Role of Surgery in Vestibular Schwannoma following prior Stereotactic Radiosurgery

Zanib Javed, Muhammad Shahzad Shamim

Abstract

Stereotactic radiosurgery (SRS) is widely used for treating vestibular schwannoma (VS), offering high tumour control rates, especially in small to medium-sized tumours. However, a subset of patients experiences SRS failure, requiring subsequent salvage microsurgery (MS). The primary reason for salvage surgery is continued tumour growth, but other causes include symptom progression and cystic enlargement. Salvage surgery is more challenging due to increased tumour adhesion to critical structures, resulting in higher complication rates, particularly for facial nerve preservation. Studies suggest subtotal resection may offer better outcomes than gross total resection in terms of facial nerve function, though treatment remains complex and outcomes vary.

Keywords: Vestibular schwannoma, stereotactic radiosurgery, salvage surgery, facial nerve.

DOI: https://doi.org/10.47391/JPMA.24-84

Introduction

There is a growing volume of research supporting stereotactic radiosurgery (SRS) as an initial treatment for vestibular schwannoma (VS) of certain sizes, with tumour control rates generally ranging from 81% to 100% over five years.[1-3] SRS is also used to treat residual tumours after microsurgery (MS) for VS. However, as the use of SRS has expanded, especially with broader indications and at times less-than-perfect outcomes, there has been a growing number of cases requiring MS after unsuccessful SRS. While there is substantial literature on primary SRS for VS, there is relatively little focus on patients who experience treatment failure.[2] This review aims to summarise the outcomes reported in the literature for patients who required salvage surgery after SRS failure.

Literature Review

The continued growth of vestibular schwannoma (VS) is the leading reason for requiring microsurgery (MS) after SRS, accounting for over 90% of salvage surgeries.[4] Other reasons for salvage surgery include worsening symptoms such as neurological decline, severe facial pain, trigeminal neuralgia, and cystic enlargement. Shuto and Matsunaga reported two cases of symptomatic cyst formation occurring 4 and 12 years after Gamma Knife surgery (GKS) for non-cystic VS.[4] They suggest that this could be caused by repeated minor haemorrhages or fluid leakage from the lesion. Due to these concerns, many authors advocate for SRS studies with longer follow-up periods to better assess the risk of delayed radiation injury or tumour control failure.[4] Figure 1a and b.

According to a recent systematic review, the average tumour size at the time of surgery after SRS was 2.44 cm, with an average volume of 5.92 cm^3. Among the various types of SRS requiring surgical salvage, Gamma Knife surgery (GKS) was the most common, accounting for 218 cases. This was followed by linear accelerator (LINAC) treatments with 30 cases, fractionated stereotactic radiotherapy (fSRT) with 23 cases, and CyberKnife (CK; Accuray) with 10 cases.[1] Transient expansion is observed in the majority of vestibular schwannomas (VS) treated with SRS. Nagano et al., found that 74% of VS treated with GKS experienced a volume increase of at least 10%, with the average tumour expanding by 47% at its peak.[5] On average, it took 12 months for the tumours to return to their pre-SRS size. These transient expansions often lead to adverse radiation effects, which most commonly occur between 6 and 18 months after treatment and resolve on their own in over half of the cases within 3–6 months. Cranial nerves and brainstem are especially prone to surgical injury during this period. As a result, many authors recommend postponing surgery during these times.1 Nonaka et al., recommend a minimum waiting period of 3 years between SRS and surgical salvage, unless severe symptoms arise.[6]

Following SRS, the increased adhesion between the tumour and cranial nerves poses difficulties in tumour resection frequently necessitating or influencing the decision to perform subtotal resection (STR), that generally leads to better facial nerve outcomes. Whitmeyer et al.,[1] reported in a systematic review that following MS after primary SRS for VS, the facial nerve preservation rate was 91.5%, lower than the 95% rate for

Department of Neurosurgery, Aga Khan University Hospital, Karachi
Correspondence: Muhammad Shahzad Shamim
Email:shahzad.shamim@aku.edu
ORCID ID: 0000-0001-8305-8854

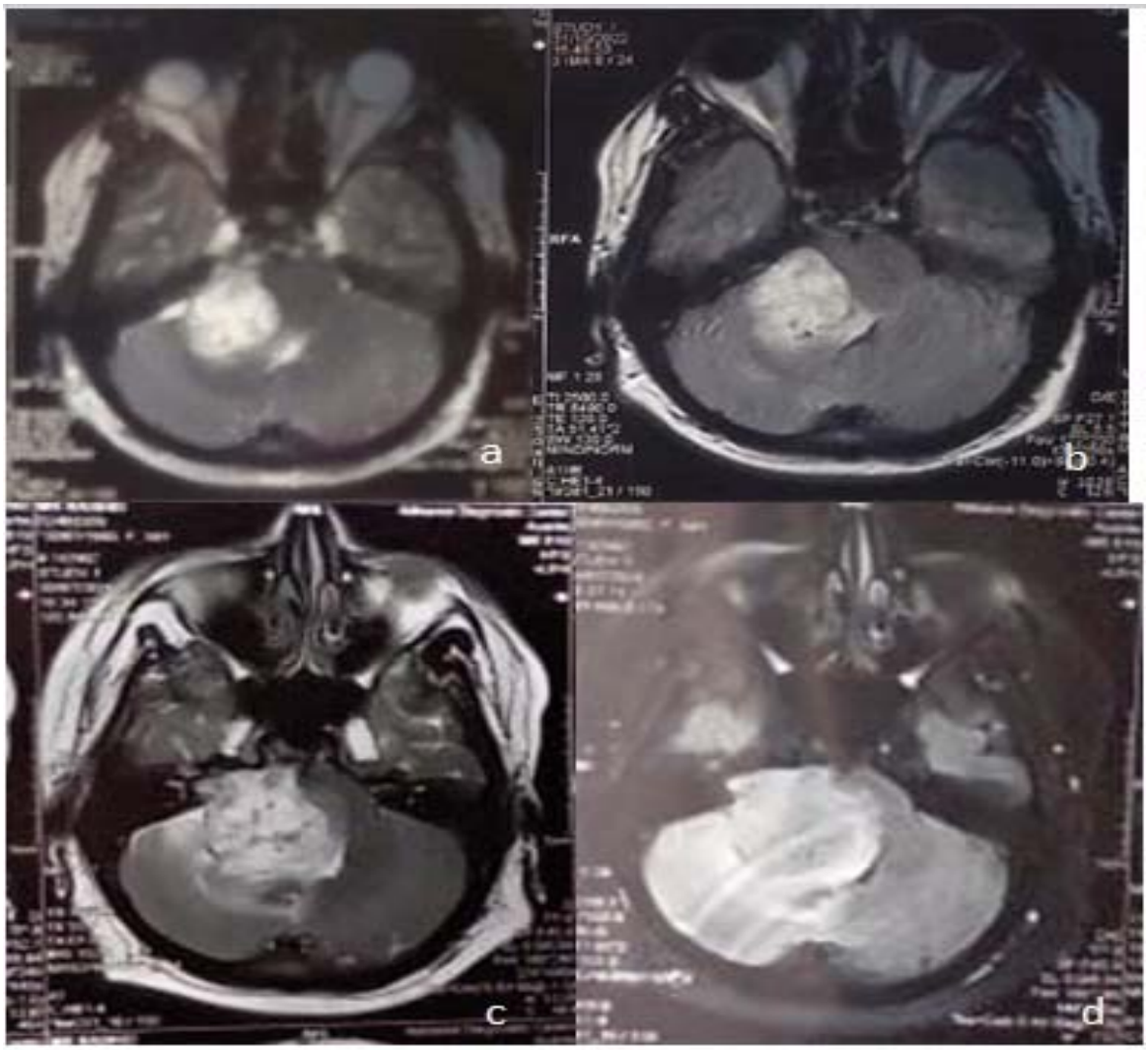

Figure-1: a and b show T2 and FLAIR axial images before SRS respectively of a young male with right CP Vestibular Schwannoma. C and d show T2 and FLAIR axial images 2 years after SRS, with worsening of symptoms and increased oedema as shown in images, based on which he underwent surgical resection.

primary MS. These findings suggest that surgery is more challenging in tumours previously treated with radiation. Additionally, a recent systematic review reported a 3.3% rate of cerebrospinal fluid (CSF) leaks, which is higher than the 2.03% rate observed in primary MS patients, indicating an increased overall complication rate in salvage surgeries. Tumours that resist SRS treatment may have a higher growth potential than residual tumours left after initial MS. The choice between pursuing gross total resection (GTR) or planning for STR remains a heavily debated issue in the literature.[7,8].

Nonaka et al., reported on 39 patients with VS who underwent surgery after unsuccessful SRS.[6] The majority (92.3%) experienced ongoing tumour growth after SRS, with a few needing surgery due to severe facial pain. Intra-operative findings demonstrated fibrous changes of the tumour mass, cyst formation, and brownish-yellow or purple discoloration of the tumour capsule. Severe adhesions between the tumour capsule and cranial nerves, vessels, and the brainstem were observed in 69.2%. Additionally, the facial nerve was more fragile and irritable in all cases. GTR was achieved in 33.3% of patients, near-total resection (NTR) in 35.9%, and STR in 30.8% of patients. New facial nerve palsy was seen in 7 (19.4%) patients after surgery.

Husseini et al., presented their experience of a quaternary referral otology and skull base center. The review included 19 patients who underwent MS after their VS continued to grow following SRS.7 The time between radiotherapy and surgery ranged from 1 to 10 years. Surgery was performed due to tumour growth, with complete removal achieved in 86.6% patients. However,

tumour dissection was difficult in 93.3% of cases. Although the facial nerve was preserved anatomically in 93.3% of patients, its function deteriorated in 73.3% after six months of follow-up. Malignant transformation of the tumour was observed in one patient.[7] A similar study included 23 patients who experienced tumour progression about 32 months after GKS, and 11 of these underwent salvage surgery. GTR was achieved in 8 patients, while 3 had small residual tumours left on the facial nerve, which did not show further growth during follow-up. At the last follow-up, facial nerve function varied, facial nerve function was grade 1 in 4 patients, grade 2 in 3 patients, grade 3 in 1 patient and grade 4 in 3 patients. The study concluded that salvage surgery after failed GKS is effective, though preserving facial nerve function is more challenging, sometimes requiring deliberate retention of small tumour remnants.[9]

Friedman et al., presented the largest series of 73 patients with VS who underwent surgical salvage after failed primary SRS, using a trans-labyrinthine approach.[10] The results showed that a conservative approach, involving partial or near-total tumour removal, led to better facial nerve outcomes compared to GTR. At one year of follow-up, 85.7% of patients with partial removal had good facial nerve function (House-Brackmann HB I/II), compared to 50% in the GTR group. Additionally, the partial removal group had fewer cases of poor outcomes (HB V or VI). The study concludes that a more conservative surgical approach after failed radiation can improve facial nerve preservation without compromising treatment effectiveness.

Lee et al., compared challenges of salvage MS via a trans-labyrinthine/trans-otic approach for VS re-growth or recurrence in patients after GKS (6 patients) with previous microsurgery (3 patients).[11] The results indicated that patients who had previously undergone GKS experienced more severe adhesion and fibrosis, making tumour dissection from the facial nerve more difficult compared to those who had prior microsurgery. Although facial nerve preservation was achieved in all GKS patients, three experienced worsened facial nerve function, unlike any in the microsurgery group.

Wise et al., presented a case-control study of 37 patients who had previously undergone SRS compared to non-irradiated control subjects matched by tumour size, age, and treatment center.[12] The median time from radiation to salvage surgery was 36 months. Following tumour progression after SRS, 49% of patients underwent gross total resection, 27% underwent near-total resection, and 24% had subtotal resection. Post-operative complications included 1 stroke, 4 CSF leaks, and 2 cases of meningitis. At long-term follow-up, 73% of patients had good facial nerve outcomes (HB Score I–II), with no cases of tumour recurrence or regrowth after a median of 26 months. Although the rate of satisfactory facial nerve function was similar between study and control groups (73% vs. 76%), less-than-complete resection was more common in the irradiated patients.[12]

Another comparative study of Gerganov et al., evaluated the outcomes of surgery in 28 with 15 patients in Group A (SRS prior to current surgery), 13 in Group B (partial tumour removal followed by SRS prior to current surgery), and 30 in the control group (with no prior treatment).[8] While complete tumour removal was achieved in nearly all patients: patients in group B faced higher risks of complications such as haematoma formation, CSF leakage, and lower facial nerve preservation. The study concluded that although surgery after failed SRS is possible, the functional outcomes tend to be worse, particularly in those who had both SRS.[8]

Conclusion

Complete surgical resection of VS is more difficult after SRS with relatively poor facial nerve outcomes and nearly impossible hearing preservation. Patients who receive radiation therapy for the treatment of vestibular schwannoma should be made aware of its potential complications and risk of failure, as well as the morbidity of surgery following failed SRS.

Disclaimer: None to declare.

Conflict of Interest: None to declare.

Funding Sources: None to declare.

References

1. Whitmeyer M, Brahimaj BC, Beer-Furlan A, Alvi S, Epsten MJ, Crawford F, Byrne RW, Wiet RM. Resection of vestibular schwannomas after stereotactic radiosurgery: a systematic review. J Neurosurg. 2020;135:881-9.
2. Hani U, Bakhshi S, Shamim MS. Stereotactic radiosurgery for vestibular schwannomas. J Pak Med Assoc 2020;70: 939-941.
3. Kazim SF, Shamim MS, Enam SA, Bari ME. Microsurgical excision of vestibular schwannomas: a tumor size based analysis of neurological outcomes and surgical complications. Surg Neurol Int 2011; 2:41.
4. Shuto T, Matsunaga S. Two cases of cystic enlargement of vestibular schwannoma as a late complication following gamma knife surgery. J Clin Neurosci. 2016; 33: 239–241.
5. Nagano O, Higuchi Y, Serizawa T, et al. Transient expansion of vestibular schwannoma following stereotactic radiosurgery. J Neurosurg. 2008; 109: 811–816.
6. Nonaka Y, Fukushima T, Watanabe K, Friedman AH, Cunningham CD, Zomorodi AR. Surgical management of vestibular schwannomas after failed radiation treatment. Neurosurg Rev. 2016;39:303-12.
7. Husseini ST, Piccirillo E, Taibah A, Almutair T, Sequino G, Sanna M. Salvage surgery of vestibular schwannoma after failed radiotherapy: the Gruppo Otologico experience and review of the literature. Am J Otolaryngol. 2013;34:107-14.

8. Gerganov VM, Giordano M, Samii A, Samii M. Surgical treatment of patients with vestibular schwannomas after failed previous radiosurgery. J Neurosurg. 2012; 116(4): 713–720
9. Aboukais R, Bonne NX, Touzet G, Vincent C, Reyns N, Lejeune JP.Progression of vestibular schawnnoma after GammaKnife radiosurgery: a challenge for microsurgical resection. Clin Neurol Neurosurg. 2018; 168: 77–82.
10. Friedman RA, Berliner KI, Bassim M, Ursick J, Slattery III WH, Schwartz MS et al. A paradigm shift in salvage surgery for radiated vestibular schwannoma. Otol Neurotol. 2011; 32: 1322–1328.
11. Lee HJ, Kim MJ, Koh SH, Chang WS, Moon IS. Comparing outcomes following salvage microsurgery in vestibular schwannoma patients failing gamma-knife radiosurgery or microsurgery. Otol Neurotol. 2017;38: 1339–1344.
12. Wise SC, Carlson ML, Tveiten OV, Driscoll CL, Myrseth E, Lund-Johansen M, et al. Surgical salvage of recurrent vestibular schwannoma following prior stereotactic radiosurgery. Laryngoscope. 2016;126: 2580–2586.