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The enlarged translabyrinthine approach for removal of large vestibular schwannomas

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Abstract

This study was carried out to validate the enlarged translabyrinthine approach for the surgical management of large vestibular schwannomas. A retrospective review of the charts of 53 patients with large tumours removed via the enlarged translabyrinthine approach at the Gruppo Otologico, Piacenza, Italy, during the last five years was carried out. The ability to control large tumours and the achievement of total removal with low morbidity and very few complications, demonstrate that tumour size does not influence the use of the enlarged translabyrinthine approach for managing large tumours.

Key words: Vestibular schwannoma; Labyrinth, surgery

Introduction

The standard translabyrinthine approach was introduced for vestibular schwannoma removal by William House in 1964 (House, 1964). Since then, controversy about the most appropriate route for excision of vestibular schwannomas has continued. The debate has been based largely upon tumour size. The consensus has often been that while small tumours may be removed through the labyrinth, larger lesions are best approached suboccipitally because of the restricted surgical view the standard translabyrinthine approach was said to offer (Hardy *et al.*, 1989).

After several years of experience, the standard translabyrinthine approach has been modified into the enlarged translabyrinthine approach by extending the area of bone removal. This has significantly increased the surgical field thus making it advantageous for the removal of vestibular schwannomas of all sizes.

It is the aim of this study to validate the enlarged translabyrinthine approach for the surgical management of large vestibular schwannomas by reviewing the outcome of our series of large tumours. This includes the success rate for total tumour removal, post-operative morbidity and complications.

Patients and methods

In the last five years, 126 vestibular schwannomas have been surgically removed by the two senior authors (M.S. and A.M.) at the Gruppo Otologico, Piacenza, Italy. All patients' charts were compiled on a computer database program which was used to generate the results of this study. The suboccipital approach was elected for tumour removal in six patients, while in 10 patients the tumour was removed through the middle cranial fossa. The translabyrinthine approach was adopted for vestibular schwannoma removal in 110 cases of which 53 cases had a large tumour. Tumours were considered large if their extracanalicular size, defined as the largest diameter outside the porus acousticus, exceeded 2.5 cm as measured by high resolution CT with contrast or MRI with enhancement. In this group of patients with large tumours, there were 29 females and 24 males whose ages ranged from 22 to 79 years with a mean age of 47 years. The tumour size ranged from 2.6 to 6.0 cm, with a mean size of 3.2 cm. There were 28 right-sided tumours and 25 left-sided. Two cases were operated on for a recurrent tumour six and seven years after an incomplete removal via a suboccipital approach performed elsewhere (Figure 1). One patient was referred to us after failure to control the tumour growth by stereotactic radiotherapy which also resulted in trigeminal nerve hypoasthesia and a facial nerve weakness. One patient with a neurofibromatosis-2 had a unilateral tumour removal.

The clinical picture at presentation is shown in Table I. Varying degrees of hearing loss at presentation were seen. While 13 patients presented with a profound hearing loss and 17 with a severe loss, 20 had a mild to moderate loss. Hearing was normal (within 20 dB with 100 per cent speech discrimination) in three patients (Figure 2). Auditory brain stem response testing was pathological in all cases with sufficient hearing adequate for performing the test. Pre-operative facial nerve function according to the House and Brackmann (1985) grading system is shown in Table II. Forty-seven cases (88 per cent) had a pre-operative Grade 1 facial nerve function.

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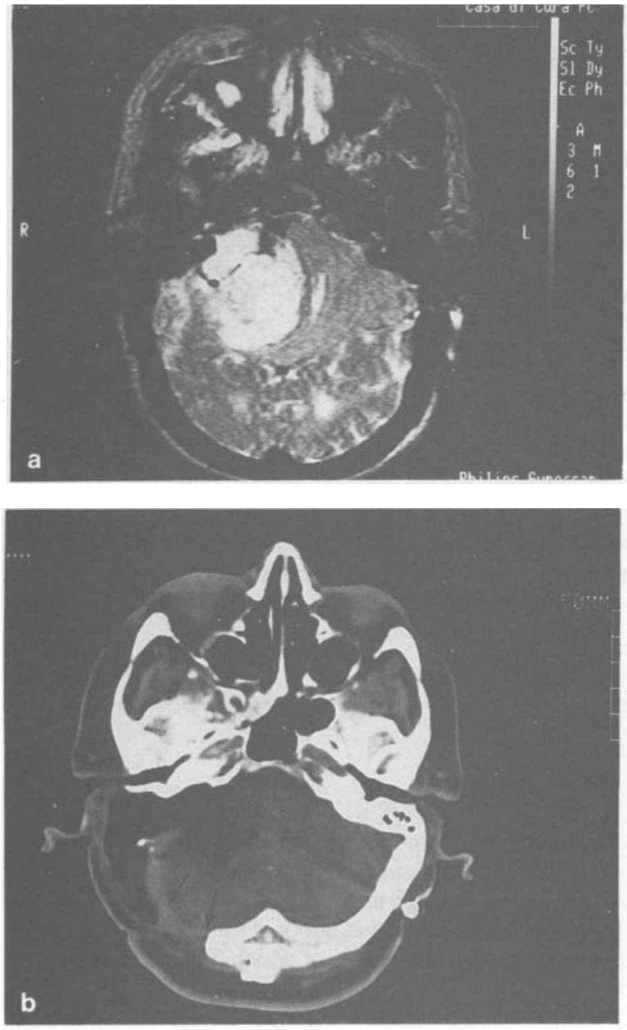

FIG. 1

A 6 cm tumour recurring after incomplete removal previously by the suboccipital approach. (a) Pre-operative MRI at T_2; (b) post-operative CT with total tumour removal. Notice the bone defect caused by the previous intervention (arrowed).

Surgical technique

The technique of the enlarged translabyrinthine approach is summarized here. A C-shaped retroauricular skin incision (3 cm from the posterior auricular fold) is made and dissected forward from the underlying musculoperiosteal layer. This subcutaneous layer is incised and retracted with silk sutures instead of using retractors to provide a shallower unimpeded surgical view. A large mastoidectomy that exposes the sigmoid sinus and 2–3 cm of the posterior cranial fossa dura behind the sinus is then carried out. Complete bone removal over and around the sigmoid sinus is essential for complete sinus compression, a manoeuvre that greatly increases the surgical view especially in anteriorly placed sinuses and small mastoid cavities. Removal of bone proceeds by exposing the dura of the posterior cranial fossa and the endolymphatic sac anterior to the sigmoid sinus, as well as the middle cranial fossa dura up to the root of the zygomatic process.

Identification of the vertical portion of the facial nerve and drilling of the retrofacial air cells is followed by labyrinthectomy. Enough bone should be removed around the skeletonized internal auditory canal. Superiorly, bone is removed from this region to permit access to the antero–superior aspect of the cerebellopontine angle (CPA) and to visualize the trigeminal nerve area. Inferiorly, the bone between the floor of the canal and the jugular bulb is removed. A high jugular bulb can be lowered by drilling the bony covering using a large diamond burr. Next, the bulb is pushed down with a large piece of oxidized cel-

TABLE I

CLINICAL PICTURE AT PRESENTATION

Number of cases	(%)
Hearing loss	50 (94%)
Tinnitus	40 (75.5%)
Instability	30 (56.6%)
Vertigo	23 (43.4%)
Vth cranial nerve hypoasthesia	21 (39.6%)
Spontaneous nystagmus	16 (30%)
Headache	4 (7.5%)
Diplopia	4 (7.5%)
Hemifacial spasm	4 (7.5%)
VIIth nerve weakness	4 (7.5%)
Nausea, vomiting	3 (5.7%)
VIIth nerve paralysis	2 (3.8%)
Vth nerve CN neuralgia	2 (3.8%)
Ataxia	1 (1.9%)

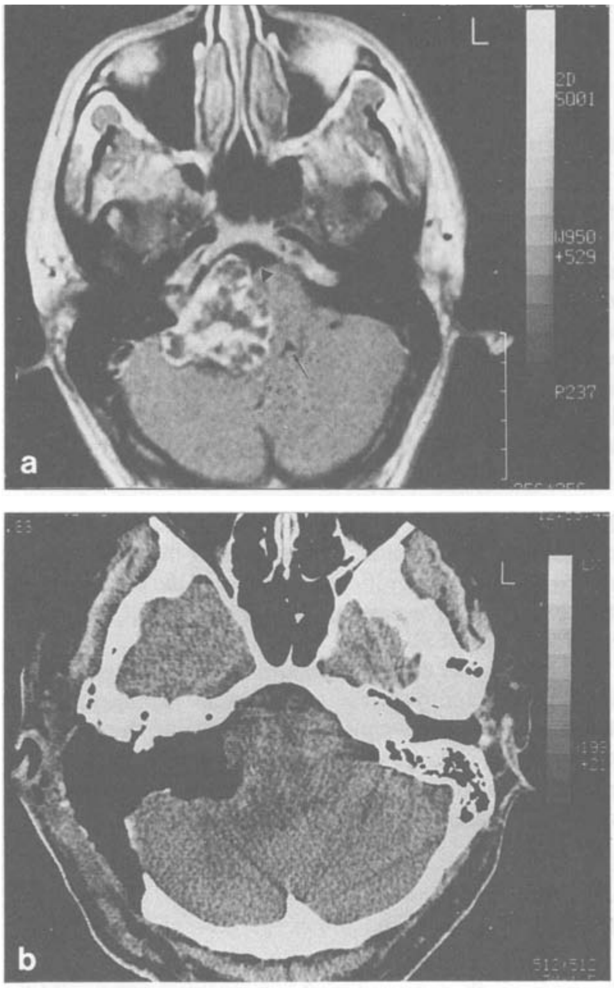

FIG. 2

A 4 cm tumour presenting in a patient with normal hearing. (a) Pre-operative MRI with gadolinium. Notice the anterior extension of the tumour to the prepontine cistern (arrowhead) and the displacement of the fourth ventricle (arrowed); (b) post-operative CT scan showing total tumour removal.

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TABLE II
PRE-OPERATIVE FACIAL NERVE GRADING (HOUSE AND BRACKMANN, 1985)

Number of cases	(%)
Grade 1	47 (88%)
Grade 2	2 (4%)
Grade 3	2 (4%)
Grade 4	0 (0%)
Grade 5	0 (0%)
Grade 6	2 (4%)
Total	53 (100%)

lulose which is gentle against the bulb and, at the same time, provides haemostasis for small bleeding lacerations of the bulb wall. The oxidized cellulose is then covered with bone wax and pushed down with a finger. This lowers the jugular bulb effectively and protects it during drilling the bone between the bulb and the internal auditory canal. Once the bulb has been lowered, it is necessary to drill out the infralabyrinthine apical cells to reach the cochlear aqueduct which is often blocked in cases of large tumours. Bone removal from this region is essential in obtaining a wide exposure of the postero–inferior CPA with the possibility of controlling the lower cranial nerves, the anterior–inferior cerebellar artery and in some cases, the vertebral artery.

After exposure of the dura of the internal auditory canal, the facial nerve is identified at the vertical crest separating it from the superior vestibular nerve. At this stage, the posterior cranial fossa dura is opened by incising the dura below the superior petrosal sinus and above the jugular bulb. This posteriorly based dural flap serves to protect the cerebellum during tumour dissection. Opening of the lateral cistern permits cerebrospinal fluid (CSF) drainage and lowering of the intracranial tension which favours retraction of the cerebellum for a better view of the CPA. This is not always possible in the case of large tumours because the tumour occupies this space. In such cases the tumour capsule is opened and intracapsular debulking is performed. It is then possible to dissect the tumour capsule from the arachnoid to open the lateral cistern. Antero–superiorly, large tumours commonly involve the trigeminal nerve. Dandy's vein is always encountered at this location and may have to be coagulated in order to facilitate the tumour dissection from the trigeminal nerve. Further intracapsular debulking reduces the tumour size allowing an easier separation of the capsule from the surrounding structures. A key step in the procedure is the identification of the brain stem roots of the facial and the vestibulocochlear nerves. Once the roots of these nerves are under control, the vestibulocochlear nerve is severed and the facial nerve is dissected from the tumour capsule in a central to peripheral direction for the maximal distance allowed for by the concomitant progressive debulking of the tumour. The facial nerve is then identified at the vertical crest and the tumour is dissected from the nerve in a central direction while preserving the arachnoid sheath surrounding the nerve.

After tumour removal, haemostasis is secured and the cavity is obliterated with abdominal fat. Fat closure of the aditus, after removal of the incus, wound closure in layers, and tight bandaging are carried out to prevent cerebrospinal fluid leakage.

Results

At surgery, anatomical variants of a small mastoid cavity were encountered in 33 cases (62.3 per cent). The sigmoid sinus was anteriorly placed in six cases (11.3 per cent) and the jugular bulb was high in five cases (9.4 per cent). An anteriorly placed sigmoid sinus together with a high jugular bulb were seen in another 14 cases (26.4 per cent). In eight cases (15 per cent), a small mastoid cavity was due to a combination of an anteriorly placed sigmoid sinus, a high jugular bulb and a low middle fossa.

Completeness of tumour removal

Total tumour removal was accomplished in all cases as proved by the post-operative MRI which failed to show evidence of a residual tumour. The enlarged translabyrinthine approach provided complete control of the CPA from the trigeminal nerve to the area of the lower cranial nerves.

Facial nerve function

Anatomical preservation of the facial nerve was successful in 43 (81.1 per cent) of the 53 procedures. The facial nerve was divided in six cases whose tumour size was 2.5–3.0 cm, three cases with a size of 3.5–4.0 cm and, one case with a size of 4.5 cm. In two of these cases where the facial nerve was divided, the nerve was found to be invaded by the tumour as predicted by the pre-operative Grade 6 facial nerve paralysis. In the rest of cases the facial nerve was thinned out and was cut during its dissection from the tumour capsule. Immediate restoration of the facial nerve continuity was carried out by rerouting of the facial nerve with end-to-end anastomosis in six cases and sural nerve grafting in four. In this series, 36 cases (67.9 per cent) had a follow-up period for post-operative facial nerve function of at least one year. Twelve cases had less than one year follow-up, four cases were lost to follow-up, and one case died 10 months post-operatively from an unrelated cause. Post-operative results of patients who had a pre-operative Grade 1 facial nerve function and a follow-up period of at least one year are reported in Table III.

Post-operative complications

Post-operative complications in this series were low (Table IV). Five patients (9.4 per cent) had a CSF leakage from the nose which required revision after failure of conservative measures including a lumbar subarachnoid drain. At the revision surgery the stapes was found luxated in two cases, and in the other three cases CSF leakage was due to extensive bone drilling connecting the infralabyrinthine with the hypotympanic cell tract. All five cases were

TABLE III
POST-OPERATIVE FACIAL NERVE GRADING (HOUSE AND BRACKMANN, 1985)

Number of cases	(%)
Grade 1	6 (20%)
Grade 2	3 (10%)
Grade 3	14 (46.7%)
Grade 4	4 (13.3%)
Grade 5	1 (3.3%)
Grade 6	2 (6.7%)
Total	30 (100%)

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TABLE IV
POST-OPERATIVE COMPLICATIONS

Number of cases	(%)
CSF leak	5 (9.4%)
Haematoma	1 (1.9%)*
Hemiplegia	1 (1.9%)*
IXth and Xth nerve paralysis	1 (1.9%)
Ataxia	0 (0%)
Brain oedema	0 (0%)
Death	0 (0%)

*Same patient.

re-operated upon with obliteration of the eustachian tube, the middle ear cavity and blind sac closure of the external auditory canal with no consequences. There was no incidence of post-operative meningitis. A 76-year-old patient with previous cardiac problems developed post-operative cerebral haematoma and hemiplegia. She died 10 months later of heart failure. One patient developed a IXth and Xth cranial nerve paralysis with dysphonia and mild dysphagia. After a one year follow-up, the patient had compensated for her deficit and is doing well.

Length of stay in hospital

Generally for patients who did not have the complication of CSF leakage this was seven days. This complication added an additional five days, on average.

Discussion

Patients having a large acoustic tumour are often a surgical challenge. The large size of the tumour, its attachment to the brain stem together with its caudal and cranial extensions towards the lower cranial nerves and the trigeminal nerve respectively, make total removal of these tumours with the least functional disability a difficult task.

The enlarged translabyrinthine approach provides a direct approach to large vestibular schwannomas by increasing the working field. Having an extradural approach mostly, this approach has the advantage of not compressing either the brain stem or the cerebellum while removing large vestibular schwannomas (House, 1968; Tos and Thomsen, 1982). Since adopting the enlarged translabyrinthine approach, we have not experienced any post-operative brain oedema or ataxia in any of our patients having large tumours. The favourable outcome of these patients is reflected in their short hospital stay. One of the merits of the translabyrinthine approach is the identification of the facial nerve at both ends of its intracranial course. With this ability to identify the facial nerve at two points, at the fundus of the internal auditory canal and at the brain stem, preservation of the facial nerve anatomical integrity in our series of large tumours was possible in 81 per cent of cases. Analysis of the post-operative facial nerve function in our series of large tumours according to the House and Brackmann (1985) grading system, shows that facial nerve function was Grade 1 in 10 per cent, Grade 1 or 2 in 30 per cent and Grade 3 or better in 76 per cent of cases compared to 71.7 per cent Grade 1, 91.3 per cent Grade 1 or 2 and 97.8 per cent Grade 3 or better achieved in our series of cases having smaller tumours (<2.5 cm) (Table V). This significant difference in the post-operative facial nerve function confirms the observations of Glasscock *et al.* (1986), Dutton *et al.* (1991) and Tos *et al.* (1991) that smaller tumours carry a better prognosis for facial nerve function than larger tumours. It also reflects the challenge in managing the facial nerve in such large tumours and the value of an unimpeded view of the course of the nerve that is offered by the enlarged translabyrinthine approach.

The incidence of CSF leakage in this series of large tumours is 9.4 per cent compared to 3.7 per cent in our series of smaller tumours (Table V). Glasscock *et al.* (1986) and Bryce *et al.* (1991) also observed a higher incidence of CSF leakage in large tumours. A recent report from the House Ear Clinic (Rodgers and Luxford, 1993) failed to show this higher incidence of CSF leakage with larger tumours. However, they reported a higher incidence of post-operative meningitis in large tumours that is absent in our series. Our current incidence of a CSF leak in large tumours compares favourably with that of others (King and Morrison, 1980; Whittaker and Luetje, 1985; Glasscock *et al.*, 1986; Hardy *et al.*, 1989; Bryce *et al.*, 1991). The higher incidence of a CSF leak in large tumours may be related to the more extensive bone drilling with opening of the air cell tracts especially in well-pneumatized mastoids. We have been using strips of abdominal fat to plug the dural defect and to obliterate the mastoid cavity. We do not routinely close the eustachian tube. The tympanic cavity is sealed with a strip of fat blocking the incudal fossa after removing the incus. However closure of the eustachian tube, as described by Jenkins and Fisch (1980), could be considered in cases of large tumours with well-pneumatized mastoids so as to further lower the incidence of a CSF leak.

The limited view provided by the classic translabyrinthine approach, has prevented considering this valuable approach for the removal of large acoustic tumours. A point that has been used to criticize this approach is the existence of limiting anatomical obstacles such as a high jugular bulb, an anteriorly placed sigmoid sinus, a low dura, and a small mastoid cavity (Gantz and Fisch, 1983). Although we encountered such obstacles during large tumour removal in this series, yet our modification of the classic translabyrinthine approach by extended bone removal has been the solution in overcoming these obstacles. In contrast to Tos and Thomsen (1991) and Sterkers (1993) who also advocate the enlarged translabyrinthine approach but leave a bony island over the sigmoid sinus, we uncover it completely to permit its effective depression using the tip of the suction irrigator instead of a retractor (Pellet *et al.*, 1990). In our experience, this provides a wider working area than if an eggshell layer of bone is left on the sinus (Russo *et al.*, 1991a and b).

TABLE V
POST-OPERATIVE FACIAL NERVE FUNCTION AND INCIDENCE OF CSF LEAK: LARGE TUMOURS *VERSUS* SMALL TUMOURS

	Large tumours (>2.5 cm) No. of cases	(%)	Small tumours (<2.5 cm) No. of cases	(%)
Post-op Grade 1	6/30	(20%)	33/46	(71.7%)
Post-op Grade 2	3/30	(10%)	9/46	(19.6%)
Post-op Grade 3	14/30	(46.7%)	3/46	(6.5%)
CSF leak	5/53	(9.4%)	2/57	(3.5%)

Chi-square test; $p<0.005$.

A high jugular bulb is not an infrequent finding, it was present in 35.8 per cent of our cases. However it has not been an impediment in our series and was well controlled throughout the enlarged translabyrinthine approach (Saleh *et al.*, 1994). Uncovering the bulb and gently depressing the periosteal lining using oxidized cellulose safely lowers the bulb which is then covered by bone wax to protect it while proceeding with bone drilling.

Modification of the classic translabyrinthine approach for the removal of large acoustic tumours by extended bone removal has improved the visualization of these tumours at their superior and inferior extents. This enabled us to perform a complete tumour resection with no incidence of residual tumour. In this respect, we in no instance found it necessary to divide the tentorium (King and Morrison, 1980) or the superior petrosal sinus (Leonetti *et al*, 1992) in order to gain additional exposure. Extended uncovering of the dura of the middle and posterior cranial fossae and the sigmoid sinus with lowering of the jugular bulb, if high, as well as drilling out of the infralabyrinthine air cell tract to the level of the cochlear aqueduct, are sufficient to provide a wide surgical access.

Sacrifice of hearing has always been a disadvantage of the translabyrinthine approach. We were not tempted to preserve hearing in this series of patients with large vestibular schwannomas although about six per cent of cases presented with normal hearing pre-operatively. Statistically, success in hearing preservation in tumours larger than 2 cm is very low whatever the surgical approach advocated (Sanna *et al.*, 1987; Cohen *et al.*, 1993; Naguib *et al.*, 1994). The surgeon should consider the price to be paid in attempting this with regard to the possible post-operative complications and the risk of leaving behind residual tumour (Tos and Thomsen, 1982; Moffat and Hardy, 1991). We have adopted a strict protocol of patient selection for hearing preservation (Sanna *et al.*, 1991; Naguib and Sanna, 1994). This protocol considers the size of the tumour and the pre-operative hearing threshold at 500, 1000, 2000 and 4000 Hz, as well as the speech discrimination score. It was applied to 561 cases comprising the larger series of the two senior authors (M.S. and A.M.) at two centres, the Gruppo Otologico and Bergamo General Hospital. Intracanalicular tumours were approached through the middle cranial fossa, while those >10 mm but <20 mm are approached through the sub-occipital approach. Tumours larger than 20 mm are removed through the translabyrinthine approach irrespective of the pre-operative hearing status.

Conclusion

The results of our study demonstrate that the tumour size does not preclude advocating the enlarged trans-labyrinthine approach for the surgical management of large vestibular schwannomas.

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