Editorial Manager(tm) for Otology & Neurotology
Manuscript Draft

Manuscript Number: ON-10-119R1

Title: Enlarged Translabyrinthine Approach with Transapical Extension in the Management of Giant Vestibular Schwannoma: Personal Experience and Review of Literaure

Article Type: Original Study

Keywords: Giant vestibular schwannoma; Acoustic neuroma; Surgery; Enlarged translabyrinthine approach; Transapical extension

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Abstract: Objective: To describe and analyze the main outcomes achieved in a series of patients with sporadic vestibular schwannoma (VS) larger than 40 mm in extrameatal diameter, defined as giant VS, submitted to microsurgery by the enlarged translabyrinthine approach (ETLA) with transapical extension.
Study Design: Retrospective chart review.
Setting: Tertiary referral center.
Patients: A retrospective chart review was conducted on 2133 patients who underwent surgery for VS from April 1987 to July 2009. One-hundred and ten cases of giant VS were elected for analysis.
Main Outcome Measures: Extent of removal, residual or recurrent disease, facial nerve integrity during surgery, long-term facial nerve function, postoperative complications.
Results: Total removal was accomplished in 91.8% of cases. In 5 patients (4.5%), total removal was accomplished in two stages. Near total removal (NTR) was performed in 7 patients (6.3%). The facial nerve (FN) was anatomically preserved in 76.4% of cases. Intraoperative FN reconstruction was performed in 8 cases. Facial nerve function after 1 year of follow up was House-Brackmann grade I to III in 75% of cases. There were no deaths in this series. Neurovascular life-threatening complications occurred in 2 patients. Cerebrospinal fluid (CSF) leak was present in 1.8% of cases.
Conclusions: Results indicate the ETLA with TA extension as an elective approach for removal of giant VS. The method permits achievement of a high rate of total removal with low incidence of complications.

Cover Letter

Piacenza (Italy), March 22, 2010.

RE: **Enlarged Translabyrinthine Approach with Transapical Extension in the Management of Giant Vestibular Schwannoma: Personal Experience and review of Literature**, by Angeli RD, Piccirillo E, Di Trapani G, Sequino G, Taibah A, Sanna M.

Word count:

Dear Prof. John K. Niparko, MD, Editor-in-Chief:

On behalf of the co-authors, I respectfully submit the enclosed material for possible publication in Otology & Neurotology. I affirm that the present study has not been submitted for publication nor has been published in whole or in part elsewhere. I attest to the fact that all authors listed on the title and authors page have read the manuscript, attest to the validity and legitimacy of the data and its interpretation, and agree to its submission to Otology & Neurotology.

Copyright transfer and the signatures of all authors will be request prior to publication of accepted manuscripts.

Yours sincerely,

Roberto D. Angeli, MD.

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***Response to the Reviewers (No Author Information)**

Dear Prof. John K. Niparko, MD, Editor in Chief

On behalf of all co-authors, I express my gratitude regarding the careful review of the article "Enlarged Translabyrinthine Approach with Transapical Extention in the Management of Giant Vestibular Schwannoma: Personal Experience and Review of the Literature" (Code ON-10-119)

The manuscript was adapted according to the reviewers' comments.

Reviewer #1.

The manuscript was effectively reduced. Every effort was made in attempt to maintain the quality of the information. Figures 2, 3, 4D and 4F were omitted, as suggested by the reviewer, as well as Figures 5A and 5B. Figure 3 was omitted because the given information was close to that described in Table 2.

In this new version, we included a statement concerning the technique of dural closure, as well as the closure of the antrum, middle ear and Eustachian tube. We also included a paragraph in which we explain our routine with regard to intraoperative cranial nerves monitoring.

Reviewer #2.

1. Figure 2 was omitted.
2. Figure 3 was omitted in an attempt to reduce the length of the article, as suggested also by the reviewer #1.
3. We eliminated the images of the second clinical case, as suggested.
4. Table 3 was omitted.
5. We included the information regarding the number of cases operated on by the ETLA approach in Table 8, now reformatted as Table 6 (two previous tables were elimitaned).

***Title and Author Page**

ENLARGED TRANSLABYRINTHINE APPROACH WITH TRANSAPICAL EXTENSION IN THE MANAGEMENT OF GIANT VESTIBULAR SCHWANNOMAS: PERSONAL EXPERIENCE AND REVIEW OF LITERATURE

Running Head: ETLA WITH TRANSAPICAL EXTENSION IN GIANT VS

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Financial disclosure:
Supported by grant from the Associazione Italiana Neuro-Otologica (A.I.N.OT).

Acknowledgments:
The authors thank Prof. Enzo Molina, from the School of Medicine of the University of Parma, Italy, and Ms. Josephine Manzella, for editorial assistance.

ABSTRACT

Objective: To describe and analyze the main outcomes achieved in a series of patients with sporadic vestibular schwannoma (VS) larger than 40 mm in extrameatal diameter, defined as giant VS, submitted to microsurgery by the enlarged translabyrinthine approach (ETLA) with transapical extension.

Study Design: Retrospective chart review.

Setting: Tertiary referral center.

Patients: A retrospective chart review was conducted on 2133 patients who underwent surgery for VS from April 1987 to July 2009. One-hundred and ten cases of giant VS were elected for analysis.

Main Outcome Measures: Extent of removal, residual or recurrent disease, facial nerve integrity during surgery, long-term facial nerve function, postoperative complications.

Results: Total removal was accomplished in 91.8% of cases. In 5 patients (4.5%), total removal was accomplished in two stages. Near total removal (NTR) was performed in 7 patients (6.3%). The facial nerve (FN) was anatomically preserved in 76.4% of cases. Intraoperative FN reconstruction was performed in 8 cases. Facial nerve function after 1 year of follow up was House-Brackmann grade I to III in 75% of cases. There were no deaths in this series. Neurovascular life-threatening complications occurred in 2 patients. Cerebrospinal fluid (CSF) leak was present in 1.8% of cases.

Conclusions: Results indicate the ETLA with TA extension as an elective approach for removal of giant VS. The method permits achievement of a high rate of total removal with low incidence of complications.

INTRODUCTION

The management of giant vestibular schwannomas (VS) has been a challenging task for skull base surgeons. These huge tumors are frequently related to compressive symptoms over cranial nerves and brainstem, as well as obstruction to the cerebrospinal fluid (CSF) pathway. Microsurgical resection is the treatment of choice for these patients.

William House detailed described the translabyrinthine approach (TLA) in 1964 (1). In the following years, some authors pointed out that this method was not suitable for accessing oversized VS because of its constricted exposure (2). Some modifications were further added to the original approach described by House in order to obtain a wider surgical view and a better control over the tumor and surrounding structures. The Enlarged TLA (ETLA) and the transapical (TA) extension are technical refinements introduced for the treatment of large and giant VS (3-5).

Only few studies have analyzed exclusively outcomes of VS equal or larger than 40 mm, defined as giant tumors. Giant, large and even medium VS are usually described together and results of the first group can't be properly analyzed. When accessing a VS, surgeons expect the approach to be safe, effective, and provide a wide surgical view with a reduced incidence of complications. When managing a giant tumor, these requirements acquire special meaning.

The aim of this study is to analyze a consecutive series of 110 giant VS with special regard to the modifications of the original TLA, extent of tumor removal, residual or recurrent disease, postoperative facial nerve function, and complications.

MATERIALS AND METHODS

We retrospectively reviewed all cases of VS submitted to microsurgical resection at the Gruppo Otologico in Piacenza - Rome, between April 1987 and July 2009. Patients were included if they had a VS larger than 40 mm, according to largest extrameatal diameter seen in latest preoperative MRI scan. Patients with

neurofibromatosis type 2 were excluded. Results are described according to the Consensus Meeting on Systems for Reporting Results in Vestibular Schwannoma (6). All patients in this series underwent surgery by the senior author (M.S.) or under his direct supervision. Tumors removed incompletely were grouped as having near total removal (NTR), when 5% or less of the tumor was unresected, or subtotal removal (STR), when more than 5% was left. Residual or recurrent disease was monitored by gadolinium-enhanced MRI scanning at 2, 12, 36 and 60 months.

The facial nerve (FN) function was assessed according to the House and Brackmann (HB) Grading Scale (7). Postoperative outcomes were scheduled after at least 1-year follow-up. All cases were directly evaluated by the senior author or his associates. Complications such as neurological dysfunctions, cerebellar symptoms and cranial nerve deficits are described only if present exclusively after surgery.

Statistical significance was calculated with Fisher's exact test when required.

SURGICAL TECHNIQUE

The ETLA includes a broad mastoidectomy in which bone anterior and posterior to the sigmoid sinus and around the middle fossa is completely removed (8). When necessary, a high placed jugular bulb and surrounding periosteum are pressed inferiorly with oxidized cellulose (Surgicel®, Ethicon) and bone wax (9). The IAC is exposed about 270º of its circumference.

The principle of the TA extension is an increase of bone removal around the IAC from 300 to 360º (Figure 1). In large and giant VS with anterior extension, the circumference of bone removal around the IAC can reach up to 320º (TA extension Type I). Cases in which the IAC is drilled up to 360º (TA extension Type II) are reserved for patients with meningeomas of the posterior surface of the petrous bone (8).

The superior ampullary nerve (SAN) has been our main anatomic guide to identify the FN. It is identified at the level of superior semicircular canal's ampulla and

detached from its bony canal. The FN is separated from the SAN by the widest part of the vertical crest, lowering the possibility of trauma (10).

For continuous intraoperative monitoring of the facial nerve we use the Nerve Integrity Monitor (NIM Response ® 2.0, Medtronic Xomed). Two pairs of subdermal needle electrodes are placed 5 mm apart in the orbicularis oculi and orbicularis oris muscles. In our protocol, we investigate the pattern of burst and train responses during the last step of tumor removal combined with intraoperative stimulation of the nerve at minimal threshold stimulation. We are not used to perform intraoperative mapping of the facial nerve.

Tumor debulking is gradually accomplished. When a large piece of tumor is coagulated, its capsule is detached from surrounding structures and then excised. Finally, only a small layer of tumor and capsule is attached to neurovascular structures which lie anteriorly. The cleavage plane is found and removal is accomplished (8). The incus is disarticulated and removed from the tympanic cavity using a right angle pick. Subsequently, attic, middle ear and Eustachian tube are plugged with dry periosteum. A careful inspection of the mastoid with a small hook will ensure that all open cells can be closed with bone wax.

Obliteration of the operative site is accomplished by packing it completely with long strips of abdominal fat in such a manner that part of the strips protrudes into the CPA. No attempt is made to suture the dural edges.

The transotic approach (TO) is an anterior prolongation of the ETLA, at the expenses of the cochlea. The middle ear is removed and the external auditory canal (EAC) is closed in two-layered blind-sac. The FN is skeletonized and maintained in place (8,11,12). We employ this approach exclusively in cases of high jugular bulb and coincident dominant sigmoid sinus. The transcochlear approach (TC) combines the removal of EAC and middle ear with posterior rerouting of the FN and removal of the cochlea (12). This approach is indicated in cases of residual tumor with preoperative FN deficit.

RESULTS

Patients

Between April 1987 and July 2009, 2133 patients underwent surgery for VS at the Gruppo Otologico (Table 1). The study group included 110 patients (59 women and 51 men) who presented an extrameatal tumor sized at least 41 mm. These patients represent 5.1% of all cases. The mean age was 42.5 years (range 18-80 yr). The right side was affected in 59 patients (53.6%). Eight patients (7.2%) had undergone previous surgery elsewhere and were classified as having residual or recurrent disease. Two patients had been previously submitted to radiotherapy. Three patients had both clinical and radiological signs of ventricular hypertension and underwent ventriculoperitoneal shunt before tumor removal. The mean length of postoperative hospital stay was 6.9 days (range 4-22 days). All patients were operated by the ETLA with TA extension, except in 7 cases in which the TO was employed and in 4 other cases in which the TC was the method of choice, according to indications already mentioned.

Completeness of removal

Staged STR was performed in 7 patients. Five patients were reoperated 6 to 8 months after the initial procedure and total removal was accomplished (Figure 2). One patient with significant cardiovascular co-morbidities presents a residual tumor sized 8 mm and has been followed for 2 years with sequential MRI scans. Up to this moment, 1 remaining patient is scheduled for a second intervention. Considering these 5 cases submitted to staged strategy, complete removal was accomplished in 101 (91.8%) patients. No recurrent disease was diagnosed in this group of patients.

Seven patients (6.3%) underwent NTR. In 1 patient, the decision was planned, secondary to advanced age. In the other cases, it was an intraoperative decision, bacause of the presence of a tight adhesion between tumor and brainstem or AICA. In

1 case, the residual tumor presented a consistent growth. The patient refused revisional surgery and was referred for radiotherapy. This patient has been followed for 8 years with a stable 5 mm lesion.

Facial nerve outcomes

Four patients presented Grade VI preoperatively. All were submitted to previous intervention elsewhere and were excluded from any further analysis. Out of 106 remaining patients, 101 presented Grade I and 5 presented Grade II before surgery.

The FN was anatomically preserved in 81 of the 106 cases (76.4%). Considering both groups (FN preserved or interrupted), 88 patients had completed the minimum required 1-year follow up at the time this study was being carried out and were available for analysis of long-term outcomes. Results were compared to those obtained in patients with VS equal or smaller than 40 mm (Table 2). In patients with VS equal or smaller than 10 mm, the incidence of Grade I was superior to 70%, and Grade VI was observed in less than 0.5% of cases. Considering the group with giant VS, 8% of patients reached Grade I after 1 year, while 25% of patients presented Grade VI. From a statistical perspective, patients with giant VS presented worst outcomes in comparison to patients with smaller tumors (χ^2, $p<0.001$).

The FN was interrupted during surgery in 25 patients (23.6%). In 8 cases, an intraoperative reconstruction was performed (end-to-end anastomosis in 1 case; sural nerve graft in 7 cases). Twelve patients were submitted to delayed hypoglossofacial anastomosis. The remaining patients refused any additional treatment.

Postoperative complications

There were no deaths related to the surgery.

One patient presented a CPA hematoma in the early postoperative period that required immediate evacuation. In another patient, an asymptomatic subdural

collection was seen in a postoperative MRI scan. Hemorrhagic infiltration of the brainstem was diagnosed in a third patient with a transitory dysfunction of the sixth, ninth and tenth cranial nerves. In the last two cases, blood collections were reabsorbed in 3 to 6 weeks.

One patient presented a persistent rhinoliquorrea that required closure of the middle ear and the Eustachian tube with perichondrium. A second patient presented CSF leak through the retroauricular incision, requiring reopening of the wound and reinforcement of the muscular suture.

Six patients presented postoperative VIth CN deficit that was recovered completely in 5 of them. Lower cranial nerve dysfunctions were seen in 3 cases, all of them transitory.

One patient developed postoperative cerebral edema, with signs of increased intracranial pressure which required external ventricular shunt.

A general overview of postoperative complications is seen in Table 3.

DISCUSSION

Most skull base surgeons deal with giant VS in their practice. In referral centers, this is particularly true. Retrosigmoid approach (RSA) and TLA are established methods for removal of these tumors. Authors who adopt the TLA emphasize the advantages of minimal cerebellar retraction and identification of the FN before its involvement with the tumor. Some authors draw attention to the necessity of extending bone removal until the posterior fossa dura, which allows retraction of the sigmoid sinus (17,20). This refinement can be considered a decisive step forward regarding the effectiveness of the ETLA.

Anderson et al. propose a combined method for removal of VS larger than 40 mm, in which RSA and TLA are employed in one single stage (13). The authors indicate the limitations of the singular approaches, as the difficult management of a high jugular bulb. In our experience, the ETLA overcomes these limitations without

additional morbidity. Patni and Kartush (14) propose a staged strategy for large VS, in which the tumor is partially removed by RSA and a second surgery is performed 4 to 6 months later by the TLA. Our opinion is that combined strategies expose patients to risks inherent to each isolated approach.

Sluyter et al. (15) propose the association of the TLA with transtentorial extension. Out of 120 patients, 12 presented postoperative aphasia, and 4 required permanent medication for seizures. We do not consider the transtentorial extension a suitable option for removal of large or giant VS because of risks of permanent neurological deficits secondary to retraction of the temporal lobe.

Out of 13 series analyzed (13-25), in 3 articles the authors describes exclusively the outcomes of VS equal or larger than 40 mm (Table 4). Samii et al. (23) and Mehrotra et al. (24) employed the RSA; Mehrotra et al. presented the higher incidence of complications in all series analyzed (Table 5), opposed to good results described by Samii et al. This may indicate the importance of personal experience in achievement of satisfactory outcomes. Briggs et al. (17) employed the TLA as the preferred method; outcomes described reveal a high incidence of total removal, FN integrity and a low incidence of complications.

Hearing preservation

A common criticism of the TLA is the sacrifice of any residual hearing function. According to Samii et al. (23), hearing preservation is possible even in patients with giant VS. In their series of 50 giant VS treated by the RSA, 9 patients had preoperative serviceable hearing. In only 3 cases (6% of the entire series) it was possible to maintain hearing at functional levels, according to the New Hannover Classification. In contrast, other authors affirm that hearing preservation is extremely unlikely in patients with VS larger than 3 cm (16,18). Facing the published results and our personal experience, we sustain the policy of employing the RSA only in patients with VS

smaller than 15 mm and hearing levels classes A or B, according to Sanna's classification (6).

Surgical technique

Extent of exposure has always been a major concern regarding lateral skull base surgery. With the ETLA, the operating field is enlarged at the expenses of bone removal. Most of the retraction is performed over the sigmoid sinus. A high jugular bulb can be securely decompressed and pushed inferiorly. The TA extension highly raised the effectiveness of the ETLA, providing an excellent control of anterior extension of the tumor. When properly performed, the ETLA with TA extension allows removal of tumors of any size.

Transcochlear and transotic approaches provide better anterior extension compared to the ETLA alone. Following introduction of the TA extension, these methods have rarely been performed in our Center.

Facial nerve outcomes

The ETLA offers the advantage of allowing direct access to FN before its involvement with the tumor, at a constant anatomical location (18). When necessary, the approach provides an excellent view to perform its immediate reconstruction. In these cases, sural nerve interposition is our procedure of choice. The end-to-end anastomosis is not indicated because traction on nerve fibers impedes adequate functional recovery. In the RSA, these types of reconstruction are not possible. We limited the use of hypoglossofacial anastomosis to cases in which the FN is not identified at brainstem.

We have observed that a silent EMG pattern during the last step of the tumor removal procedure is more likely to be associated with poor long-term and short-term outcome than one in which considerable spontaneous or mechanically elicited activity is found.

Completeness of removal

Incomplete removal may result either from unpredictable intraoperative circumstances or from a planned NTR. Our philosophy has always been to perform total removal. Nevertheless, planned partial removals have been considered in elderly patients, supported by the general belief that VS are benign slow-growing tumors (26). In cystic VS, there is a trend to leave the capsule unresected, avoiding surgical trauma to underlying brainstem or vital vessels (27).

Patients submitted to a two-staged strategy form a group in which the tumor is extremely adherent to the brainstem. Tumor debulking is related to excessive bleeding and vital sign changes, as bradycardia or raising arterial pressure. In these cases, staged strategy could be considered a life-saving intraoperative decision. Our policy is to perform a second stage 4 to 6 months later, by the same approach.

Postoperative Complications

In the last years, rates of mortality in most studies have been drastically reduced (Table 5). Deaths usually result from neurovascular disorders such as arterial occlusion, perioperative bleeding or trauma to brainstem. Patients with larger tumors are more exposed to risk. Giant VS are extremely adherent to underlying structures and the anatomy is always distorted.

In this series, neurovascular life-threatening complications occurred in 2 cases. One patient developed a cerebral edema followed by intracranial hypertension. A second patient had a CPA hematoma requiring immediate intervention. The ETLA offers an unique advantage in these cases. Once the fat strips are removed, the CPA is promptly accessed and the hematoma can be evacuated. Another remarkable advantage of the ETLA is the minimal cerebellar retraction, which reflects our low incidence of postoperative ataxia.

Most cases of CSF leak have been successfully managed with supportive measures. Cases requiring reintervention are described as 1 to 5% in most studies (Table 5). In the present series, 2 patients (1.8%) needed surgical management. Our recent studies (28) revealed an overall incidence of 0.55% of CSF leak requiring revisional surgery in more than 1800 cases of VS operated by the ETLA. Our incidence greatly fell after we adopted the method of closing the dural defect with abdominal fat strips instead of sutures of the dura.

Lower cranial nerve deficits are usually temporary but related to a long hospital stay because of problems concerning swallowing disorders and aspiration pneumonia. Removal of bone between IAC and jugular bulb permits an excellent control over the region of these nerves. Therefore, we do not perform intraoperative monitoring of the lower cranial nerves in cases of VS removed through ETLA.

From a clinical perspective, oversized VS are associated to a higher incidence of cranial nerve deficits and cerebellar ataxia. Life-threatening complications such as CPA hematoma or trauma to the brainstem have an incidence around 1%, even in patients with giant tumors (Table 6).

Conclusion

The advantages of the ETLA with TA extension, in comparison to the RSA, include: 1) easy identification of the FN in an invariable position in the fundus of the IAC; 2) FN can be dissected from its emergency in the brainstem up to the fundus, allowing intraoperative reconstruction in cases of anatomical interruption; 3) management of the high jugular bulb with the possibility of lowering it and achieving optimal results over lower cranial nerves, 4) minimal or no cerebellar retraction; 5) in case of CPA hematoma in the postoperative period, the approach permits rapid control of bleeding and prompt evacuation.

The outcomes achieved in this series indicate that ETLA with TA extension is the elective approach for removal of giant VS. In our experience, the method permits

the achievement of a high rate of total removal of tumors with extremely low incidence of major complications.

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FIGURE LEGENDS

FIGURE 1. Diagram illustrating the extension of traditional TLA to ETLA with TA extension by increasing the drilling around the IAC. (FN: facial nerve; CN: cochlear nerve; SV and IV: superior and inferior vestibular nerves; V: vertical crest; H: horizontal crest; AE: anterior extension)

FIGURE 2. Two-stages removal in a 28 year-old female. Right side. T1-weighted MRI scan. A and B) Axial and coronal preoperative scan demonstrating a 50 mm tumor. C) Axial postoperative scan demonstrating the presence of residual tumor after subtotal removal. D) Axial postoperative scan demonstrating complete removal.

Figure 1

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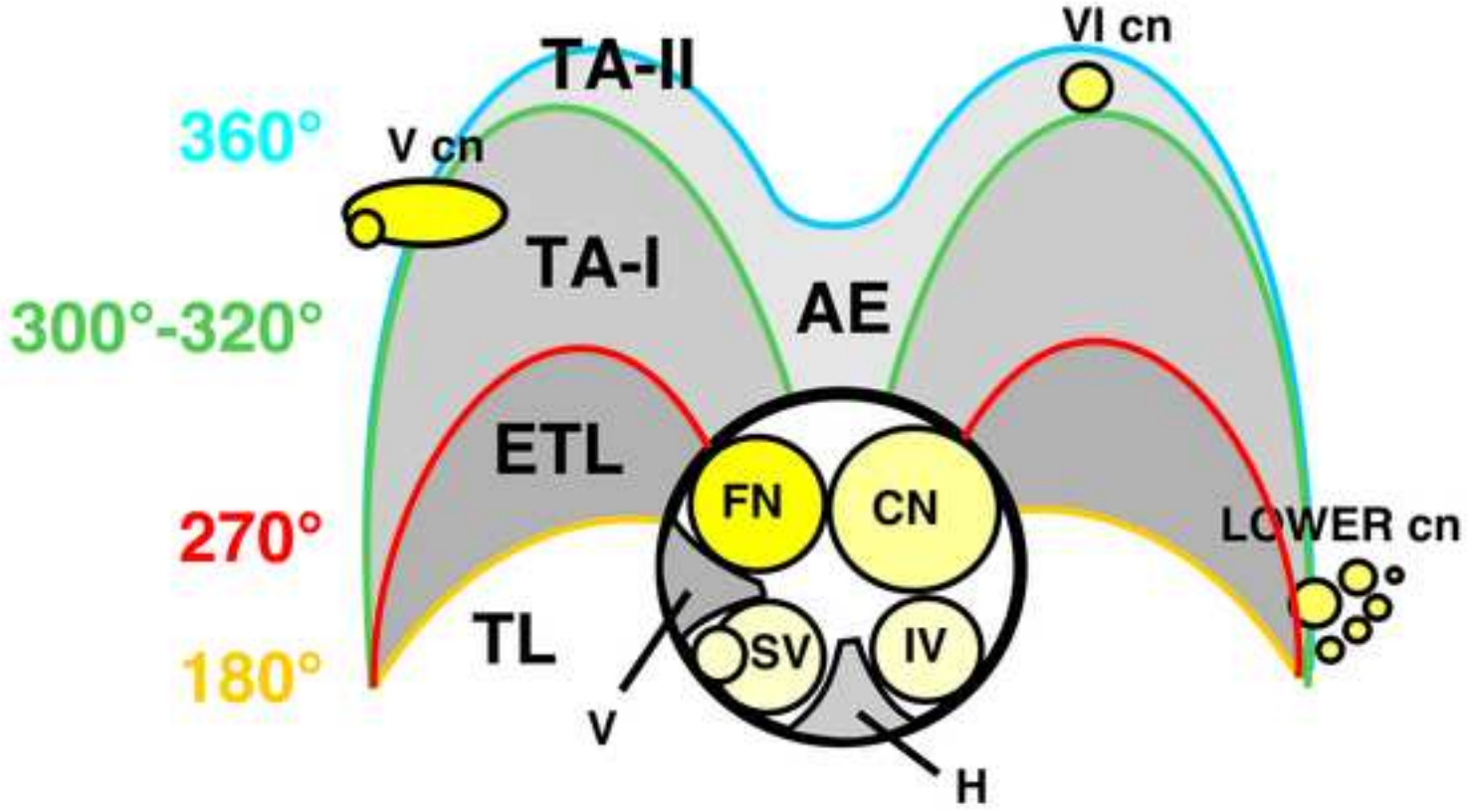

TL = translabyrinthine

ETL = extended translabyrinthine

TA-I = Transapical type I

TA-II = transapical type II

Figure 4A

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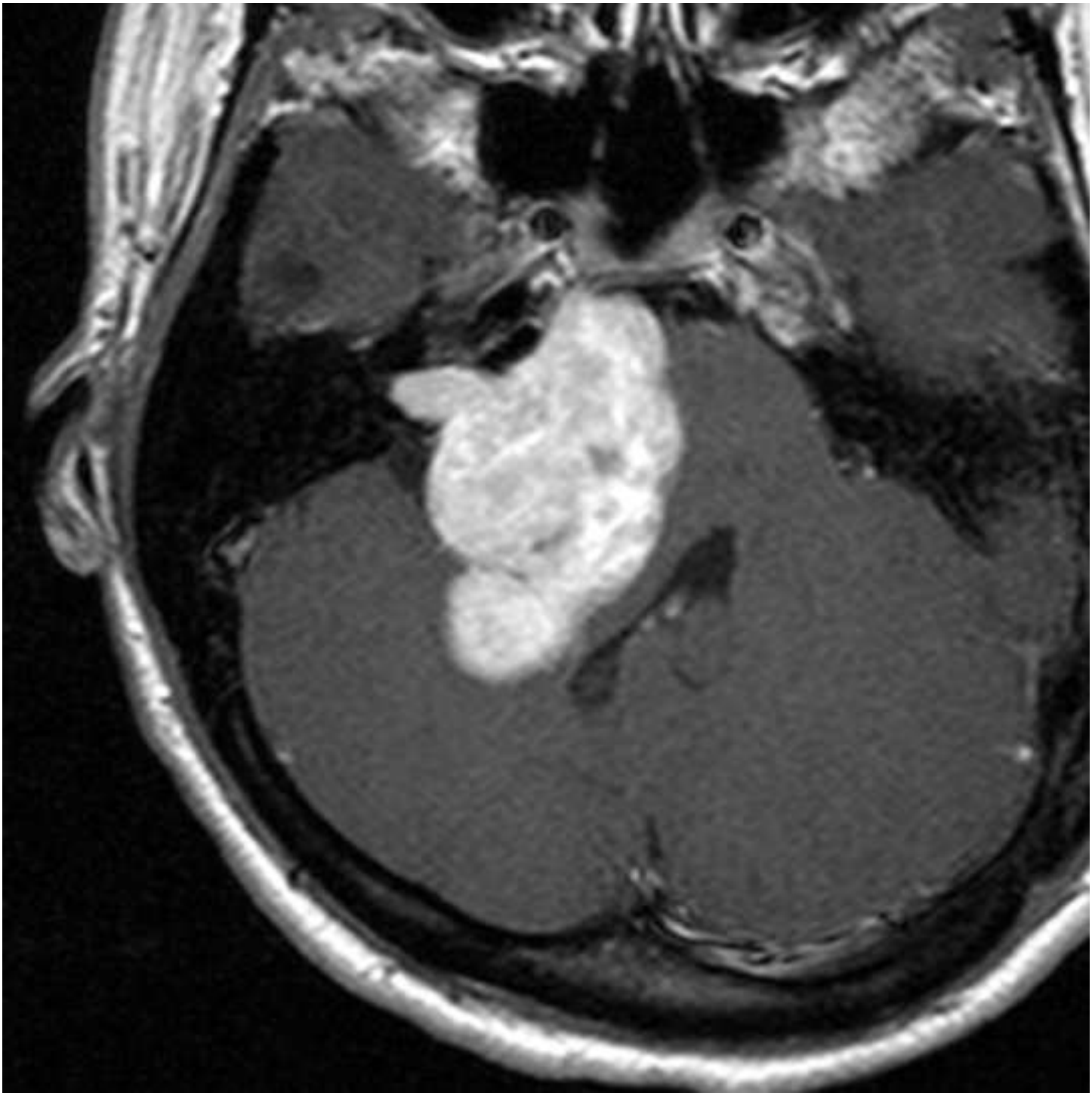

Figure 4B

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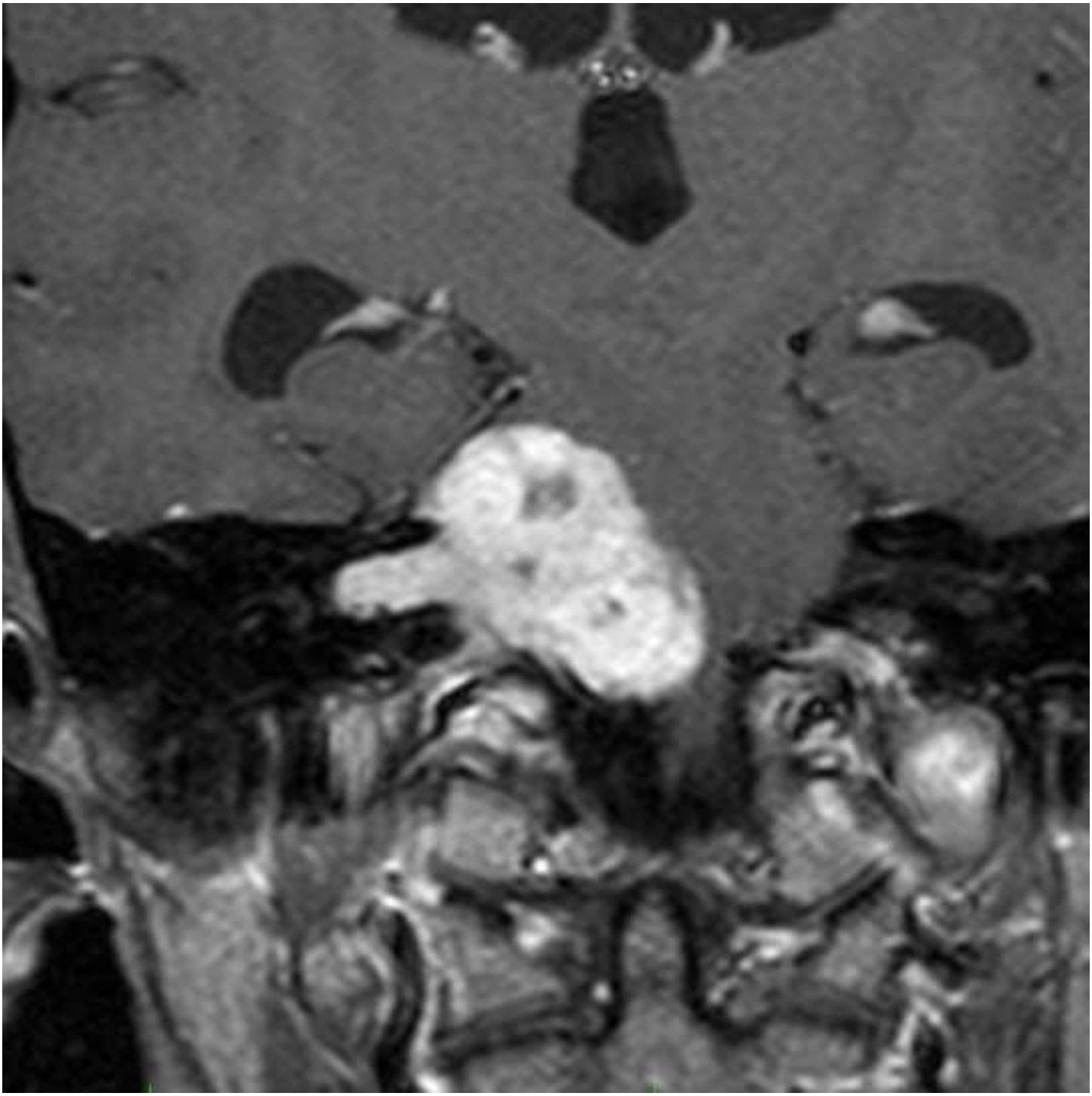

Figure 4C

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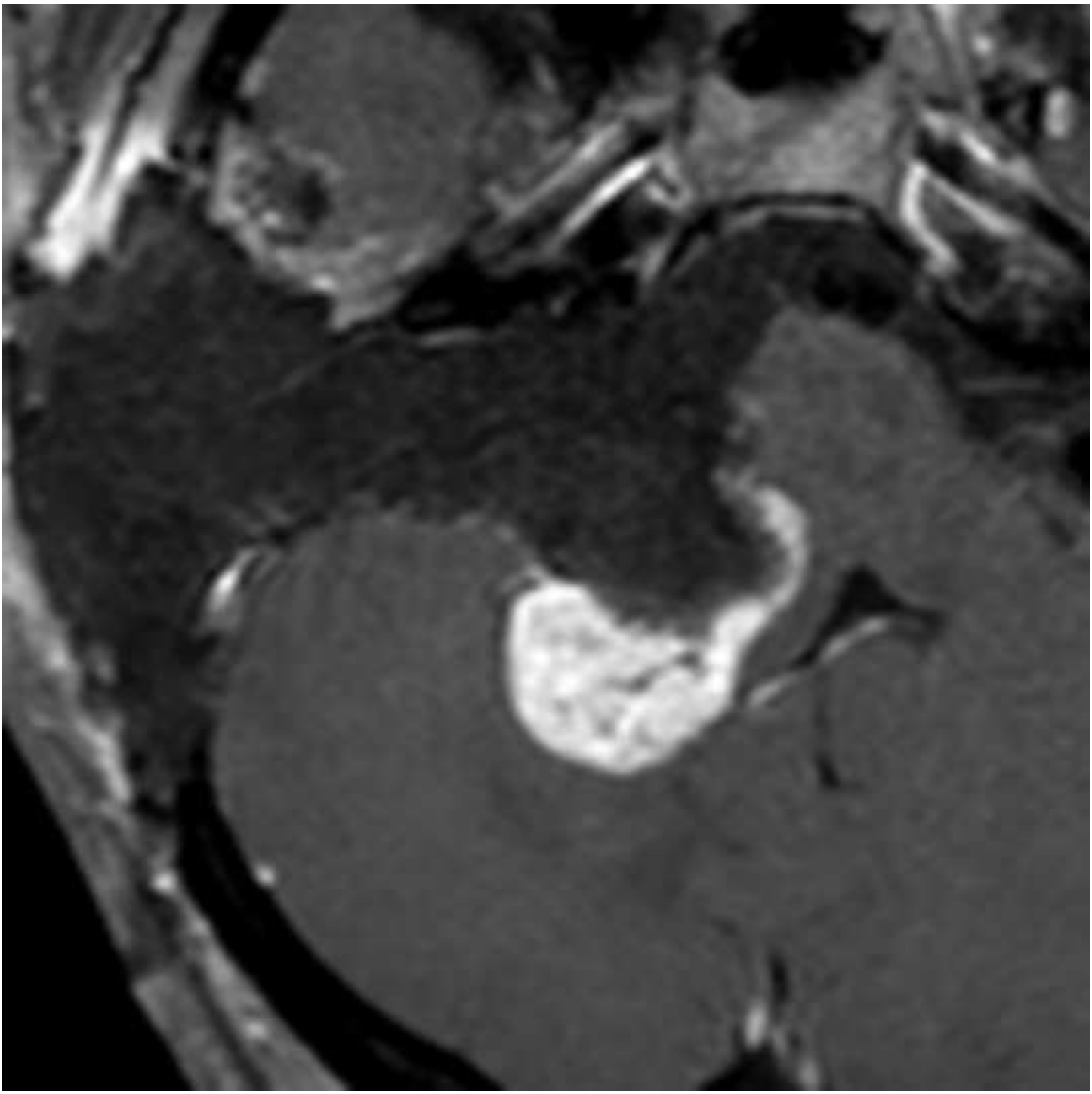

Figure 4D

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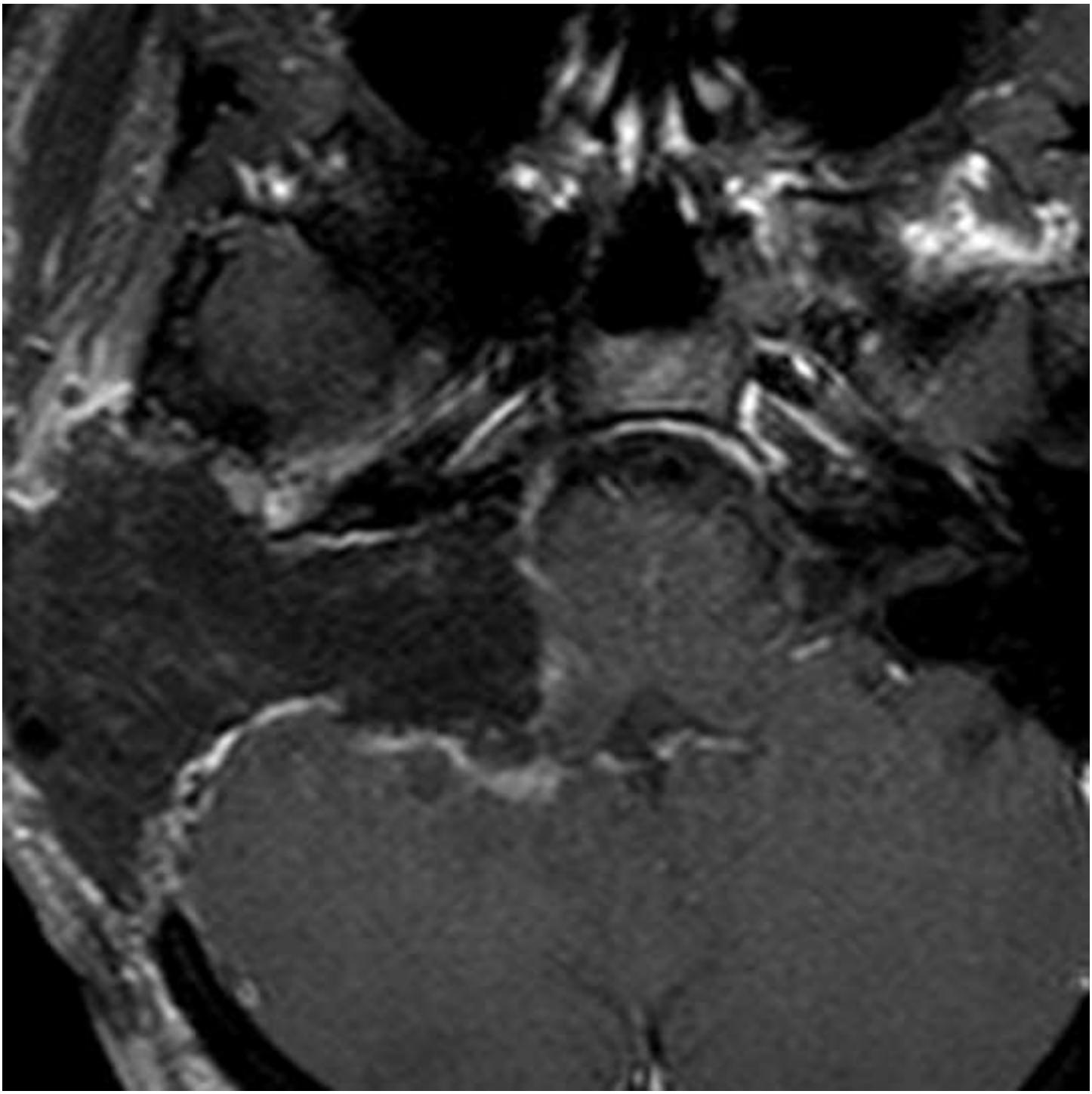

Table

TABLE 1. *Distribution of the entire series (2133 cases), ranked by size**

Size		No.	%
Intrameatal		296	13.9
1 to 10 mm	Small	484	22.7
11 to 20 mm	Medium	603	28.3
21 to 30 mm	Moderately Large	465	21.8
31 to 40 mm	Large	175	8.2
> 40 mm	Giant	110	5.1
Total		**2133**	**100**

*According to Kanzaki et al (6).

TABLE 2. *Long-term (1 year) FN function in 1808 cases (%)*

Size	Intrameatal	< 11 mm	11 to 20 mm	21 to 30 mm	31 to 40 mm	**> 40 mm**
Cases	274	406	506	389	145	**88**
HB Grade						
I	76.5	73.1	48.2	22.6	16.5	**7.9**
II	8.9	9.6	13.6	9.3	8.2	**7.9**
III	13.8	15.8	29.4	47.3	35.9	**46.6**
IV	0.4	1.0	3.8	8.7	11.0	**9.1**
V	-	-	1.1	2.3	6.9	**3.4**
VI	0.4	0.5	3.9	9.8	21.5	**25.0**

TABLE 3. *Postoperative complications (110 cases)*

Complication	Cases	%	Comments
Mortality	0	0	
CSF leak	2	1.8	Revision surgery in both cases
Subcutaneous CSF collection	3	2.7	Conservative management
Meningitis	0	0	
Vascular			
CPA hematoma	1	0.9	Revision surgery
Subdural hematoma	1	0.9	Spontaneous involution
Brainstem hematoma	1	0.9	Spontaneous involution
Cranial nerve dysfunction			
Vth	1	0.9	Permanent
VIth	9	8.2	Permanent in 1 patient
IXth or Xth	5	4.5	Spontaneous involution in all cases
Cerebellar symptoms	5	4.5	Spontaneous involution in all cases
Cerebral edema	1	0.9	Required ventriculoperitoneal shunt
Abdominal hematoma	2	1.8	Required revision surgery

TABLE 4. *Review of literature: overall results*

Main author	Year	Cases	Size	Giant VS	Total removal	FN integrity	Approach
Tos	1989	400	all sizes	149	98.7%	89.2%[a]	TLA
Briggs	1994	167	≥ 40 mm	167	95.2%	91.6%	TLA
Lanman	1999	190	≥ 30 mm	68	96.3%	93.7%	TLA
Sluyter	2001	120	≥ 20 mm	48	91.7%	80.8%	TLA - TT
Pareschi	2002	71	> 25 mm	19	100%	78.9%[a]	ETLA
Mamikoglu	2002	81	≥ 30 mm	29	95.1%	85.2%	TLA
Sanna	2004	175	≥ 30 mm	45	85.1%	84.8%	ETLA+TA/TC/TO
Roland Jr.	2004	56	≥ 30 mm [b]	[d]	73.2%	92.8%	TLA (84% of cases)
Patni	2005	34	> 30 mm	[d]	98%[c]	100%	RSA + TLA (staged)
Anderson	2005	71	≥ 30 mm	29	95.7%	[d]	RSA + TLA (combined)
Mehrotra	2008	62	> 40 mm	62	90.3%	87.1%	RSA
Godefroy	2009	50	> 25 mm	[d]	26%	96%	TLA
Samii	2009	50	> 40 mm	50	100%	92%	RSA
This study	2010	110	> 40 mm	110	91.8%	76.4%	ETLA+TA/TC/TO

[a] result achieved in VS equal or larger than 40 mm.
[b] authors consider the intracanalicular portion of tumor.
[c] authors consider total and near total removals.
[d] data not available or unclear.
TLA indicates translabyrinthine approach; TT, transtentorial; RSA, retrosigmoid approach; ETLA, enlarged translabyrinthine approach; TO, transotic approach; TC transcochlear approach.

TABLE 5. *Review of literature: postoperative complications (%)*

Main author	Deaths	Vth	VIth	LCN	Atassia	CPA hematoma	Meningitis	CSF leak [a]
Roland	-	-	7.1	-	-	3.6	-	3.6
Lanman	-	4.7	3.7	-	0.5	1.6	3.7	1.1
Mehrotra	11.3	-	-	19.3	-	1.6	6.5	33.8[b]
Samii	-	-	-	6.0	-	-	-	2.0
Sanna	0.6	0.6	6.8	0.6	-	1.7	-	2.3
Briggs	-	-	-	1.8	7.8	1.8	7.2	3.6
Pareschi	-	-	-	1.4	-	-	4.2	2.8
Godefroy	-	-	-	-	-	-	5.9	1.9
Mamikoglu	-	-	-	6.2	-	1.2	3.7	4.9
This study	-	0.9	5.4	2.7	4.5	0.9	-	1.8

[a] requiring revisional surgery
[b] authors do not specify how many cases required revisional surgery

TABLE 6. *Postoperative complications according to preoperative VS size in 2133 patients out of 1941 removed through ETLA(%)*

Size	Intrameatal	1 to 10 mm	11 to 20 mm	21 to 30 mm	31 to 40 mm	> 40 mm
Cases	296	484	603	465	175	110
Deaths	-	-	-	0.2	0.6	0
CSF	0.7	1.0	0.2	0.9	1.7	1.8
Meningitis	-	-	0.3	0.2	-	-
CPA hematoma	-	-	-	0.2	1.7	0.9
Subdural hematoma	-	0.4	-	0.4	0.6	0.9

Brainstem hematoma	-	-	-	-	1.1	0.9
Vth CN dysfunction	-	-	-	0.2	0.6	0.9
VIth CN dysfunction	-	-	0.2	1.3	4.6	5.4
LCN dysfunction*	-	0.2	0.3	1.0	1.1	2.7
Cerebellar ataxia	-	0.2	0.3	1.0	2.3	4.5
Cerebral edema	-	0.2	0.3	0.4	-	0.9
Postural instability	0.3	2.0	0.7	0.6	1.7	5.4
Abdominal hematoma	0.3	0.2	0.2	-	-	1.8

* LCN: lower cranial nerves