

## Prognosis of Tinnitus After Acoustic Neuroma Surgery—Surgical Management of Postoperative Tinnitus

Michihiro Kohno<sup>1</sup>, Masanobu Shinogami<sup>2</sup>, Hidehiko Yoneyama<sup>3</sup>, Osamu Nagata<sup>4</sup>, Shigeo Sora<sup>1</sup>, Hiroaki Sato<sup>1</sup>

### Key words

- Acoustic neuroma
- Neurinoma
- Surgery
- Tinnitus
- Vestibular schwannoma

### Abbreviations and Acronyms

**AAO-HNS:** American Academy of Otolaryngology—Head and Neck Surgery  
**ABR:** Auditory brainstem response



From the Departments of <sup>1</sup>Neurosurgery, and <sup>2</sup>Otolaryngology, Tokyo Metropolitan Police Hospital, Tokyo; <sup>3</sup>Department of Otolaryngology, Yoneyama Clinic, Fujinomiya; and <sup>4</sup>Department of Anesthesiology, Saitama Medical Center of Jichi University, Saitama, Japan

To whom correspondence should be addressed:  
 Michihiro Kohno, M.D., Ph.D.

[E-mail: mkouno-nsu@umin.ac.jp]

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### INTRODUCTION

There are many articles on tinnitus associated with acoustic neuromas but fewer on postoperative changes of tinnitus (2-4, 7, 8, 10, 12, 14, 17, 18, 21, 22, 27, 32, 39, 41). Tinnitus in patients with acoustic neuroma is considered to lower the patients' quality of life (2, 3, 10, 13, 22), although it does not seriously disturb the activities of daily living (28). Surgeons who treat acoustic neuromas should take interest in patients' tinnitus, so we performed a retrospective study on pre- and postoperative tinnitus at a high-volume center where the follow-up rate was quite high. This study adopted a direct interview method (11, 17, 32) to determine the patients' impressions on postoperative changes of tinnitus, instead of a questionnaire method (2, 3, 7, 10, 14, 22, 32, 39, 41), which was frequently chosen in similar studies, because patients'

■ **OBJECTIVE:** Tinnitus is a bothersome symptom for patients with acoustic neuroma. We studied the possibility of surgical control of postoperative tinnitus associated with acoustic neuroma.

■ **METHODS:** Postoperative changes and prognosis of tinnitus were studied in 367 patients treated surgically via a lateral suboccipital retrosigmoid approach.

■ **RESULTS:** Postoperative prognosis of tinnitus was as follows: resolved in 20%, improved in 22%, unchanged in 35%, changed in 10%, and worsened in 14% of 290 patients who had preoperative tinnitus, and no tinnitus in 78% and appeared in 22% of 77 patients without preoperative tinnitus. Prognosis of postoperative tinnitus was influenced by age, tumor size, preoperative hearing acuity, types of preoperative hearing disturbance, and conditions of the cochlear nerve after tumor resection. Worse prognosis of postoperative tinnitus in the preoperative tinnitus group was found in younger patients, smaller tumor size, better preoperative hearing function, and normal or retrocochlear type of hearing disturbance. Regarding the conditions of the cochlear nerve after tumor resection, prognosis of tinnitus was significantly worse in the group of anatomically preserved cochlear nerve without useful hearing than in the group of cut cochlear nerve.

■ **CONCLUSIONS:** Deciding whether to cut the cochlear nerve during acoustic neuroma surgery by referring to a flowchart, we proposed in cases where hearing preservation is not intended or judged less possible contributes to controlling postoperative tinnitus. However, regardless of whether the cochlear nerve was cut intraoperatively, tinnitus remained unchanged in 37% of patients, suggesting that their tinnitus originates in the brainstem or post-brainstem pathways before surgery, and it is considered difficult to control postoperative tinnitus in these cases.

complaints of tinnitus should be the priority (32).

This study examined ways of intraoperatively controlling the prognosis of tinnitus, which would be beneficial for both patients and surgeons. To determine the relations with preoperative tinnitus and postoperative changes of tinnitus, the following factors were analyzed: sex, side, age, tumor size, preoperative and postoperative hearing acuity, types of preoperative hearing disturbance, tumor consistency, nerve of origin, initial symptoms, interval from initial symptoms to correct diagnosis, degree of extension in the internal auditory canal, pitch areas of disturbed hearing in audiograms, and

conditions of the postoperative cochlear nerve.

### PATIENTS AND METHODS

Of 430 consecutive patients with acoustic neuroma who underwent surgery from September 2004 to November 2010 at the Department of Neurosurgery of the Tokyo Metropolitan Police Hospital, 367 patients were included in this study, excluding 17 cases of neurofibromatosis type 2, 41 cases with a history of surgery and/or radiation therapy, and 5 cases with incomplete preoperative interview and/or examinations. In these 367 patients, postoperative changes and prognosis of tinnitus were

analyzed retrospectively using many clinical parameters based on a large, detailed database of pre- and postoperative clinical findings.

Operative indications at the above institution were as follows: tumors compressing the brainstem in patients under 60 years old, large or cystic tumors and/or tumors with occlusive or communicating hydrocephalus in patients more than 60 years old, and tumors with high regrowth speed or in younger patients in whom preservation of hearing is intended even if the tumors do not reach the brainstem. Our operative policy for resecting acoustic tumors is to achieve the maximum amount of tumor removal without causing serious persistent postoperative facial nerve palsy. We usually decide whether to perform total or near-total removal by referring to continuous facial nerve monitoring (1, 26). In all cases in this study, the senior neurosurgeon (M.K.) performed the intradural operation via a lateral suboccipital retrosigmoid approach (25), and he has performed more than 600 acoustic neuroma surgeries as of February 2012.

**Table 1** shows a summary of the 367 patients in this study, composed of 168 (45.8%) men and 199 (54.2%) women with 169 (46.0%) right- and 198 (54.0%) left-side tumors. The mean age of the 367 patients was  $46.0 \pm 12.3$  (14–76) years, and the patients were categorized into the following 4 groups: <35 years old ( $n = 76$ , 20.7%), 35–44 years old ( $n = 97$ , 26.4%), 45–54 years old ( $n = 90$ , 24.5%), and  $\geq 55$  years old ( $n = 104$ , 28.3%); and also into 2 groups: <45 years old ( $n = 173$ , 47.1%) and  $\geq 45$  years old ( $n = 194$ , 52.9%) in the studies associated with age. Regarding tumor size, the maximal diameter of the cisternal portion of the tumor was measured according to the guidelines of the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) (9) and intrameatal tumor was regarded as 0 mm. The mean tumor size of the 367 patients was  $24.5 \pm 11.5$  (0–64) mm, and the patients were categorized into 3 groups: <20 mm group ( $n = 125$ , 34.1%); 20–29 mm group ( $n = 119$ , 32.4%); and  $\geq 30$  mm group ( $n = 123$ , 33.5%) in the studies associated with tumor size. Tumor consistency was classified into 3 groups based on the preoperative MR images: solid type ( $n = 218$ , 59.4%), cystic

type ( $n = 31$ , 8.4%), and mixed type, which contained a solid or cystic part in more than 30% of the tumor volume ( $n = 118$ , 32.2%). The mean degree of extension in the internal auditory canal measured on the preoperative MR images was  $77.3 \pm 26.6$  (0%–100%). Preoperative hearing function was assessed by AAO-HNS classification (9), composed of 123 (33.5%) class A, 72 (19.6%) class B, 54 (14.7%) class C, and 118 (32.2%) class D in 367 patients (**Table 1**), whereas there were 96 (33.1%) class A, 58 (20.0%) class B, 44 (15.2%) class C, and 92 (31.7%) class D in 290 patients who had tinnitus preoperatively (preoperative tinnitus group) and 27 (35.1%) class A, 14 (18.2%) class B, 10 (13.0%) class C, and 26 (33.8%) class D in 77 patients without preoperative tinnitus (no preoperative tinnitus group). Regarding the pitch extents of hearing, 125–500 Hz, 1000–2000 Hz, and  $\geq 3000$  Hz were defined as low pitch, middle pitch, and high pitch, respectively, in this study. Preoperative hearing was disturbed in low pitch in 193 (52.6%), middle pitch in 259 (70.6%), and high pitch in 287 patients (78.2%) (**Table 1**). Types of preoperative hearing disturbance were judged with findings of auditory brainstem response (ABR), distortion product otoacoustic emissions, self-recording audiometry, filtered speech audiometry, directional hearing test, and alternate binaural loudness balance test, and categorized into 4 groups: not disturbed (N) group ( $n = 26$ , 7.1%), inner ear type (I) group ( $n = 33$ , 9.0%), retrocochlear type (R) group ( $n = 96$ , 26.2%), and both inner ear and retrocochlear type (B) group ( $n = 212$ , 57.8%). Initial symptoms were sudden-onset hearing symptoms (hearing disturbance and/or tinnitus) ( $n = 138$ , 37.6%), no sudden-onset hearing symptoms (hearing disturbance and/or tinnitus) ( $n = 99$ , 27.0%), dizziness or vertigo ( $n = 75$ , 20.4%), and other symptoms or incidental ( $n = 55$ , 15.0%). The mean interval from initial symptoms to final correct diagnosis was  $36.2 \pm 47.8$  (0–360) months. The nerve of origin was judged based on the intraoperative findings and was categorized into 4 groups: superior vestibular nerve group ( $n = 182$ , 49.6%), inferior vestibular nerve group ( $n = 155$ , 42.2%), cochlear nerve group ( $n = 4$ , 1.1%), and undetermined group ( $n = 26$ , 7.1%). The cochlear nerve was preserved anatomically

in 187 patients (51.0%), and useful hearing function (AAO-HNS class A and B) was preserved in 65 patients and was not preserved (AAO-HNS class C and D) in 122 patients. The preservation ratio of useful hearing was 63.7% in 102 patients in whom hearing preservation was intended for small tumors with both preoperative good hearing function and clearly recognized V wave in ABR. The cochlear nerve was cut at the root entry zone beside the brainstem in 180 patients (49.0%).

Two hundred ninety patients (79%) had tinnitus (preoperative tinnitus group) and 77 patients (21.0%) were without tinnitus before surgery (no preoperative tinnitus group), and prognosis was categorized into resolved (R), improved (I), unchanged (U), changed (C), and worsened (W) in the preoperative tinnitus group, and into not appeared (N) and appeared (A) in the no preoperative tinnitus group. “Changed” was defined as the condition in which a patient reported that the sound type of postoperative tinnitus was changed without feeling that it had improved or worsened.

Postoperative follow-up was performed at 1 month (interview on postoperative state and changes of tinnitus, examination of hearing function), 4 months (interview), 1 year (interview and magnetic resonance imaging), and every year (interview and magnetic resonance imaging) after surgery. The mean follow-up was 35.6 (15–86) months, and the follow-up rate at 1 year after surgery was 97%.

Statistical analysis was performed using JMP 9.0.2 software (SAS Institute, Cary, North Carolina, USA), and values of  $P < 0.05$  were considered statistically significant. The comparisons of averages between 2 groups and among more than 3 groups were analyzed by Student *t* test and by the Tukey-Kramer honestly significant difference (HSD) test, respectively. The comparisons of proportions on ordinal variables and on nominal variables were analyzed by Wilcoxon rank sum test and by  $\chi^2$  test, respectively.

The protocol of this study was approved by the ethics committee of the Tokyo Metropolitan Police Hospital.

## RESULTS

Regarding the timing when the postoperative tinnitus became stable, postoperative tinnitus state changed at more

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