The Journal of Laryngology and Otology
May 1998, Vol. **112,** pp. 441–445

Pre-operative and per-operative factors conditioning long-term facial nerve function in vestibular schwannoma surgery through translabyrinthine approach

Olivier deguine, M.D.*, André Maillard, M.D.†, Alain Bonafe, M.D.‡,
Hassan El Adouli, M.D.*, Michel Tremoulet, M.D.†, Bernard Fraysse, M.D.*

Abstract

Facial nerve function was evaluated in 103 patients, after vestibular schwannoma removal through the translabyrinthine approach. The mean follow-up was 43 months (minimum six months). Grade I facial function was achieved in 100 per cent of stage I schwannomata compared with 36 per cent of stage IV schwannomata. Grade I or II facial function was found in 78 per cent of homogeneous schwannomata, compared with 48 per cent of heterogeneous schwannomata. Facial function was preserved in 89 per cent of cases, if the angle between the internal auditory canal and the schwannoma was >66°, compared with 54 per cent if the angle was <66°. There was 82 per cent of normal facial function when the nerve appeared normal after tumour removal, compared with 18 per cent when the nerve was traumatized. When the ratio (stimulation threshold at the internal auditory canal/stimulation threshold at brainstem) was <2, post-operative facial function was preserved in 87 per cent of cases, compared with 13 per cent when the ratio was >2.

Key words: Vestibular schwannoma; Surgery, operative; Facial nerve

Introduction

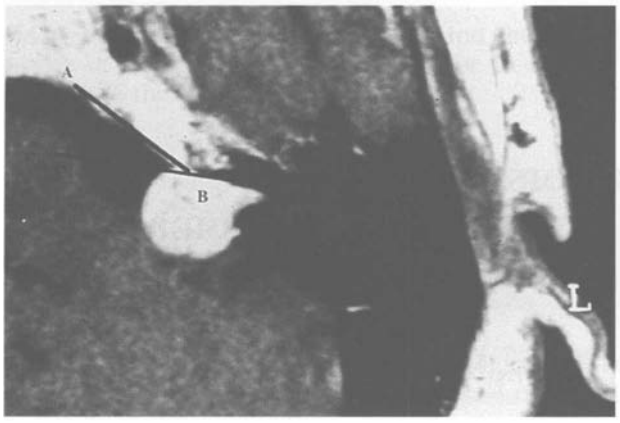
The goals of vestibular schwannoma surgery have been changing with time. The translabyrinthine approach introduced by House in the early 60's has completely changed the perioperative mortality and has markedly improved facial nerve conservation in vestibular schwannoma surgery. Cooperation between ENT surgeons and neurosurgeons has contributed to extend the goals of vestibular schwannoma surgery from preservation of life with total tumour excision, to preservation of the facial nerve function. The aim of this study is to evaluate pre- and per-operative factors contributing to influence post-operative facial nerve function through translabyrinthine approach.

Materials and methods

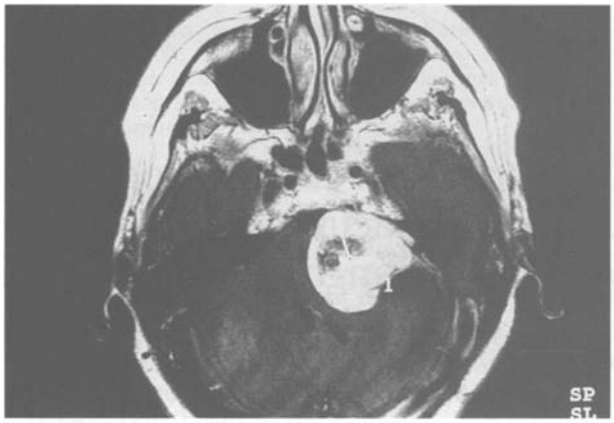
One hundred and three patients with unilateral vestibular schwannomata were selected for this retrospective study: 55 male (53 per cent) and 48 female (47 per cent). The mean age of patients was 53 years (minimum = 16 years; maximum = 74 years). All of the patients were operated by the same oto-neurosurgical team (BF + MT), through the translabyrinthine approach, with preservation of facial nerve continuity. The minimum interval between surgery and the post-operative evaluation was six months (minimum = six months, maximum = 10 years, mean 43 months).

Pre-operatively, patients had had clinical examination, audiometry, brainstem evoked response audiometry, computed tomography (CT) scan, electronystagmography, electromyography and facial evaluation according to the House and Brackmann scale; MRI was performed for the last years, but not considered for this study. Schwannomata were classified according to the Koos classification (stage I: intrameatal, stage II: extrameatal ≤2 cm, stage III: extrameatal ≤3 cm, stage IV: extrameatal >3 cm). The angle between the schwannoma and the petrous bone was measured on the pre-operative CT scan in 64 patients; it was defined as the angle between the long axis of petrous bone, and a tangential line along the anterior pole of the tumour, on a slice passing through the internal auditory canal (Figure 1). Homogenicity or heterogenicity was assessed on pre-operative imagery (Figure 2). Regular contrast enhancement, with no difference of density or signal inside the tumour defines a homogeneous schwannoma, whereas heterogenicity is defined by irregular contrast enhancement, or by the presence of

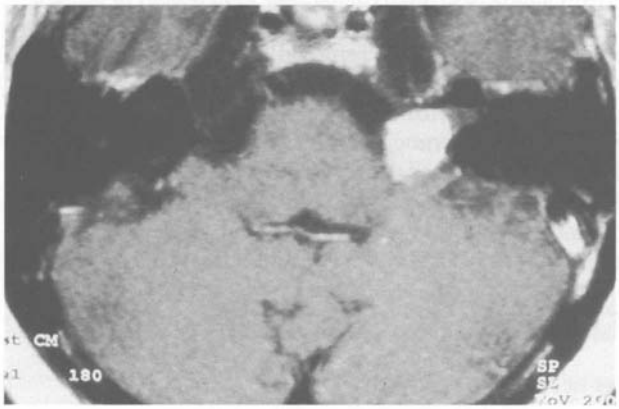
From the Departments of Otolaryngology*, Neurosurgery† and Neuroradiology‡, Centre Hospitalier Universitaire de Toulouse, Hôpital Purpan, Toulouse, France.
Accepted for publication: 9 March 1998.



(a)



(c)

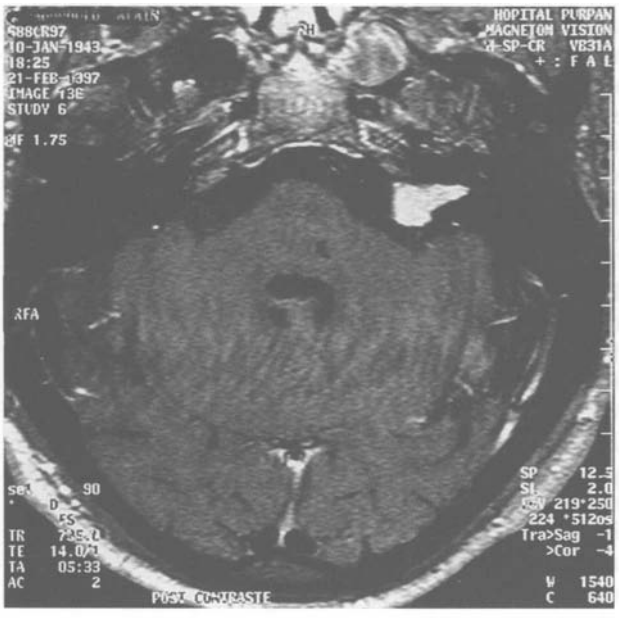


(b)

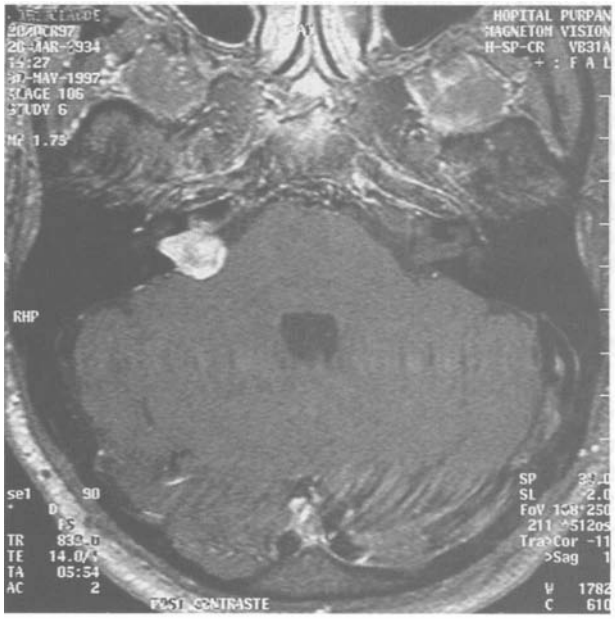
FIG. 1

Angle between vestibular schwannoma and petrous bone.
1a: calculation of the angle.
AB = line along the great axis of the petrous bone
CD = tangent line to the anterior pole of the tumour, on a plane passing through the internal auditory canal, at the anterior part of the porus
Δ = angle between vestibular schwannoma and petrous bone
1b: angle >66° (homogeneous schwannoma).
1c: angle >66° (heterogeneous schwannoma).

different density (or signal intensity) areas inside the tumour. The tumours were homogeneous or heterogeneous: it was a qualitative characteristic, without quantification. During surgery, the facial nerve was continuously monitored using the electromyographic monitor (NIM II, Xomed-Nicolet®). At the end of the procedure, the condition of the nerve was noted (normal, abnormal: stretched, oedematous, haematoma of the sheath). In 42 patients, it was stimulated at the root, where it leaves the brainstem, and at the internal auditory canal, to calculate the ratio: R = stimulation threshold at the brainstem/stimulation threshold at the internal auditory canal. The stimulation threshold was defined as the minimum



(a)



(b)

FIG. 2

Homogeneous schwannoma (2a) and heterogeneous schwannoma (2b)

https://doi.org/10.1017/S0022215100140733 Published online by Cambridge University Press

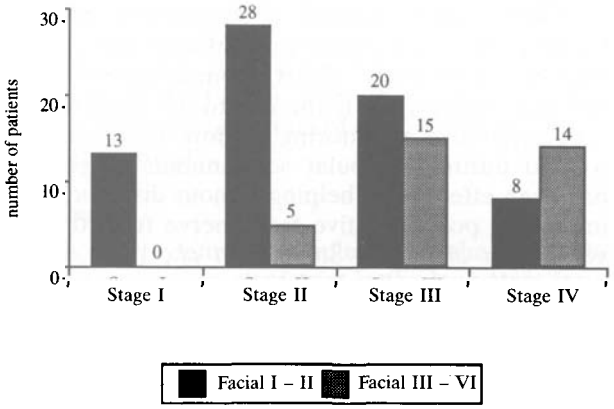


FIG. 3
Distribution of post-operative facial function compared to the Koos stage of schwannoma.

current level sufficient to elicit an electromyographic response due to facial nerve stimulation of 100 μv or more. Patients were evaluated post-operatively using the House Brackmann scale. Statistical comparisons were made using Chi-square.

Results

Pre-operative electromyography of the facial nerve had a greater sensitivity than clinical evaluation: there was an electrical lesion (increased duration of motor unit potentials) in 23 patients (22 per cent), whereas facial dysfunction was present in only four patients (four per cent). There was, however, no correlation between pre-operative EMG and post-operative clinical function. Other factors were not significantly correlated to the post-operative facial nerve function: the pre-operative audiometry (0–30 dB/30–90 dB/>90dB), electronystagmography (normal/decreased response/absence of response), state of the porus (normal/enlarged).

Post-operative facial function, compared to the size of schwannoma is reported in Figure 3. Post-operative facial function is highly correlated to tumour size: stage III *vs* stage I: $p<0.01$; stage IV *vs* stage I: $p<0.001$; stage III *vs* stage II; $p<0.03$; stage IV *vs* stage II: $p<0.001$. There was no difference when we compared stage I *versus* stage II, or stage III *versus* stage IV.

The angle between the tumour and the internal auditory canal was evaluated in 64 patients. Post-operative facial function as a function of the angle between schwannoma and petrous bone is reported in Table I. There was a significant correlation ($p<0.05$; Chi 2 test with Yates correction) between this angle and the post-operative facial function.

Density of the schwannoma was evaluated in 69 patients. Repartition of homogeneous and heterogeneous schwannoma and correlation of the homogeneity or heterogeneity of the tumour with post-operative facial nerve function is reported in Table II. There was a significant correlation between a good post-operative facial nerve function (Facial nerve grade I–II), and the homogenicity of the schwannoma ($p<0.05$ with Yates correlation).

Per-operative facial nerve stimulation was performed in 42 patients. Stimulation was delivered through a monopolar electrode, at the root of the nerve, and at the level of the internal auditory canal (IAC). R1 is the amplitude of the electromyographic facial response (in μV) for a stimulation at the root, R2 is the amplitude of the electromyographic facial response (in μV) for a stimulation at the IAC. R1 and R2 are noted for the minimal intensity required to obtain a response. R is the ratio R1/R2. There is a significant relationship between a ratio R<2, and a good post-operative facial function ($p<0.03$) (Table III).

At the end of the procedure, the macroscopical appearance of the facial nerve, in the cerebellopontine angle was noted. The relationship between post-operative nerve function and appearance of the nerve is reported in Figure 4. The nerve was considered as abnormal when it was oedematous, stretched or if there was a haematoma of the sheath.

TABLE I
POST-OPERATIVE FACIAL FUNCTION COMPARED TO THE ANGLE BETWEEN TUMOUR AND PETROUS BONE

	Facial I–II (*n*)	Facial III–IV (*n*)
<66°	25	21
>66°	16	2

TABLE II
REPARTITION OF HOMOGENEOUS AND HETEROGENEOUS SCHWANNOMATA, AND CORRELATIONS TO POST-OPERATIVE FACIAL FUNCTION

	Facial nerve grade I–II	Facial nerve grade III–IV
Homogeneous	33	9
Heterogeneous	13	14

Discussion

Despite the greater sensitivity of electrophysiological tests compared to clinical testing, pre-operative electrical tests of the facial function have not yet proven their prognostic value. Kartush *et al.* (1987) could not find any significant correlation between pre-operative ENoG and post-operative facial nerve function for tumours of the petrous bone, but there was a trend to a worse prognosis when the ENoG amplitude was greatly reduced. Prasad *et al.* (1993) found a relationship between normal pre-operative ENoG and long-term post-operative facial function; however, as they show a correlation between pre-operative ENoG and tumour size, it seems difficult to affirm that the prognostic value of ENoG is completely independent of tumour size. Thomsen *et al.* (1985), using conventional electromyography, did not find any significant correlation between pre-

TABLE III
CORRELATION BETWEEN PER-OPERATIVE FACIAL NERVE STIMULATION AND POST-OPERATIVE FACIAL FUNCTION

	Facial nerve grade I–II	Facial nerve grade III–IV
R1/R2 < 2	28	3
R1/R2 > 2	3	8

https://doi.org/10.1017/S0022215100140733 Published online by Cambridge University Press

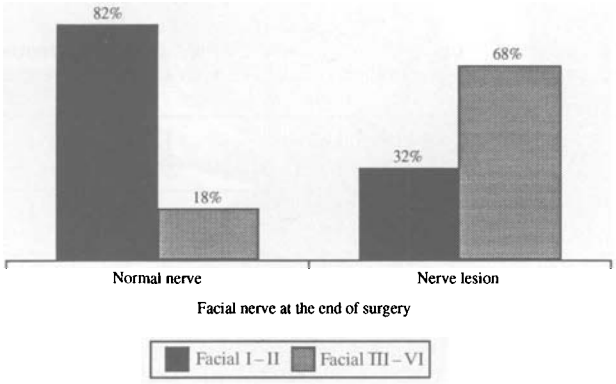


FIG. 4
Correlation between appearance of the nerve at the end of surgery, and post-operative function.

operative electrophysiological findings and post-operative facial nerve function. Our experience is similar.

The correlation between post-operative facial nerve function and size of the tumour is widely accepted by the majority of authors. It is one of the major factors influencing the outcome of the facial nerve in vestibular schwannoma surgery.

Neuroimaging is reliable for the diagnosis of cerebellopontine angle (CPA) tumours. It is helpful for analysis of the relationship between the schwannoma and certain anatomical landmarks. Some indirect data may give interesting information concerning the outcome of facial function in CPA tumours; Ruth *et al.* (1985) found a correlation between the displacement of the fourth ventricle, and the post-operative facial nerve function. Moulin *et al.* (1995) found a correlation between the extra-canalicular diameter of the tumour measured on MRI, and post-operative facial nerve function. Correlation between facial nerve function and the schwannoma internal auditory canal angle or density (homogeneous/heterogeneous) of the schwannoma had not yet been studied. The facial nerve function was poorer when the angle was <66°. This could be explained by the anatomical position of the nerve at the porus; as the facial nerve is anterior at this level, it is exposed to compression between the tumour and the edge of the porus. This compression may impair the vascularisation, of the nerve and weaken it. The porus is the most common site of damage of the facial nerve, during translabyrinthine surgery (Tos *et al.*, 1992). The angulation of the nerve between the porus and the tumour increases the risk of surgical trauma during dissection, especially if the nerve is thinned out.

Heterogenicity may be due to necrosis, haemorrhage into the tumour haemosiderin, or cyst formation. One can imagine that heterogeneous tumours might undergo sudden changes of volume, whereas the volume of homogeneous tumours uniformly increases. Arriaga *et al.* (1993a) found that post-operative facial nerve function was non-linearly correlated to tumour volume, and suggest that small diameter increments, especially in large tumours, may be associated with greater changes in volume, with corresponding deterioration of post-operative facial function. Intratumoural haemorrhage or cyst expansion may modify the size of tumour, provoking direct compression and/or oedema, and increasing the risk to the facial nerve.

Per-operative monitoring is now routinely performed during vestibular schwannoma surgery. It has been effective in helping tumour dissection and improving post-operative facial nerve function (Silverstein *et al.*, 1993; Sterkers *et al.*, 1994). Many authors have emphasized the prognostic value of *stimulation* of the facial nerve at the end of surgery: Beck *et al.* (1991) found a correlation between the immediate post-operative facial nerve function, and the amplitude of the contraction (>500 μV) elicited by a stimulation at the root at the lowest level (0.05 mA). Kirkpatrick *et al.* (1991) found a correlation between per-operative neural conduction and post-operative facial nerve function, but this correlation was not significant for large tumours. However, the authors do not define the site of stimulation, and the tumours were excised by different approaches. Lalwani *et al.* (1994) found a correlation between the threshold of proximal stimulation after tumour removal, and the facial nerve function one year after surgery; this correlation was not found for immediate post-operative facial nerve function. Silverstein *et al.* (1994) found a correlation between the threshold eliciting a facial nerve response, and the post-operative facial nerve function: when the stimulation at the root elicited a response for a threshold <0.1 ma, 95 per cent of patients had a final grade I. Between 0.11 mA and 0.2 mA, the final grade was II or better in 82 per cent of patients. In a previous study (Berges *et al.*, 1993), our team reported the value of stimulating the nerve in two sites: at the root, and at the internal auditory canal. This method compares the portion of the nerve which has been exposed to the surgical trauma, and may have suffered as a result of close relationship with the tumour, and the intra-petrous portion, less exposed to the dissection. The use of a ratio R (R = stimulation threshold at the brainstem/stimulation threshold at the internal auditory canal) is useful to compare patients independently of absolute thresholds which could be influenced by local variations (electrode location, modifications due to electrical conductivity). This study confirms the prognostic value of the ratio R on the long-term facial function.

One of the major factors contributing to preserve facial nerve function is the anatomical preservation of the nerve. Lesions of the sheath, stretching, haematoma or oedematous lesions of the nerve contribute to facial weakness. Nevertheless, in our experience, 32 per cent of patients who had nerve lesions at the end of the procedure had a grade I or II long-term facial function, whereas 82 per cent had a grade I or II post-operative facial function when the nerve was intact. This evolution may be compared to the House Institute data reported by Arriaga *et al.* (1993b), and is a strong argument to preserve the nerve at the end of surgery, even in case of apparent trauma; as the facial function may change in the long term, and as the recovery of

anastomosis is rarely better than grade III (Moffat *et al.*, 1989), a graft should be performed after a minimum delay of follow-up (six to 12 months) (Arriaga *et al.*, 1993b). We reserve per-operative grafting for cases of section of the facial nerve during tumour removal.

Conclusion

This study confirms the influence of the size of the tumour as a prognostic factor in the long-term facial function after surgery. It suggests that one considers the structure of the schwannoma (homogeneous/heterogeneous), and to measure the angle between the tumour and the internal auditory canal and that these factors may influence facial function. Per-operative monitoring, in addition to the help it provides for tumour dissection, is a good indicator of facial function at the end of surgery, and has a prognostic value for long-term facial function. When the continuity of the nerve has been preserved, it must be respected, even if there is oedema, haematoma of the sheath or stretching. As some patients (32 per cent) may recover a good facial function in the long-term in spite of nerve lesion, grafting should be performed at a second stage operation, after a sufficient follow-up.

Acknowledgement

The authors thank Dr E. Chapotot, M.D., for the statistical analysis in this manuscript.

References

Arriaga, M. A., Long, S., Nelson, R. (1993a) Clinical correlations of acoustic neuroma volume. *American Journal of Otology* **14:** 465–468.

Arriaga, M. A., Luxford, W. M., Atkins J. S. Jr., Kwartler, J. A. (1993b) Predicting long-term facial nerve outcome after acoustic neuroma surgery. *Otolaryngology – Head and Neck Surgery* **108:** 220–224.

Beck, D. L., Atkins, J. S. Jr., Benecke, J. E. Jr., Brackmann, D.E. (1991) Intraoperative facial nerve monitoring: prognostic aspects during acoustic tumor removal. *Otolaryngology – Head and Neck Surgery* **104:** 780–782.

Berges, C., Fraysse, B., Yardeni, E., Rugiu, G. (1993) Intraoperative facial nerve monitoring in posterior fossa surgery: prognostic value. *Skull Base Surgery* **3:** 214–216.

Kartush, J. M., Niparko, J. K., Graham, M. D., Kemink, J. L. (1987) Electroneurography: preoperative facial nerve assessment for tumors of the temporal bone. *Otolaryngology – Head and Neck Surgery* **97:** 257–261.

Kirkpatrick, P. J., Watters, G., Strong, A. J., Walliker, J. R., Gleeson, M. J. (1991) Prediction of facial nerve function after surgery for cerebellopontine angle tumors: use of a facial nerve stimulator and monitor. *Skull Base Surgery* **1:** 171–176.

Lalwani, A. K., Butt, F. Y., Jackler, R. K., Pitts, L. H., Yingling, C. D. (1994) Facial nerve outcome after acoustic neuroma surgery: a study from the era of cranial nerve monitoring. *Otolaryngology – Head and Neck Surgery* **111:** 561–570.

Moffat, D. A., Croxson, G. R., Baguley, D. M., Hardy, D. G. (1989) Facial nerve recovery after acoustic neuroma removal. *Journal of Laryngology and Otology* **103:** 169–172.

Moulin, G., Dessi, P., Andre, P., Cannoni, M., Pellet, W., Zanaret, M., Emram, B., Chagnand, C., Giusano, B., Bartoli, J.-M. (1995) Role of magnetic resonance imaging in predicting late facial motor function after removal of vestibular schwannomas by the translabyrinthine approach. *Journal of Laryngology and Otology* **109:** 394–398.

Prasad, S., Hirsch, B. E., Kamerer, D. B., Durrant, J., Sekhar, L. N. (1993) Facial nerve function following cerebellopontine angle surgery: prognostic value of electroneurography. *American Journal of Otology* **14:** 326–329.

Ruth, H. R., Luetje, C. M., Whittaker, C. K. (1985) Acoustic tumors: preoperative measurement and correlation with postoperative facial nerve function. *Otolaryngology – Head and Neck Surgery* **93:** 160–163.

Silverstein, H., Rosenberg, S. I., Flanzer, J., Seidman, M. D. (1993) Intraoperative facial nerve monitoring in acoustic neuroma surgery. *American Journal of Otology* **14:** 524–532.

Silverstein, H., Willcox, T. O. Jr., Rosenberg, S. I., Seidman, M. D. (1994) Prediction of facial nerve function following acoustic neuroma resection using intraoperative facial nerve stimulation. *Laryngoscope* **104:** 539–544.

Sterkers, J. M., Morrison, G. A., Sterkers, O., El-Dine, M. M. (1994) Preservation of facial, cochlear, and other nerve functions in acoustic neuroma treatment. *Otolaryngology – Head and Neck Surgery* **110:** 146–155.

Thomsen, J., Zander Olsen, P., Tos, M. (1985) Pre- and postoperative facial nerve testing in patients with acoustic neuromas. *Acta Otolaryngologica (Stockh)* **99:** 239–244.

Tos, M., Youssef, M., Thomsen, J., Turgut, S. (1992) Causes of facial nerve paresis after translabyrinthine surgery for acoustic neuroma. *Annals of Otology, Rhinology and Laryngology* **101:** 821–826.

Address for correspondence:
Olivier Deguine,
ENT Department,
Centre Hospitalier Universitaire de Toulouse,
Hôpital Purpan,
Place du Docteur Baylac,
31059 Toulouse Cédex,
France.

Fax: +33 05 61 49 36 44
e-mail: deguine@cerco.ups-tlse.fr