ENLARGED TRANSLABYRINTHINE APPROACH FOR THE MANAGEMENT OF LARGE AND GIANT ACOUSTIC NEUROMAS: A REPORT OF 175 CONSECUTIVE CASES

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The translabyrinthine approach was once considered inadequate for the removal of acoustic neuromas (ANs), but that theory has few proponents today. Over the years, the translabyrinthine approach has been modified into the enlarged translabyrinthine approach, with experience and technical refinements leading to a wider access. Between April 1987 and December 2001, the Gruppo Otologico of Piacenza-Rome was able to remove 175 ANs 3 cm or larger in size from the cerebellopontine angle by adopting this modified surgical technique. These tumors represented 24.7% of all 707 ANs for which surgery was performed during the same period of time. Among the 175 cases, there was only 1 death. The incidence of complications was very low and was comparable to results previously published in the literature. Consequently, the hospital stay was short, with a mean of 7.3 days (5.1 days in the last 45 cases). The preoperative ipsilateral hearing was already compromised in 119 of the 175 cases (68%; class C/D according to the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology–Head and Neck Surgery, 1995). From our results, we can conclude that the use of the enlarged translabyrinthine approach in AN surgery is not dependent on tumor size. On the contrary, the advantages of a low rate of morbidity and a short hospital stay are ample proof that this is the best approach for the removal of large ANs.

KEY WORDS — acoustic neuroma, cerebrospinal fluid leak, complication, enlarged translabyrinthine approach, facial nerve, tumor, vestibular schwannoma.

INTRODUCTION

Large acoustic neuromas (ANs) are likely to be removed by surgical intervention. Radiotherapy and conservative management are not options to be taken into consideration unless there are serious contraindications to surgery. Moreover, it is well-known that hearing preservation is unlikely in patients with large tumors. The aim of surgical treatment in large acoustic tumors is to achieve the highest possible percentage of total tumor removal while keeping the incidence of mortality and morbidity as low as possible.

Nowadays, two principal approaches are being adopted to remove large ANs: the retrosigmoid approach (RSA) and the enlarged translabyrinthine approach (ETLA). The RSA is preferred by many neurosurgeons for the removal of ANs of any size.

The traditional translabyrinthine approach (TLA) for AN removal was first described and popularized by William House[1] in the 1960s as an alternative to the traditional suboccipital approach. Since then, controversies have been raging regarding the better approach for removal of ANs. Initially, the TLA was considered to be a good choice only for smaller tumors, whereas the RSA was adopted for larger ones because of the belief that it gave wider surgical access. Many surgeons do not believe that total removal of large tumors (>3 cm) is possible with the TLA because of the perceived limitations on the viewing and operating space within the cerebellopontine angle (CPA).

Over the years, the experience gained with the TLA has led to significant improvements. These technical changes led to the opportunity to enlarge the approach (ETLA)[2-4] and overcome the initial problems. The technical refinements include extended bone removal on the middle fossa and posterior fossa dura, the exclusion of self-retaining retractors, and techniques for the reduction of tumor size.

The TLA provides us with the advantages of early identification of the distal portion of the facial nerve (FN) in the internal auditory canal (IAC) and the possibility of removing the whole tumor with minimal or no cerebellar retraction. These advantages become more pronounced when one is dealing with large tumors.

Our study aimed to validate whether the ETLA is suitable for removing large ANs by analyzing our case reports and by highlighting the incidence of total tumor removal, postoperative FN function, postop-

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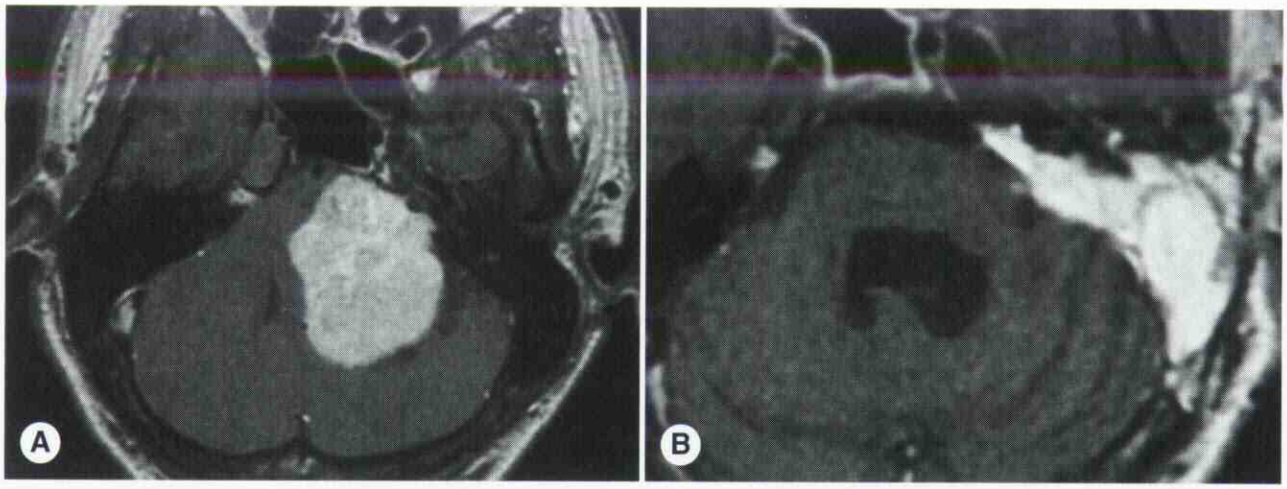

Fig 1. T1-weighted magnetic resonance scan with contrast. **A)** Preoperative scan shows giant vestibular schwannoma producing cerebellar compression and displacement of fourth ventricle and extending to prepontine cistern. **B)** Scan performed 1 year after operation shows complete tumor removal with presence of fat in cerebellopontine angle. Cerebellum has regained its normal morphology.

erative complications, and length of hospital stay. These results will be compared with those previously published in the literature.

Rationale. The rationale of the ETLA is to obtain lateral access to the IAC and the CPA. Its main advantage is that it allows the removal of the lesion with no cerebellar retraction. The performance of the ETLA is not limited by the tumor size. Further bone removal toward the petrous apex (transapical extension)[5] provides the surgeon with steadier control over the anterosuperior portion of the CPA and, in particular, over the area of the fifth cranial nerve and the prepontine cistern. This is particularly useful in cases of large tumors with anterior extension (Fig 1).

Technical Refinements. Some modifications to the original surgical approach have been introduced that are very useful in dealing with large tumors. The details of these modifications are published elsewhere,[2] but we would like to highlight some pertinent points here. The cutaneous incision is larger than the traditional one. It is a C-shaped incision that extends from the mastoid tip up to a point 2 to 3 cm above the superior origin of the auricle, passing 4 to 5 cm behind the retroauricular sulcus.

After initial drilling, we have a 3-cm exposure of the middle fossa and the retrosigmoid dura. During the procedure, the lateral part of the posterior wall of the external auditory canal can sometimes obstruct the view of the posterior fossa. Thinning of this wall and the removal of its most lateral aspect further widen the viewing angle of the posterior fossa.

The identification and skeletonization of the third segment of the FN contributes to enlarge the surgical area. The identification of the FN in the IAC becomes easier if the surgeon first identifies the superior ampullary nerve, which runs in a separate thin bony channel in the most lateral aspect of the IAC.[6] The anterior wall of this channel is the vertical crest, medial to which lies the meatal segment of the nerve.

By using a large diamond bur, the surgeon thins and removes the bone that covers the sigmoid sinus all the way to the jugular bulb, permitting the displacement of the sinus and the posterior fossa dura with delicate pressure of the suction-irrigator. We believe that leaving a bony island on the sinus is of no use, and also might act as an obstacle. Removal of the bone between the sigmoid sinus and the jugular bulb allows better control over the region of the lower cranial nerves.

If necessary, it is possible to decompress a high jugular bulb with the help of a large diamond bur, thus keeping the surrounding periosteum intact. The bulb then needs to be detached very carefully from the bone and pushed down with the protection of a large piece of absorbable hemostatic material (Tabotamp, Ethicon, New Brunswick, New Jersey), which will also control possible bleeding. A large piece of bone wax (Ethicon) is then laid on the absorbable hemostatic material, which serves to keep the bulb in its new position, as well as protect it from the bur.[7]

The inferior wall of the IAC is identified and progressively thinned by drilling parallel to its long axis; then both the IAC itself and the surrounding dura are released. The same technique is applied for the superior walls of the IAC, widely removing the suprameatal cells. The aim of such extensive drilling is to enhance control over the IAC from 180° to 270°. In large and giant tumors, as well as in those characterized by marked anterior extension, it is possible to partially remove the bone situated anterior to the IAC

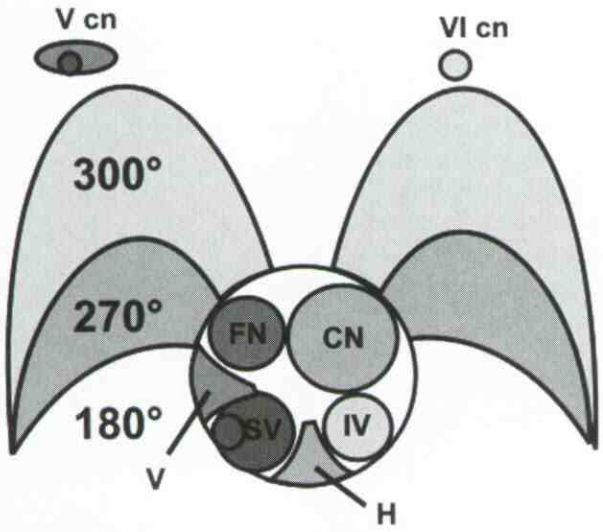

Fig 2. Diagram illustrates extension of traditional translabyrinthine approach to enlarged translabyrinthine approach and enlarged translabyrinthine-transapical approach to deal with large and giant tumors by increasing extent of bone removal around internal auditory canal. V cn — trigeminal nerve, VI cn — abducent nerve, FN — facial nerve, CN — cochlear nerve, SV — superior vestibular nerve, IV — inferior vestibular nerve, V — vertical crest, H — horizontal crest.

and reach the apical compartment of the petrous bone. This can be achieved by further drilling the bone around the IAC circumferentially and extending the control over it to 300° to 320° (translabyrinthine-transapical approach[5]; Fig 2).

Another modification that ensures better tumor removal and protection of vital structures is gradual debulking of the tumor. Reduction of the tumor size enables recognition of structures hitherto hidden. Careful and judicious use of the bipolar cautery at the tumor–brain stem interface causes shrinkage of the tumor, which further facilitates dissection.

MATERIALS AND METHODS

In this retrospective study, all ANs 3 cm or larger that were treated surgically at the Gruppo Otologico of Piacenza-Rome between April 1987 and December 2001 by the senior author (M.S.) and his exclusively neuro-otologic team were taken into consideration. Since the 1980s, the senior author has been regularly performing the ETLA for the removal of ANs 3 cm or larger. The tumor size was measured as the maximum diameter of the extracanalicular component of the tumor, based on the latest radiologic evaluation available. The tumors that were removed incompletely were grouped as having subtotal removal, irrespective of the residual tumor size, even if the residual tumor was only a microscopic remnant along the FN.

The preoperative and postoperative functioning of the FN was clinically evaluated by the Gruppo Otologico in accordance with the classification proposed by House and Brackmann.[8] The evaluation was not based on a telephone interview or a questionnaire. The level of the patients' preoperative hearing was evaluated according to the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology–Head and Neck Surgery (1995).[9]

TABLE 1. DISTRIBUTION OF TUMORS OF ENTIRE SERIES ACCORDING TO SIZE (707 CASES)

Size	*No.*	*%*
Intracanalicular	80	11.3
<1 cm	83	11.7
1.1 to 1.9 cm	207	29.3
2 to 2.9 cm	162	22.9
3 to 3.9 cm*	130	18.4
>4 cm*	45	6.3

*Large and giant tumors.

The principal parameters considered in this study were the incidences of mortality and perioperative morbidity, the postoperative FN function, and the percentages of total and subtotal removal. Statistical significance was calculated with Fisher's exact test when required.

RESULTS

Between April 1987 and December 2001, the Gruppo Otologico of Piacenza-Rome performed 707 AN removal procedures; every principal surgical approach was used in this series. One hundred seventy-five cases had a diameter of 3 cm or larger, with an average size of 3.5 cm (range, 3 to 5.4 cm). These tumors represented 24.7% of the series. Table 1 sums up the 707 tumors, ranked by size.

The study group included 95 men and 80 women with an average age of 48 years (range, 18 to 79 years). The tumor was on the right side in the majority of the patients (right side, 96; left side, 79). Ten patients had residual tumors[10] after undergoing removal via an RSA at another center; 5 had neurofibromatosis type 2 (1 of whom underwent a bilateral operation).

The ETLA was used in 167 cases; 6 of these patients had the middle ear, the eardrum, and the external auditory canal removed, with the closure of the external auditory canal skin as a cul-de-sac. Of the remaining patients, 2 underwent operation via a transotic approach.[4,11,12] We used this approach for large ANs before adopting the concept of transapical extension of the ETLA, after which we never used it for such tumors. Six patients who had a residual tumor with anterior extension toward the internal carotid artery and preoperative facial paralysis underwent operation via the modified transcochlear approach[12-14]; 1 of these patients had an extremely

TABLE 2. FACIAL NERVE FUNCTION IN 19 CASES WITH REPAIR AND FOLLOW-UP OF AT LEAST 1 YEAR

House-Brackmann Grade	*Anastomosis*		
	End-to-End	*Sural Nerve Graft*	*Hypoglossal Nerve–Facial Nerve*
III	5	4	1
IV	0	3	1
V	1	1	1
VI	1	1	0
Total	7	9	3

Six cases are not included here because of no or inadequate follow-up.

large tumor, and the exposure had to be further increased by adding an orbitozygomatic extension.[15]

Total removal of the tumor was performed in the majority of cases (149 of 175; 85.1%); total removal was achieved in 1 stage in all but 1 patient, in whom it had to be staged. A planned subtotal removal was performed in 21 elderly patients (12%). This subtotal removal was planned before the operation to diminish the operative risks to the FN. In 5 cases (2.9%), an unplanned subtotal removal had to be performed because of the tumor's firm adherence to the brain stem, which led to changes in the patient's vital signs during the dissection of the tumor in 4 cases and to the development of significant intraoperative bleeding in 1 patient. All of the patients lost all hearing on the operated side. However, we would like to highlight that only 16 patients (9.1%) had a hearing level that was class A, and 40 patients (22.8%) class B, in accordance with the standards set by the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology–Head and Neck Surgery (1995).[9]

Regarding FN function, of the 175 patients, 23 (13.1%) had a preoperative deficit of grade III or worse; 9 of these had a grade VI paralysis as a result of a previous operation elsewhere. Of these 9, the FN was anatomically intact in 5 and interrupted in 4. Of the remaining 171 patients with an anatomically intact FN before operation, the FN was anatomically preserved in 145 (84.8%). In the remaining 26 cases (15.2%), the nerve was interrupted during the tumor

TABLE 3. COMPLICATIONS

Complications	*No. of Patients*
Death	1
Cerebellopontine angle hematoma	3
Transitory hemiplegia	2
Transitory aphasia	1
Subarachnoid hemorrhage	1
Subdural parietal hematoma	1
Brain stem hematoma	1
Cerebrospinal fluid leak (no operation required)	2
Cerebrospinal fluid leak (operation required)	4
Subcutaneous abdominal hematoma	7
Visual deficit due to sigmoid sinus thrombosis	1
Sixth cranial nerve deficit	12*
Transient cerebellar disturbance	8
Trigeminal neuralgia	1
Subcutaneous cerebrospinal fluid collection	1
Sensory deficit	2

*Two permanent.

removal. The reconstruction was performed with an end-to-end anastomosis in 8 cases and with a sural nerve graft in 11 cases. Six patients required a second operation for a hypoglossal-facial nerve anastomosis. One patient did not consent to a secondary hypoglossal-facial nerve anastomosis. The FN function of these patients is summarized in Table 2. Overall, 115 patients with anatomically preserved FNs were followed up for 1 year, of whom 34 (29.5%) had excellent FN function (grade I or II) and 48 (41.7%) had good function (grade III; Fig 3).

There was 1 death. Among the complications encountered, transitory sixth cranial nerve deficit was the most common, occurring in 12 patients, followed by transitory cerebellar disturbance in 8 patients (4.8%). Abdominal subcutaneous hematoma at the site of fat harvest occurred in 7 patients (4%), and a cerebrospinal fluid (CSF) leak was seen in 6 cases (3.4%). The other complications of the series are presented in Table 3.

The average postoperative hospital stay was 7.33 days (range, 3 to 30 days). Over the years, the duration of hospital stay has progressively diminished,

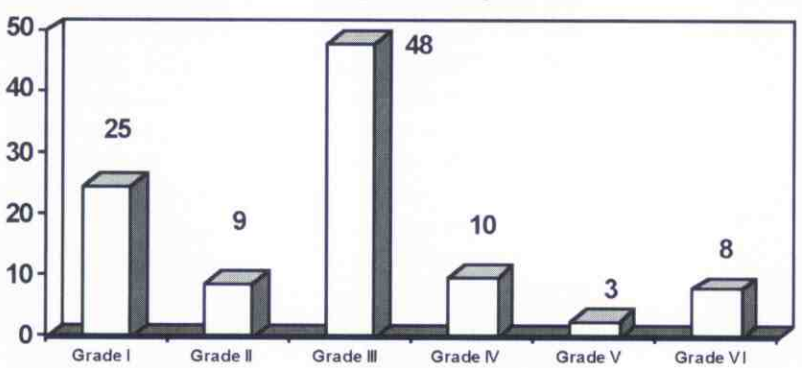

Fig 3. Functional facial nerve results in cases with anatomic preservation and follow-up of 1 year or more (103 cases; figures indicate number of patients). Twelve patients are not included because they did not have normal facial nerve function before operation, and 30 patients were not included because they had no or inadequate follow-up.

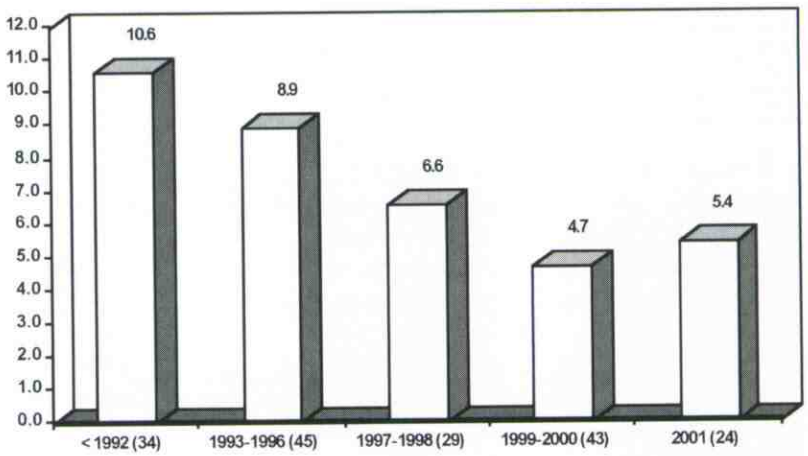

Fig 4. Average hospital stay (in days) over time in cases of large or giant tumors. Figures in parentheses are number of patients in that period.

dropping to 5.1 days in the last 45 cases (Fig 4). Only 13 patients required a postoperative stay longer than 10 days.[16]

DISCUSSION

Surgical removal of large ANs is a challenge. A large tumor size, compression of the brain stem, and extension of the lesion cranially toward the trigeminal nerve, caudally toward the lower cranial nerves, and/or medially toward the prepontine cistern are factors that render the removal of the tumor difficult.

Our personal experience acquired over the years has demonstrated that large and giant tumors may be treated without sacrificing the cranial nerves and without dealing with problems of partial resection and the possible risks associated with a second procedure to remove the residual tumor. Our results further validate those published by other authors.[17-19]

For more than 20 years, surgeons have had discussions about the proper approach to adopt for AN removal. Such discussions are further complicated when one is dealing with large or giant tumors. Many surgeons do not perform the TLA because of the expected limitations of vision and operating space within the CPA.

After the introduction of technical refinements, the ETLA has demonstrated significant advantages in the removal of ANs and other tumors of the CPA, particularly in dealing with large tumors. We perform the ETLA in all cases of tumors with nonserviceable hearing (independent of the size of the tumor) and in all cases of large tumors in spite of the presence of good hearing. In fact, we believe that hearing preservation is not practical when one is attempting total resection of large or giant ANs. In spite of the stress being laid on the importance of an early diagnosis, our case series represents a 24.7% incidence of tumors that were 3 cm or larger in size at the time of diagnosis (Fig 5). This incidence has declined only slightly in recent years.

The TLA described and popularized by William House[1] was initially used on small tumors, and the RSA was preferred for the removal of larger ones. A few surgeons then started combining both approaches to deal with large tumors.[3,20,21] With the progressive application of technical modifications, it has been possible to adapt the TLA, subsequently defined as the ETLA, to tumors of a larger dimension. For this kind of tumor, the RSA often requires a prolonged cerebellar retraction, whereas the ETLA together with

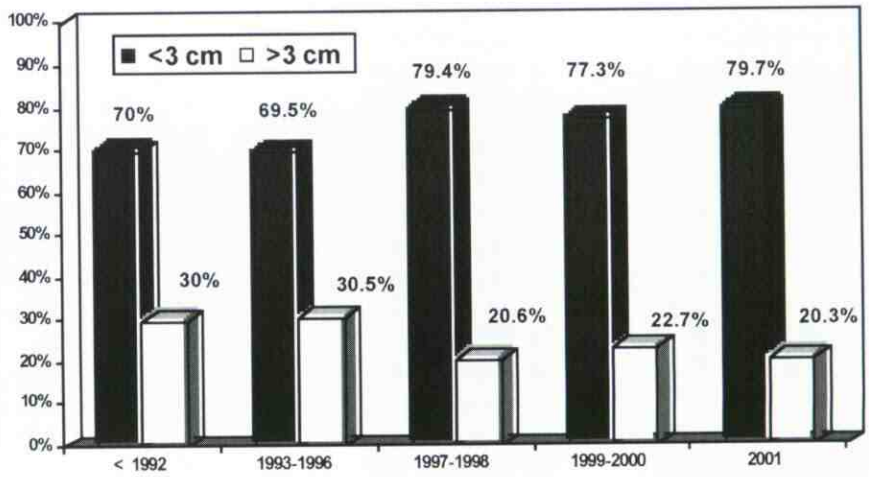

Fig 5. Distribution of large tumors over time and its relation with entire series (707 cases). Size is given as largest extrameatal diameter of tumor.

the transapical extension avoids this. Any approach that decreases the incidence of cerebellar retraction or manipulation is likely to minimize the incidence of morbidity and thereby enhance recovery.

Some authors prefer combining the TLA with a transtentorial approach for larger tumors with anterior extension.[22-24] Such a combination requires division of the tentorium and superior petrosal sinus. It also requires retraction of the temporal lobe, leading to possible complications such as epileptic seizures and aphasia. In our opinion, with the extension of the craniotomy in the direction of the middle cranial fossa, independent of tumor size, it is not necessary to divide the tentorium[22-24] or dissect the superior petrosal sinus[25] to enhance the view.

The principal advantages offered by the ETLA in AN surgery include the unlikelihood of cerebellar manipulation, the opportunity to identify the FN at both ends by directly controlling the fundus of the IAC, and easy access to the surgical area in case of a postoperative hematoma. The (probably necessary) reconstruction of the FN seems to be technically simpler to perform by this approach because of the direct control over the fundus of the IAC.[26,27]

A systematic application of the ETLA to large ANs has provided the opportunity to progressively improve the postoperative results, with a decreased incidence of the principal complications and a shorter postoperative hospital stay, partly related to the total absence of cerebellar compression and manipulation. In rare cases of large residual tumors[10] with significant anterior extension and long-standing FN palsy in patients who have already undergone operation with the RSA, the modified transcochlear approach is recommended. This approach is particularly helpful when the tumor compresses the brain stem anteriorly and extends to the prepontine cistern.[12-14] The removal of the external and middle ear in this approach provides us with a direct and shorter access to the cistern. Such a direct access without retraction permits relatively safe resection of tumors that have been previously classified as unresectable.

Completeness of Tumor Removal. One of the principal goals in AN surgery is the total removal of the tumor. The indications for a planned subtotal removal, leaving a fragment attached to the brain stem and/or the FN, are normally very selective. In our center, this is reserved for patients who are 70 years of age or older and/or in poor health, with the intention of safeguarding their principal neurologic functions, including that of the FN, as far as possible. The probability of a residual tumor's growing further in elderly patients to such an extent that a second intervention would be required is very low. Subtotal removal was planned in our series in 21 of 175 cases (12%), and in 5 cases (2.8%) it occurred unplanned because intraoperative risks dissuaded us from continuing the surgery further.

In the majority of these cases, only microscopic deposits were left on the seventh cranial nerve. These 21 cases are being regularly monitored radiologically, and so far none has shown any evidence of regrowth. However, we would like to add that most of these cases have undergone operation in the past 2 or 3 years, and it is too early to comment on their recurrence because the follow-up period is inadequate. Of the 5 patients with unplanned partial removals, 1 underwent stereotactic radiotherapy, 1 had a stable residual tumor at 1 year after surgery, and 2 had postoperative magnetic resonance imaging that did not show any lesion. The last patient has shown evidence of regrowth and is currently awaiting reoperation.

The percentage of subtotal removal is slightly higher than that reported by other authors,[17,18] who also took into consideration smaller tumors in their case studies. Our figure of 14.8% would be reduced substantially, to 3.6%, if we were to consider our entire series of 707 cases through December 2001, as subtotal removal is practically unknown in smaller tumors. None of our cases treated with the ETLA, except the ones mentioned above, have shown any evidence of recurrence.

Mortality Data. Death after AN surgery is generally dependent on occlusion of the anteroinferior cerebellar artery or brain stem trauma caused by surgical manipulations or perioperative bleeding. The incidence of perioperative and postoperative death has significantly decreased over the years in specialized centers, to less than 1%.[15,17,28] It is obvious that these rare deaths are more frequent in patients with tumors of larger dimensions. In our case report, the only patient who died had a particularly vascularized 3-cm AN. This patient represents the only death in a series of 707 neuromas treated surgically up to December 2001. There was uncontrollable bleeding leading to hematoma in the CPA and finally invading the ventricles. This led to an irreversible coma and the death of the patient after 7 days.

Hematomas of Cerebellopontine Angle. The development of a hematoma in the CPA is the most serious postoperative complication in AN surgery. Because it causes a rapid worsening of the patient's state of consciousness, it is necessary to keep the patient under constant neurologic monitoring for the first 24 to 48 hours. To assess the level of consciousness, we usually awaken him or her and remove the endotracheal tube as soon as the operation is over. When an emergency evacuation is required, the ETLA

provides us with a significant advantage: the ability to reach the CPA hematoma very quickly by removing the sutures and extracting the abdominal fat. In the case of extreme emergencies, this procedure can also be performed in the ward, thereby saving valuable time.

Postoperative hematoma occurred in 3 cases in our series. Two cases required surgical drainage of the hematoma; 1 patient died, as mentioned above. In the last case, there was a delayed diagnosis because of a metabolic decompensation, and so we preferred conservative management using an external ventricular shunt and serial radiologic monitoring. Because of the tumors considered in the study group, the incidence of postoperative CPA hematomas (2.3%) is slightly higher than that reported by Samii and Matthies[28] (1.7%), who included tumors of all sizes in their report. The incidence in our study would be significantly reduced (0.4%; 3 of 707) if we took into consideration tumors of all sizes, because we have never encountered a postoperative CPA hematoma in a smaller AN.

Anatomic Preservation of Facial Nerve. One of the routine aspects of AN surgery is the preservation of the FN anatomy. However, this goal might be difficult to achieve in dealing with tumors larger than 3 cm,[8,18,23,26,29,30] mainly because of compression of the nerve by the tumor, which causes a progressive thinning and stretching of the nerve. In particular situations, it might even be difficult to distinguish the nerve from the tumor capsule. In such a situation, the ETLA offers the advantage of allowing identification of the nerve at both ends (the fundus of the IAC and its emergence from the brain stem), and therefore dissection can be performed in both mediolateral and lateromedial directions. Moreover, intraoperative monitoring of the FN is routinely used to minimize the risk of injury to the FN.[31,32]

Anatomic interruption of the FN in our series occurred in 3.6% (26 of 171), which is comparable with the rates in other case reports.[17,23,28] This percentage is naturally higher than that for removal of the smaller ANs with the ETLA during the same period of time (2.9%).

When the FN cannot be anatomically preserved, the best solution is to immediately reconstruct it with the help of a graft. In such a situation, the ETLA seems to be better than the RSA because it allows direct access to the fundus of the IAC. The grafting procedures have been described elsewhere.[27]

Facial Nerve Function. Although some patients who had large tumors may have had their FN anatomically preserved, their postoperative function is not as satisfactory as that of patients who had smaller tumors, because of surgical trauma to the nerve, previously compressed and/or stretched by the tumor. The relationship between the tumor size and the prognosis of the FN has already been studied by many other authors.[19,29,33]

The analysis of the postoperative facial function in our study group shows that 71.3% (82 of 115) achieved a satisfactory result (grades I to III; Fig 5). Only 115 patients were considered for the analysis, as these were the patients who had a follow-up of 1 year or more. These results are poorer than those obtained for patients with tumors smaller than 3 cm in size, of whom 94% achieved facial function between grades I and III. We do not agree with the authors[17] who consider grade IV an acceptable functional result.

It was very difficult to compare the results reported by various centers, because they considered tumors of different sizes in their series, they used different methods for measuring the dimensions of the tumor, their evaluation of the postoperative FN function was often based on telephone interviews and/or questionnaires,[17,23,28] and their criteria for selecting the approach were not necessarily the same. In any event, the results achieved by surgeons with ample experience probably do not differ from each other significantly.

Hearing Preservation. The ETLA itself precludes any possibility of hearing preservation. However, the majority of large tumors present with a certain degree of compromised hearing before operation. In our series, only 16 patients presented with a preoperative hearing level of class A according to the American Academy of Otolaryngology–Head and Neck Surgery (1995).[9]

Statistically, the rate of conservation of hearing in tumors larger than 2 cm is very low.[3,34-37] Ebersold et al[38] did not report any success in hearing preservation in tumors larger than 4 cm. Other authors reported measurable hearing in only 4% of patients with tumors larger than 2 cm removed via the RSA.[39,40] The surgeon must be aware of the price to be paid in the form of postoperative complications or leaving behind a residual tumor while attempting to preserve hearing.[41-43]

Nowadays, in our center, the criteria followed for selecting a patient to undergo hearing preservation surgery are very stringent, and we prefer as a safer option the ETLA when the preoperative data do not suggest a realistic possibility of achieving a hearing level of class A or B and in tumors more than 2 cm in size, barring a few exceptional cases.

Cerebrospinal Fluid Leak. A CSF leak is one of

the most serious postoperative complications of AN removal. It is said that tumor size determines the incidence of CSF leaks,[44] but results reported previously show that this is not always true.[45,46]

In this series, a CSF leak appeared in 3.4% of patients (6 of 175), as compared to a rate of 1.15% in tumors smaller than 3 cm on which the ETLA was used during the same period. These percentages seem to suggest that size might play a role in determining the incidence of CSF leaks, but the difference between them is not statistically significant ($p = .087$). As a result of the progressive introduction of specific technical refinements,[2,3,45,46] the last 87 cases of tumors larger than 3 cm treated surgically between September 1994 and December 2001 did not show any evidence of a CSF leak.

Of the 6 cases with a CSF leak (5 with rhinorrhea and 1 with a cutaneous leak), 4 required revision surgery, whereas in the remaining 2 the leak resolved spontaneously after conservative treatment with a lumbar drain.

Other Complications. Our case series does not include a single instance of postoperative meningitis, which is frequently mentioned by other authors (3%).[28,47] A report from the House Ear Institute mentions a higher incidence of meningitis in larger tumors, probably because during operation on large tumors the meninges are exposed for a long time.[47] For this reason, we usually administer postoperative antibiotic therapy (piperacillin, 2 g every 4 hours) for more than 48 hours if the intervention lasts longer than 8 hours.

Postoperative paralysis of the lower cranial nerves may significantly influence the quality of the patient's life. This complication might be temporary, but it often prolongs the postoperative hospital stay because of problems concerning swallowing and aspiration pneumonia. Paralysis of the lower cranial nerves is more likely to occur with the RSA because of the stretching of the nerves caused by the cerebellar retraction. Samii and Matthies[28] report an incidence of 5.5% in the immediate postoperative period. The incidence of a temporary lower cranial nerve deficit was also reported after intervention with the ETLA.[18] In our series, we only had 1 patient with paralysis of the 9th and 10th nerves; this patient had spontaneous compensation. This was probably the result of scrupulous removal of all bone that was medially situated between the sigmoid sinus and the jugular bulb.[7] Furthermore, the dural opening can be extended inferiorly to provide better control over the lower cranial nerves without any need for cerebellar retraction.

As far as the rare cerebellar disturbances are concerned, particularly ataxia and dysmetria, the ETLA is safer than the RSA because it causes hardly any significant cerebellar compression. This fact becomes more pronounced in cases of large tumors, especially in elderly patients. This advantage is further confirmed by the fact that none of our patients suffered from any permanent cerebellar problems, which are mentioned in other case reports.

None of our patients suffered from postoperative epileptic episodes, as reported in centers in which the enlargement of the approach is obtained by sectioning the tentorium and/or the superior petrosal sinus.[23,25]

Postoperative Hospital Stay. The duration of the postoperative hospital stay is a parameter that has rarely been given significance in the AN literature.[15-17] To our knowledge, there is only 1 study[16] that focuses on the duration of the patient's postoperative recovery after AN removal. This parameter is becoming more important because of the attention being given to the reduction of health care expenditures. The progressive reduction in hospital stay is testimony to the progressive reduction of complications, especially CSF leaks, and the minimal cerebral and cerebellar manipulation required by the ETLA.

CONCLUSIONS

The misconception that the TLA gives restricted vision and limited control over the CPA dissuades surgeons from using this approach for the removal of large ANs. The existence of anatomic obstacles that are quite difficult to overcome, such as a high jugular bulb, an anteriorly placed sigmoid sinus, low-lying dura of the middle cranial fossa, and a small mastoid cavity, have been considered as contraindications to this approach. Over the years, the experience acquired in performing operations in a large number of patients who have disease of the CPA and skull base has helped some specialized otoneurosurgical centers to develop a series of improvements on the traditional TLA that allow a surgeon to deal with anatomic variations that might act as an obstacle to the removal of large ANs.

A review of 175 patients who underwent removal of large ANs (≥3 cm) via the ETLA shows a high rate of total tumor removal with a low rate of complications. The ETLA requires less cerebellar retraction than the RSA, and offers the possibility of identifying the FN both at the IAC and at the brain stem. Therefore, it is possible to have good anatomic and functional preservation of the FN with a very low incidence of major complications, including CSF leaks.

The results of our study demonstrate that tumor

size need not play an important role in the adoption of the ETLA for AN removal, if the technical refinements are applied properly. On the contrary, the reduced morbidity and the shorter hospital stay render the ETLA the best approach for tumors larger than 3 cm.

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