Absence of residual tumor tissue after Gamma Knife radiosurgery followed by resection of a vestibular schwannoma: illustrative case

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BACKGROUND Late pathology after vestibular schwannoma radiosurgery is uncommon. The authors presented a case of a resected hemorrhagic mass 13 years after radiosurgery, when no residual tumor was found.

OBSERVATIONS A 56-year-old man with multiple comorbidities, including myelodysplastic syndrome cirrhosis, received Gamma Knife surgery for a left vestibular schwannoma. After 11 years of stable imaging assessments, the lesion showed gradual growth until a syncopal event occurred 2 years later, accompanied by progressive facial weakness and evidence of intrallesional hemorrhage, which led to resection. However, histopathological analysis of the resected specimen showed hemorrhage and reactive tissue but no definitive residual tumor.

LESSONS This case demonstrated histopathological evidence for the role of radiosurgery in complete elimination of tumor tissue. Radiosurgery for vestibular schwannoma carries a rare risk for intrallesional hemorrhage in select patients.

Illustrative Case

The patient was a 56-year-old man who was diagnosed with a left vestibular schwannoma that presented with left-sided tinnitus and hearing loss (Fig. 1). He had multiple comorbidities, including hypertension, diabetes mellitus, myelodysplastic syndrome, and a liver transplant for cirrhosis that required immunosuppression. He was not a suitable candidate for resection, and in 2007, the lesion was treated with 13 Gy Gamma Knife surgery. Serial imaging displayed tumor control for 11 years until a scan showed a slight asymptomatic interval increase.

Meanwhile, the patient developed non-Hodgkin lymphoma, which was treated with rituximab, accompanied by anemia, thrombocytopenia, and leukopenia that required treatments with colony-stimulating factors and erythropoietin alpha. He also developed paraparesis with a plausible diagnosis of transverse myelitis, which required him to use a wheelchair. Anticoagulation for deep vein thrombosis (DVT) prophylaxis was initiated.

ABBREVIATION DVT = deep vein thrombosis.

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Notably, our patient experienced delayed phase, scar tissue begins to replace the coagulation necrosis. Many promote theories of a dose- and time-accessible, a few studies have described the professional hemorrhage, necessitating its resection. It provided a unique situation for his liver transplant, non-Hodgkin lymphoma, myelodysplastic syndrome and low platelets, and anticoagulation for DVT prophylaxis. According to the study by Carlson et al., there could be a predicted 25-fold increased risk of intratumoral hemorrhage in persons with compromised coagulation.

**Discussion**

Here we describe an unusual case of a vestibular schwannoma that was treated by radiosurgery and developed delayed intrasellar hemorrhage, necessitating its resection. It provided a unique insight into the histopathological findings of postradiosurgery specimens as well as the evolution of hemorrhages in vestibular schwannoma lesions and their risk factors.

**Observations**

Although histopathology after radiosurgery is not frequently accessible, a few studies have described the findings of postradiosurgical specimens. Many promote theories of a dose- and time-dependent pattern of changes in treated tissue, in which postradiosurgery tumor changes occur over months to years after treatment.

In the months after radiosurgery, coagulation necrosis, apoptosis, interstitial edema, and reactive astrogliosis occur. A variety of vascular changes and sometimes less predictable adverse events, including cysts and aneurysms, may occur.

In the delayed phase, scar tissue begins to replace the coagulation necrosis. Notably, our patient’s pathology showed marked fibroblastic scarring process, which was nevertheless disrupted by the acute hemorrhage, leading to fresh granulation tissue. Intratumoral hemorrhage can occur in both naïve and treated vestibular schwannomas, in which tumor growth control rates exceed 90% after radiosurgery. Various descriptions of vestibular schwannomas with intratumoral hemorrhage have been reported, and they typically present with acute symptom progression, including headache, disequilibrium, and rapidly progressive hearing loss. Although less common, facial and trigeminal nerve deficits can also occur. Management is based on the urgency of the situation.

In our high-risk surgical patient who initially was stable, the primary choice was observation. As clinical and radiological deterioration occurred, we opted for surgical intervention. The evolution of rare intralesional hemorrhage in vestibular schwannoma has been previously studied. Sughrue et al. found that many tumors contained microhemorrhages. Of the specimens studied, 23% were composed of blood in more than a quarter of the volume, and hemorrhage comprised more than half of the volume in 4% of tumors. The histopathological analysis by Liu et al. agreed with the high rate of intratumoral microhemorrhage, mentioning that hemosiderin deposition occurred in more than half of the 18 schwannomas analyzed. Although microhemorrhages in vestibular schwannoma are frequent, a larger hemorrhage and continued bleeding, as in the case of our patient, likely require a secondary factor. A two-hit phenomenon has been discussed in previous reports of vestibular schwannoma with intratumoral hemorrhage. Niknafs et al. summarized several extratumoral factors that could exacerbate microhemorrhages, including hypertension, pregnancy, head trauma, and antithrombotic agents.

In our patient, underlying radiation changes could provide the initial hit, which was exacerbated by secondary factors, most notably numerous hematological comorbidities, including immunosuppression for his liver transplant, non-Hodgkin lymphoma, myelodysplastic syndrome and low platelets, and anticoagulation for DVT prophylaxis. According to the study by Carlson et al., there could be a predicted 25-fold increased risk of intratumoral hemorrhage in persons with compromised coagulation.

**FIG. 1.** Magnetic resonance imaging of the patient’s left vestibular schwannoma on the day of radiosurgery (A, with contrast) and 13 years later, on the day of hemorrhagic mass expansion (B, without contrast).

**FIG. 2.** Histology of granulation tissue. A: H&E stain at ×20 magnification of myofibroblasts with vascular proliferation and histiocytic inflammation consistent with granulation tissue. B–D: Immunohistochemical stains show that few residual cells express S100 (B), myofibroblasts within the granulation tissue express SMA (C), and extensive histiocytic inflammation is highlighted by CD168 (D).
Lessons
Our case demonstrates histopathological evidence of a virtually complete regression of vestibular schwannoma after radiosurgery with reactive changes. However, radiosurgery for vestibular schwannoma carries a potential risk for intralesional hemorrhage, which may be more pronounced in patients with hematological comorbidities.

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Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Conception and design: Berger, Goflnos, kondziolka. Acquisition of data: Galbraith, Snuderl, Goflnos, kondziolka. Analysis and interpretation of data: all authors. Drafting the article: Berger, Snuderl, kondziolka. Critically revising the article: Berger, Snuderl, Goflnos, kondziolka. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Berger. Administrative/technical/material support: kondziolka.

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