoplastic craniotomy of 4 × 5 cm is performed. Important landmarks can be used: the "gray line" of the superior semicircular canal (below the eminentia arcuata) and the superior petrosal nerve, which together form an angle of some 130 degrees. Bisectioning of this angle usually corresponds to the axis of the internal auditory canal. Enlarged middle cranial fossa surgery consists of ample bone resection, using a diamond burr in front of, above, and behind the internal auditory canal and even posterior (medial) to the superior semicircular canal. The otoneurosurgeon must be very careful not to injure the cochlea, labyrinth, or Fallopian canal with the facial nerve.

Use of the computer-assisted surgery system (CAS) can be of great advantage even in middle cranial fossa surgery; this is a computer-supported imaging technique that offers new possibilities of three-dimensional orientation in the surgery field in real time ("surgical navigation"). By a large excision of the petrous bone, broad exposure of the internal auditory canal, cerebellopontine angle, and brainstem can be achieved. That exposure permits removal not only of small- and medium-size acoustic neurinomas but of large tumors to-

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Table 1. Diagnosis of Enlarged Middle Cranial Fossa Surgery (n = 450)

Disorder	No. of patients
Acoustic neurinoma	
Unilateral	311
Bilateral	10
Menière's disease	73
Meningioma	11
Fracture of the petrous bone	10
Cholesteatoma	10
Facial neurinoma	7
Hemifacial spasm	3
Lipoma	2
Chondroma	1
Other diagnosis	12

Table 2. Results of Unilateral Acoustic Neurinomas After Surgery Via the Extended Middle Cranial Fossa Approach (n = 311)

	Tumor Size			
Outcome	**Small**	**Medium**	**Large**	**Total**
No. of operations	48	133	130	311
Complete removal	48	133	123	304
Facial nerve anatomically preserved	48	133	129	310
Cochlear nerve anatomically preserved	40	100	96	236
Candidate for hearing preservation (0–90 dB)	42	124	110	276
Success of hearing preservation	30	73	32	135
Hearing preservation	71%	59%	29%	49%
Facial nerve (House I–II)	98%	98%	82%	91%

tally, up to a size of 3–4 cm. The trigeminal nerve often may be visible in large acoustic neurinomas using this approach. In cases of large neurinomas, the middle meningeal artery and superior petrosal sinus usually are resected for additional mobilization of both the temporal and the cerebellar dura blades.

After conclusion of surgery in the internal auditory canal and the cerebellopontine angle, the dural flaps are replaced. One or two layers of free muscle fascia flaps together with fibrin glue (Tisseell; Immuno, Heidelberg, Germany) produce a safe, waterproof, and airproof reconstruction of the dural defect above the internal auditory canal over the cerebellopontine angle. The extradural space below the craniotomy is filled with Gelfoam soaked in fibrin glue, in lieu of fixation of the dura by sutures. Complete hemostasis during surgery is extremely important. Hemorrhages can be controlled using Gelfoam soaked in fibrin glue or collagen-fleece (Tissuvlies; Immuno). In the case of a hemorrhage very close to the cranial nerves (e.g., the facial nerve) or other important anatomical structures, a special microelectrocauter has been developed (Howmedica-Leibinger, Freiburg, Germany) [9]. The bone flap is refixed by vicryl sutures and bone pasted together with fibrin glue. After suture of the temporal muscle, a Redon drain must be inserted. The surgery is finished by a double-layer skin suture. The patient stays in intensive care for approximately 2 days.

RESULTS

Enlarged middle cranial fossa surgery is a fairly difficult approach but, in skilled hands, the complication rate can be described as very low (Tables 2, 3). In a series of 311 unilateral acoustic neurinoma surgeries, the mortality was 0.6%. Two patients with an acoustic neurinoma died, one because of an acute postoperative hemorrhage and the second because of a general anesthesia problem. Three patients with postoperative hemorrhages and two with intraoperative bleeding could be managed without any neurological disturbances. Overall in acoustic neurinoma surgery, the percentage rate of meningitis (1.6%), cerebrospinal fluid fistula (1.6% requiring surgery), secondary wound healing (1.2% requiring surgery), and neurological deficits were fairly low. Some patients (1.9%) developed a temporary cerebral disorientation or speech difficulty (especially in the case of surgery on the left side) over a period of a few days. Only a few patients (4.3%) complained of severe headaches after surgery.

In 311 unilateral acoustic neurinomas, total tumor removal was achieved in 98%. The facial nerve could be preserved anatomically in 99%. House I or House II classification was demonstrated in 91% of all tumors 1 year or more after surgery (Table 4). In small- and medium-sized tumors, this percentage rose to 98%. A late

Table 3. Complications of Extended Middle Cranial Fossa Approach in Acoustic Neurinoma Surgery (n = 321 cases)

Complication	No. of Cases	Percentage
Mortality (1 each, acute hemorrhage and general anesthesia)	2	0.6
Hemorrhage	5	1.6
Brain edema	2	0.6
Meningitis	5	1.6
Cerebrospinal fluid fistula (surgery necessary)	5	1.6
Secondary wound healing (surgery necessary)	4	1.2
Transitory epileptic seizure	2	0.6
Transitory aphasia	6	1.9

Table 4. Facial Nerve Function of 220 Patients After Surgery of a Unilateral Acoustic Neurinoma

	Tumor size			
House index	Small (n = 41)	Medium (n = 87)	Large (n = 92)	Percentage of Total (n = 220)
I–II	98	98	82	91
III–IV	2	2	13	7
V–VI	0	0	5	2

Note: Follow-up greater than 1 year after extended middle cranial fossa approach.

poor functional and cosmetic facial nerve function (House VI) occurred in only 2.0% of 220 patients (postoperative follow-up > 1 year). The cochlear nerve could be preserved anatomically in 76% of cases. Sometimes, this nerve had to be sacrificed because of tumor infiltration.

It was possible to preserve the hearing function in 49% of all patients (see Table 2) who had a preoperative hearing function (71% in small tumors). A close correlation was seen between the size of the tumor and the preoperative hearing level for the success of postoperative hearing preservation. After acoustic neurinoma surgery, 36% of our patients exhibited no tinnitus, 1% experienced the start of tinnitus, and 63% continued to experience tinnitus (Table 5). Tinnitus usually decreased or disappeared in 45% of our cases, and 76% of the patients suffered preoperative tinnitus. In 10% of the cases, the tinnitus disappeared after the surgery. In 35%, an improvement began and, in 45%, tinnitus was unchanged on the diseased side. In 10%, the tinnitus started to worsen after surgery (Table 6). No correlation was seen between intensity of tinnitus and tumor size. The tinnitus usually could be influenced positively in patients with preserved hearing function. In the postoperative follow-up period of 10 years, the hearing function of patients who retained hearing usually remained stable.

DISCUSSION

Different approaches are available to treat the pathological structures in the cerebellopontine angle and internal auditory meatus [1–5, 10, 11]. Using the so-called enlarged middle cranial fossa approach, the surgeon can achieve excellent exposure of the middle cranial fossa, internal auditory canal, cerebellopontine angle, and brainstem [6, 8, 9, 12].

Table 5. Results of Tinnitus After Acoustic Neurinoma Surgery

No tinnitus	36%
Starting of tinnitus	1%
Tinnitus	63%

Table 6. Influence of Acoustic Neurinoma Surgery for Tinnitus

Disappeared	10%
Improved	35%
Unchanged	45%
Worse	10%

The advantages of this procedure are unique: excellent exposure of the fundus, internal auditory meatus, porus acusticus internus, and cerebellopontine angle to the brainstem and good identification of the facial nerve, cochlear nerve, superior and inferior vestibular nerves, retractor in extradural position, and avoidance of compression of the cerebellum. Use of the enlarged middle cranial fossa approach allows performance of many different otoneurosurgical interventions:

- Total removal of small, medium, and large acoustic neurinomas with an extrameatal diameter of up to 3–4 cm
- Neurovascular decompression in patients with hemifacial spasm or Menière's disease or neurectomy of the vestibular nerve in patients with Menière's disease, furthermore, treatment of extradurally located diseases of the middle cranial fossa
- Decompression or grafting of the facial nerve
- Repair of extensive cerebrospinal fluid fistulas in fractures of the petrous bone
- Removal of pseudotumors, such as cholesterol granulomas or penetrating cholesteatomas in the middle cranial fossa

The enlarged middle cranial fossa approach constitutes function-preserving surgery. During acoustic neurinoma surgery, facial nerve lesions or total deafness have many causes, including tinnitus intraoperatively or postoperatively, and must be considered:

- No identification of the facial nerve or the cochlear nerve (intraoperative monitoring useful)
- Insufficient surgical technique (brusk drilling, coagulation)
- Mechanical trauma (compression or traction of the cranial nerves)
- Wrong direction of tumor mobilization close to cranial nerves VII or VIII

Table 7. Acoustic Neurinoma Surgery and Conclusions for Hearing Preservation and Tinnitus

Preoperative tinnitus	76%
No preoperative and postoperative tinnitus	24%
No tinnitus after surgery	36%
Positive influence of tinnitus after surgery	45%
Positive influence of tinnitus in cases of hearing preservation	
Rarely a tinnitus occurs after acoustic tumor surgery	
Correlation of severity of tinnitus and level of the hearing function after surgery	
Correlation of preoperative level of hearing function and success of hearing preservation	
Correlation of success of hearing preservation and size of the tumor	

Insufficient reduction of tumor size (insufficient capsular debulking) before preparation of the facial and cochlear nerves

Inability to remove the tumor totally

Insufficient instrumentation

Unpredictable reasons (sudden loss of cerebrospinal fluid, vasospasm during surgery)

Use of some special developments intraoperatively can lower the complication rate and raise the success rate of surgery considerably (House I and II in 98% and hearing preservation of between 50% and 70% in small and medium-sized tumors). Cases of hearing preservation present a good chance (45%) for a positive influence on tinnitus. Usually, a correlation of severity of tinnitus and level of hearing function exists after surgery. A tinnitus occurs fairly rarely after acoustic tumor surgery. Preoperative level of hearing function and success rate of hearing preservation are closely correlated. Finally, the success rate of hearing preservation and size of the tumor are correlated to a large degree (Table 7).

In our group, 76% of patients exhibited preoperative tinnitus. No preoperative and postoperative tinnitus occurred in 24%. Postoperatively, 36% were unaffected by tinnitus. No correlation between intensity of tinnitus and tumor size was seen (Table 7). Intraoperative developments that can help to lower the complication rate consist of special surgical techniques, fibrin glue (management of hemorrhage, waterproof and airproof closure of the surgery field); special microinstruments (microelectrocauter, microscissors at different angles) [9]; intraoperative monitoring of cranial nerves VII and VIII electromyography, (BAEP) [13]; and a CAS system consisting of rapid and confident intraoperative recognition of anatomical landmarks in the middle cranial fossa [9,12].

Our technique of choice for treating pathological structures in the region of the middle cranial fossa, internal auditory meatus, and cerebellopontine angle is the enlarged middle cranial fossa approach. It allows function-preserving surgery of the facial nerve, cochlear nerve (including a good chance for hearing preservation and positive effect for tinnitus), and cerebral structures, with an extremely low postoperative complication rate.

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