



Functional Preservation After Planned Partial Resection Followed by Gamma Knife Radiosurgery for Large Vestibular Schwannomas

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■ **OBJECTIVE:** The treatment goal for vestibular schwannomas (VS) has been changed from total removal of the tumor to functional preservation with long-term tumor growth control. The small- to medium-sized VS can be treated by stereotactic radiosurgery, but large VS require surgical decompression for the relief of cerebellar dysfunction and increased intracranial pressure. We have been performing planned partial surgical resections followed by gamma knife radiosurgery (GKS) for large VS. Here, we evaluate a recent series of such cases from the standpoint of functional outcomes.

■ **METHODS:** From January 2000 to May 2013, we treated 40 patients with large unilateral VS (maximum tumor diameter at least 25 mm) with planned partial tumor removal followed by GKS for functional preservation. The median maximum diameter of the tumors was 32.5 mm (range 25–52 mm). All patients underwent surgery via the retrosigmoid approach, and tumors situated on the ventral and in the internal auditory canal intentionally were not removed, thus preserving cranial nerve functions. GKS was performed 1–12 months after surgical resection (median interval 3 months). The median tumor volume at GKS was 3.3 cm³ (range 0.4–10.4 cm³) and the median prescribed dose was 12 Gy (range 10–12 Gy). The median follow-up period after GKS was 65 months (18–156 months).

■ **RESULTS:** At the final follow-up, facial nerve preservation (House-Brackmann grade I–II) was achieved in 38 patients (95%; House-Brackmann grade I: 92.5%, II: 2.5%). Among the 14 patients with preoperative pure tone average (PTA) less than 50 dB, 6 of them (42.9%) maintained PTA

less than 50 dB at the last follow-up. Two patients improved from severe hearing loss to PTA less than 50 dB (1 patient after surgery and 1 patient one and half years after GKS). Five- and 10-year tumor growth control occurred in 86% of patients. Four patients (10%) required salvage surgery; the predictive factor was tumor volume greater than 6 cm³ at GKS ($P = 0.01$).

■ **CONCLUSIONS:** Planned partial removal of large VS followed by GKS achieved a high rate of facial nerve and hearing preservation. To achieve long-term tumor growth control, the tumor volume at GKS after planned partial surgical resection should be smaller than 6 cm³. Our results revealed that patients with hearing preservation postoperatively have a chance of maintaining hearing function, even though the possibility exists of deterioration by long-term follow-up after surgical intervention and GKS. Furthermore, some patients with severe hearing loss before treatment have the chance of hearing improvement, even those with large VS.

INTRODUCTION

The main treatment goal for vestibular schwannomas (VS) has been changed from simply tumor growth control to additional functional preservation of the facial nerve and hearing (46). Gamma knife radiosurgery (GKS) became the mainstream treatment of small- to medium-sized VS, because it is less invasive and useful for long-term functional preservation of the facial nerve and hearing while also demonstrating the ability to

Key words

- Acoustic neuroma
- Gamma knife
- Hearing
- Radiosurgery
- Retrosigmoid approach
- Vestibular schwannoma

Abbreviations and Acronyms

GKS: Gamma knife radiosurgery

HB: House-Brackmann

PTA: Pure tone average

VS: Vestibular schwannomas

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control tumor growth (7, 14, 26). Surgical resection is indicated for large VS to relieve cerebellar dysfunction and to release increased intracerebral pressure (19, 40), but hearing preservation after surgical resection is still a significant challenge (46), even though facial nerve preservation rates are improving via microsurgical techniques.

We have been treating large VS with planned partial resection followed by GKS (19). This treatment protocol has been developed for cases in which we consider the preservation of cranial nerve function to be more important than total tumor removal, because tumor growth control can be achieved by subsequent GKS if the tumor has been debulked to an appropriate size for GKS. We first reported planned partial surgical resection followed by GKS for large VS in 2003 (19). Following further advances and continued experiences, we now present an evaluation of a recent series of cases using this procedure.

PATIENTS AND METHODS

We propose the following treatment strategies for VS: 1) small VS (<15 mm) are observed after a “wait-and-scan” approach, and at the time of tumor growth, GKS (Leksell gamma knife unit; Elekta AB, Stockholm, Sweden) is performed. Medium-sized VS are divided into 2 subgroups: a) the smaller ones (15–25 mm) are treated by GKS at diagnosis (except for elderly patients) and b) for the slightly larger ones (25–30 mm), the decision to perform GKS or surgical resection depends on the patient’s neurologic condition, if the patient has no neurologic deterioration other than hearing disturbance, GKS is indicated, but if they have cerebellar ataxia and/or trigeminal neuropathy, we recommend surgical resection. 3) Tumors with a maximum diameter ≥ 3 cm are treated by surgical resection for the purpose of improving cerebellar dysfunction and reducing the increased intracranial pressure or for relief of trigeminal neuropathy.

From January 2000 to May 2013, using GKS and/or surgery we treated 381 patients presenting with unilateral VS. Among these, 327 patients were treated with GKS alone, and 54 underwent surgical resection (including 40 planned partial surgical resections followed by GKS, 12 salvage surgeries after GKS, 4 salvage surgeries after planned partial resection and GKS, and 2 surgical resections alone). In the present study, following further advances and continued experiences, we evaluated the treatment results of planned partial resections of large unilateral VS (maximum tumor diameter ≥ 25 mm, as discussed previously) followed by GKS conducted during this period.

There were 19 men and 21 women, with a median 60.5 years (range 33–82 years). One patient had a regrowth of a tumor after surgery performed 10 years before at another institute, but the other patients were all treated initially in our institute. The preoperative symptoms were hearing disturbance in 37 patients (93%), cerebellar ataxia in 32 patients (80%), trigeminal neuropathy in 30 patients (75%) including 1 patient with trigeminal neuralgia, facial weakness in 13 patients (33%) including House and Brackmann (HB) grade (15) II in 11 patients and HB grade III in 2 patients related to tumor growth. Fourteen patients (35%) had pure tone average (PTA) less than 50 dB preoperatively, 16 (40%) had some preserved hearing (PTA >50 dB, ≤ 110 dB), and 10 (25%) had no preserved hearing (PTA >110 dB). The median maximum tumor diameter was 32.5

mm (range, 25–52 mm). Eight patients underwent the surgery even though their tumors were smaller than the critical 30 mm in maximum diameter (range 25–29 mm, see above under treatment strategies), because of their symptoms of cerebellar ataxia and or trigeminal neuropathy (Table 1).

Surgical Technique

Partial surgical resections were performed as previously described (19), by use of the retrosigmoid approach; the tumors situated on the ventral and in the internal auditory canal were intentionally not removed, with the following modifications. We have used auditory brain stem monitoring in patients with useful preoperative hearing. The ultrasonic aspirator is thought to be dangerous to use close to the ventral side of the tumor, because of the facial and cochlear nerves running along this side. In addition, a bipolar coagulator is used minimally to prevent injury to the surrounding nerves and cottonoid pressure to control bleeding from within the tumor. The tumor close to the cerebellum is removed as much as possible for obtaining a suitable size for GKS (19). In this step, the ventral side of the tumor is reduced to approximately 2–3 mm in thickness; at this volume, the residual tumor tissue is of suitable size for

Table 1. Characteristics of 40 Patients Before Planned Partial Surgical Resection Followed by GKS

Characteristics	Values
Median age in years (range)	60.5 (33–82)
Symptoms: number of patients (%)	
Hearing disturbance	37 (93)
Cerebellar ataxia	32 (80)
Trigeminal neuropathy	30 (75)
Facial weakness	13 (33)
Headache attributable to increased intracranial pressure	4 (10)
Hydrocephalus	2 (5)
Hearing level (pure tone average, dB) (%)	
0–30	8 (20)
31–50	6 (15)
51–80	12 (30)
81–110	4 (10)
≥ 111	10 (25)
Tumor characteristics	
Cystic VS (%)	24 (60)
Maximum tumor diameter, mm: number of patients (%)	
25–29	8 (20)
30–39	23 (57.5)
40–49	4 (10)
50–52	5 (12.5)
GKS, gamma knife radiosurgery; VS, vestibular schwannoma.	

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