Communicating Hydrocephalus Associated with Intracranial Schwannoma Treated by Gamma Knife Radiosurgery

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OBJECTIVE: **Gamma knife radiosurgery (GKRS) has been established as an effective and safe treatment for intracranial schwannoma. However, serious complications can occur after GKRS, including hydrocephalus. The pathophysiology and risk factors of this disorder are not yet fully understood. The objective of the study was to assess potential risk factors for hydrocephalus after GKRS.**

METHODS: **We retrospectively reviewed the medical radiosurgical records of 244 patients who underwent GKRS to treat intracranial schwannoma. The following parameters were analyzed as potential risk factors for hydrocephalus after GKRS: age, sex, target volume, irradiation dose, prior tumor resection, treatment technique, and tumor enhancement pattern. The tumor enhancement pattern was divided into 2 groups: group A (homogeneous enhancement) and group B (heterogeneous or rim enhancement).**

RESULTS: **Of the 244 patients, 14 of them (5.7%) developed communicating hydrocephalus. Communicating hydrocephalus occurred within 2 years after GKRS in most patients (92.8%). No significant association was observed between any of the parameters investigated and the development of hydrocephalus, with the exception of tumor enhancement pattern. Group B exhibited a statistically significant difference by univariate analysis ($P = 0.002$); this difference was also significant by multivariate analysis ($P = 0.006$).**

CONCLUSION: **Because hydrocephalus is curable, patients should be closely monitored for the development of this disorder after GKRS. In particular, patients with intracranial schwannomas with irregular enhancement patterns or cysts should be meticulously observed.**

INTRODUCTION

Intracranial schwannoma is estimated to account for 5%–9% of all intracranial tumors, most of which (about 90%) are vestibular schwannoma (VS). Among the nonvestibular schwannoma tumors, trigeminal schwannoma (TS), glossopharyngeal schwannoma (GS), and facial schwannoma (FS) account for 0.8%–8%, 2.9%–4%, and 1.9%, respectively.[1,2] Surgical resection is the gold standard treatment method for intracranial schwannoma. However, intracranial surgery carries the considerable possibility of complications involving cranial nerve injury.[3] In recent years, many authors have reported that gamma knife radiosurgery (GKRS) is effective for tumor control and the preservation of cranial nerve function for intracranial schwannoma.[4-6] In contrast to open surgery, GKRS does not require anesthesia and is less invasive. Thus GKRS has become an attractive alternative treatment method, especially for patients with small tumors, old age, and/or poor medical conditions.[4]

However, patients who undergo GKRS can experience complications such as edema, cyst formation, and hydrocephalus as adverse radiation effects.[7,8] Hydrocephalus following GKRS is often presented by several clinical symptoms, including neurologic deficits.[9,10] Moreover, the general anesthesia required by a shunt operation could be problematic for some patients who undergo GKRS. Some authors have reported that communicating

Key words
- Complication
- Gamma knife radiosurgery
- Hydrocephalus
- Schwannoma

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
FS: Facial schwannoma
GKRS: Gamma knife radiosurgery
GS: Glossopharyngeal schwannoma
Gy: Gray
MRI: Magnetic resonance image
SPSS: Statistical Package for the Social Sciences
TS: Trigeminal schwannoma
VS: Vestibular schwannoma

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hydrocephalus develops more frequently after GKRS than after surgical resection.[10,11] The pathophysiology of hydrocephalus after GKRS and its risk factors have been evaluated only in a limited number of studies.[12-14] In the current study, we investigated cases of hydrocephalus after GKRS for intracranial schwannoma and analyzed potential factors that contribute to the development of hydrocephalus.

METHODS

The study population was composed of a consecutive series of 275 patients with intracranial schwannoma who were treated by GKRS between January 1997 and December 2012. We excluded patients who were lost to the study for various reasons such as loss of follow-up. In addition, patients who underwent a shunt operation before GKRS or patients who already had an enlarged ventricle at GKRS were excluded from this study. After excluding ineligible patients, 244 qualified for this study and were included in the analysis.

The patients underwent magnetic resonance imaging (MRI) on a Leksell stereotactic instrument. We used a Leksell KULA system (Elekta Instrument, Stockholm, Sweden) until January 2002, after which we used a Leksell Gamma Plan system 10.1 (Elekta AB).

All patients who were treated by GKRS for intracranial schwannoma underwent follow-up MRI for treatment evaluation 6 months postoperative, and then the assessment was conducted on a yearly basis.

The diagnosis of hydrocephalus was made from the following established criteria: 1) disproportionate enlargement of the ventricles relative to the degree of sulcal prominence, 2) enlargement of the anterior third ventricle with reduction of the mamillopontine distance, and 3) uniform smooth thinning and elevation of the corpus callosum.[11] Exclusion criteria included noncommunicating hydrocephalus due to mechanical compression and senile hydrocephalus. To distinguish GKRS-related hydrocephalus from senile hydrocephalus, we added to the assessment time of occurrence of hydrocephalus and sudden worsening of symptom. According to several reports, GKRS-related hydrocephalus developed within 24 months postoperative[7,10,15]; thus we used timeframe to define GKRS-related hydrocephalus in the present study. In addition, patients who experienced sudden worsening of symptoms were included in the GKRS-related hydrocephalus group.

To analyze the relationship between potential risk factors and hydrocephalus after GKRS, we assessed the following parameters:

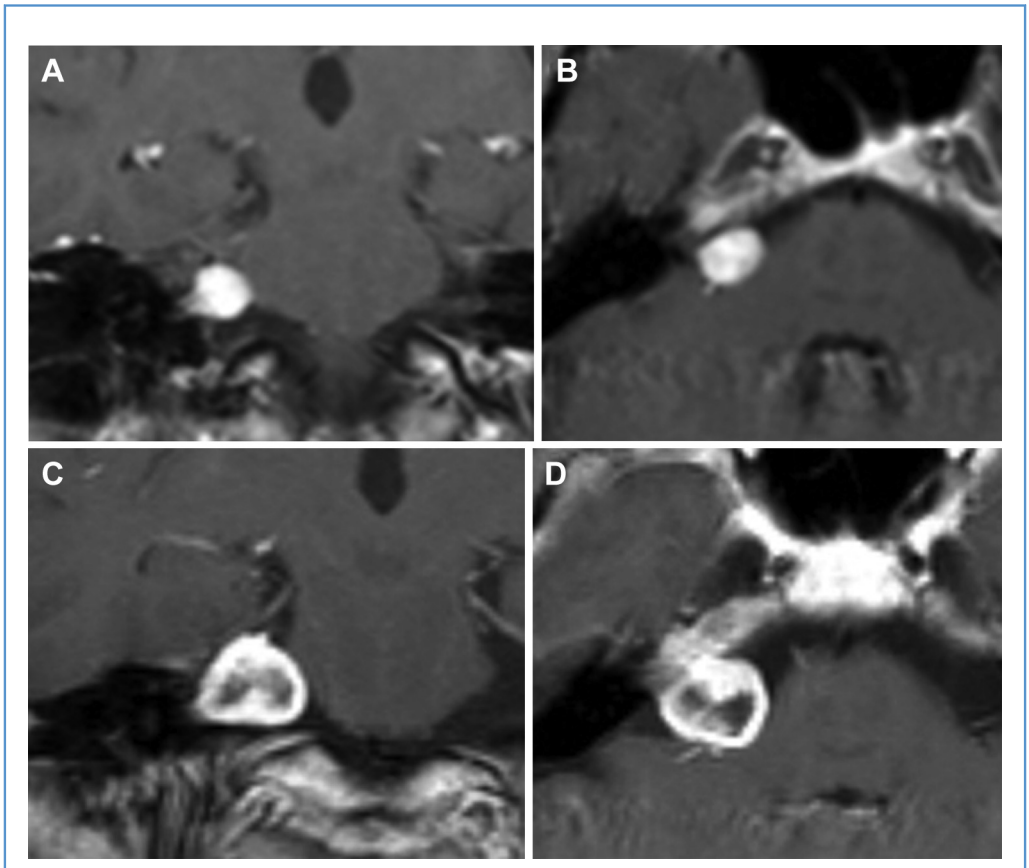

Figure 1. T1-weighted contrast-enhanced magnetic resonance image (MRI) taken at the time of gamma knife surgery. (**A**) Coronal T1-weighted, contrast-enhanced MRI scan showing a homogenously enhanced right vestibular schwannoma, defined as a type A tumor. (**B**) Axial T1-weighted, contrast-enhanced MRI scan of a type A tumor. (**C**) Coronal T1-weighted, contrast-enhanced MRI scan showing a heterogeneously rim-enhanced vestibular schwannoma, defined as a type B tumor. (**D**) Axial T1-weighted, contrast-enhanced MRI scan of a type B tumor.