Natural History, Multimodal Management, and Quality of Life Outcomes of Trigeminal Schwannomas

Serge Makarenko¹ Vincent Ye¹ Ryojo Akagami¹

¹Department of Surgery, Vancouver General Hospital, University of British Columbia, Vancouver, British Columbia, Canada

J Neurol Surg B 2018;79:586–592.

Address for correspondence Serge Makarenko, MD, BSc, Division of Neurosurgery, Department of Surgery, University of British Columbia, Vancouver General Hospital, 899 West 12th Avenue, Vancouver, BC V5Z 1M9, Canada (e-mail: serge.makarenko@vch.ca).

Abstract

Background Trigeminal schwannomas are the second most common among intracranial schwannomas. These can arise from anywhere between the root and the distal extracranial branches of the trigeminal nerve. Clinical presentation depends on location and size, including but not limited to facial hypesthesia or pain, headaches, dizziness, ataxia, and diplopia. Literature is strikingly scant discussing the natural history of these lesions, while the treatment goals are heavily dependent on tumor presentation. Management decisions must be individualized to each tumor and each patient, while attempting to maximize the quality of life. We present the natural history of these lesions as well as their management by surgical resection or radiation therapy, and report long-term quality of life outcomes.

Methods Between 2001 and 2015, 24 patients (66.7% female) with trigeminal schwannomas were diagnosed and managed at Vancouver General Hospital. We analyzed the clinical presentation, surgical results, resection rates, patient quality of life, and complications. To complete the evaluation, we prospectively collected 36-Item Short Form Health Survey (SF-36) quality of life assessments for comparison.

Results We identified 12 patients treated with a craniotomy and surgical resection, 4 were treated with radiation therapy, while 8 patients were followed by observation. Mean age of study cohort was 49.2 years (range, 23–79 years), and most patients presented with facial hypesthesia (54.2%) and headaches (37.5%), while 37.5% were incidental findings. There were no major differences in patient demographics between the three groups. Patients offered surgery had larger lesions (mean diameter, 3.4 ± 1.1 cm) when compared with those that were irradiated or observed, and were more likely to have extracranial extension. Overall patient quality of life improved following treatment (Δ SF-36 + 12.9) at 3.9 years.

Conclusions The treatment goals of trigeminal schwannomas focus on improvement in neurologic symptoms, relief of mass effect, and preservation of cranial nerve function. We demonstrate that smaller lesions found incidentally with minimal symptoms can be followed safely with serial imaging, with 1 of 9 (11.1%) progressing to require treatment over the course of 7.1 years. Management of trigeminal schwannomas should be individualized with an involvement of a multidisciplinary skull base team.

Keywords

- trigeminal
- schwannoma
- quality of life
- radiation
- surgery
- observation

received
September 24, 2017
accepted after revision
March 31, 2018
published online
May 10, 2018

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Stuttgart · New York

DOI <https://doi.org/10.1055/s-0038-1651503>.
ISSN 2193-6331.

Introduction

Trigeminal schwannomas are rare intracranial tumors of the skull base, accounting for up to 0.5 to 1.5% of intracranial lesions.^{1–3} They are, however, the second most common among intracranial schwannomas. These tumors are mostly histologically benign, and can arise at any point along the course of the trigeminal nerve, from its root to the distal extracranial branches.⁴ The presentation is variable, with many asymptomatic lesions discovered incidentally. Other lesions can present with facial hypesthesia, facial pain, headaches, diplopia, dizziness, and ataxia. Several schemes have been devised to describe these lesions, including the Jefferson classification and its modifications, or the Yoshida and Kawase classification (► **Table 1**).^{5–7}

Management of trigeminal schwannomas is approached by a multidisciplinary team that includes neurosurgery, otolaryngology, and radiation oncology. The treatment paradigm varies depending on the surgeon and center experience. Unfortunately, the scientific literature is surprisingly devoid of discussions pertaining to the natural history of trigeminal schwannomas. Small, incidentally found tumors rarely cause symptoms, and conservative management with serial imaging is considered.⁸ Should there be any questions pertaining to the accuracy of the diagnosis such as atypical radiographic characteristics, clinical course suggesting a rapidly progressing tumor, or other factors questioning the diagnosis of trigeminal schwannoma, biopsy may be considered for histopathologic analysis. Percutaneous biopsy of Meckel cave can be obtained, or alternatively, a more aggressive microsurgical debulking for complete or partial tumor resection. For surgical approaches, open microsurgical resection is the treatment of choice, with pure endoscopic and endoscopic-assisted techniques attempted in several case series with reasonable results.^{1,4} Radiation therapy is considered for patients with small- to moderate-sized tumors with intact cranial nerve (CN) function, or for patients with neurologic symptoms isolated to trigeminal CN dysfunction as these symptoms are likely to improve after treatment. It is also an option for residual tumors. Ultimately, management

decisions are individualized to each tumor, each patient, and each community as the management of these potentially benign lesions involves neurologic structures, damage of which has a high impact on patient quality of life (QoL).

We report a series of 24 trigeminal schwannomas that were managed between 2001 and 2015 by the senior author. The management paradigm at our institution involved observation of incidentally found and asymptomatic lesions, whereas those that were causing symptoms were considered for treatment. Radiation was selected for patients who preferentially selected that treatment or had additional comorbidities that prevented them from being a good surgical candidate. Our results are presented with focus on tumor control, treatment morbidity, and complications as compared between the three cohorts. In addition to natural history of trigeminal schwannomas, we provide long-term follow-up data complemented by QoL outcomes in the management of trigeminal schwannomas.

Methods

We undertook a retrospective review of the neurosurgical database at the Vancouver General Hospital. Between 2001 and 2015, 24 patients were diagnosed and managed for trigeminal schwannomas jointly at Vancouver General Hospital and the British Columbia Cancer Agency. A careful review of clinical records and radiological analysis was made and patients were categorized according to the management of their lesion: surgical resection and approach, radiotherapy, or observation with serial imaging. For patients in each category, we analyzed the tumor characteristics, clinical presentation, treatment results, complications, and patient-perceived QoL.

Tumor characteristics were analyzed for size (in anteroposterior [AP], lateral, and craniocaudal dimensions), and assigned a classification grade according to the middle and posterior fossae and extracranial space (MPE) Yoshida and Kawase classification (► **Table 1**).^{6,7} Each patient had their clinical presentation recorded at the time of their initial diagnosis and at the end of the treatment course, which includes postradiation outcomes for those patients treated with radiation therapy. Patients are reviewed at weekly multidisciplinary stereotactic conference that includes a neurosurgeon, neuro-oncologist, and a radiation oncologist.

36-Item Short Form Health Survey (SF-36) QoL questionnaires were collected at the time of the initial visit, and subsequent follow-ups. Additional surveys were mailed to patients to collect prospective data for long-term follow-up.⁹

Statistical Analysis

The patient demographics, clinical presentation, tumor imaging characteristics, surgical approaches, and postoperative outcomes were analyzed using descriptive statistics. The gross total resection (GTR) rates (determined from operative reports and confirmed on postoperative magnetic resonance imaging [MRI] imaging) for every studied tumor were compared. A *p*-value of < 0.05 was considered statistically significant. Data were collected using Microsoft Excel 2010 (Microsoft Corporation) and all variables were tested for an

Table 1 Yoshida and Kawase classification of trigeminal schwannomas based on tumor location

Type	Location
P	Posterior fossa, originate from root of trigeminal nerve
M	Middle fossa, originate from Gasserian ganglion or peripheral branch at the lateral wall of the cavernous sinus
E	Extracranial peripheral branch of trigeminal nerve
MP	Dumbbell-shaped tumor located both in the posterior and middle fossae
ME	Dumbbell-shaped tumor located in the middle fossa and extracranial space
MPE	Tumor located in the posterior, middle cranial fossae, and extracranial space

association perioperatively, and between cohorts. Categorical variables were tested using a chi-square test. When variables did not meet the assumptions of minimum expected frequencies required by the chi-square test, Fisher's exact tests were conducted. The Benjamini–Hochberg procedure was implemented to assure a false discovery rate no higher than 5% among the multiple comparison tests performed. Continuous data were tested for a nonnormal distribution using the Shapiro–Wilk test. Student's *t*-test was performed on normally distributed data, and Wilcoxon rank-sum test conducted on statistically significant nonnormally distributed data. One-way analysis of variance (ANOVA) was used to compare dependent variables within each group, assuming homogeneity of variances that was confirmed using Levene's test for homogeneity of variances. Observations were assumed to be independent. Given the assumptions of homogeneity of variances have not been violated, Welch or Brown and Forsythe tests were not used. The statistical analyses were conducted using JMP, Version 9.0.1 for Mac.

Results

Patient Population

We retrospectively reviewed the medical files and imaging studies of patients with trigeminal schwannomas treated at the Vancouver General Hospital and the British Columbia Cancer Agency between January 2001 and December 2015. We identified 24 patients who fulfilled the criteria. The mean patient age was 49.2 years (range, 23–79 years), and there was a clear female predominance in the series (66.7% female). Those patients that underwent surgical resection were younger, and had larger tumors than those patients that had radiation therapy or were followed with imaging (3.43 vs. 2.03 vs. 1.83 cm, $p = 0.0037$). Twelve patients underwent surgical resection given the size of their lesion or symptomatology. One 19-year-old patient with an incidental presentation had the lesion followed with imaging initially, but then underwent resection when growth was demonstrated 4 years after the initial presentation. Three of the patients had a planned subtotal resection due to significant invasion of the cavernous sinus proper on pre-operative imaging, and subtotal resection with adjuvant radiation treatments were done postoperatively. There was one patient that had a recurrence (7.1%) who was followed with serial imaging. Four patients underwent radiation therapy and eight patients were managed conservatively with serial imaging. Of those patients undergoing radiation,

Table 3 Tumor characteristics ($n = 24$)

	Surgical resection ($n = 12$)	Radiotherapy ($n = 4$)	Observation ($n = 8$)
Tumor size			
Small (< 1.9 cm)	1 (7.14)	2 (50.0)	6 (75.0)
Medium (2.0–2.9 cm)	3 (21.4)	0 (0.0)	1 (12.5)
Large (3.0–3.9 cm)	5 (35.7)	2 (50.0)	1 (12.5)
Extra-large (> 4.0 cm)	4 (33.3)	0 (0.0)	0 (0.0)
Tumor type			
Solid tumor	8 (66.7)	4 (100.0)	7 (87.5)
Mixed tumor	4 (33.3)	0 (0.0)	1 (12.5)
Yoshida/Kawase classification			
Type M	2 (16.7)	1 (25.0)	1 (12.5)
Type P	0 (0.0)	1 (25.0)	5 (62.5)
Type E	1 (7.14)	0 (0.0)	0 (0.0)
Type MP	4 (28.6)	2 (50.0)	2 (25.0)
Type ME	3 (21.4)	0 (0.0)	0 (0.0)
Type MPE	2 (14.2)	0 (0.0)	0 (0.0)

Note: Values are presented as the number of patients (%) unless noted otherwise.

three were due to symptoms and one was due to patient preference (►Table 2). They received fractionated stereotactic radiotherapy (FSRT) to a dose of 5,040 cGy in 28 fractions over 5.5 weeks. The median length of clinic follow-up for all patients was 79 months (range, 18–162 months) with no difference between the cohorts. ►Table 2 summarizes the demographics of the patient population.

Characteristics of Trigeminal Schwannomas

MRI was obtained in all cases and characterized. The size of each trigeminal schwannoma was measured in each compartment in coronal, axial, and sagittal views, with the tumor size being defined as the largest size in any single plane. The characteristics of the 24 cases of trigeminal schwannoma are summarized in ►Table 3. There were 9 small tumors (< 2 cm); 4 patients had a medium-sized tumor (2–3 cm). In 12 cases (50%), the maximum tumor dimension was greater than 3 cm; these were classified as large (3–4 cm) or extra-large (> 4 cm)

Table 2 Baseline characteristics of patients presenting with a trigeminal schwannoma ($n = 24$)^a

Baseline characteristics	Surgical resection ($n = 12$)	Radiotherapy ($n = 4$)	Observation ($n = 8$)	<i>p</i> -Value
Women	7 (58.3)	4 (100)	5 (62.5)	
Median age, y (range)	41.5 (23–57)	68.5 (58–79)	45.0 (24–71)	0.0020
Mean tumor size	3.43	2.03	1.83	0.0037
Follow-up (mo)	67.4	84.9	89	0.4674

^aValues are presented as the number of patients (%) unless noted otherwise.

as in other studies.¹⁰ Larger lesions were treated with surgical resection while smaller tumors underwent radiotherapy or were observed. Solid-type tumors were predominant over mixed solid and cystic-type in this series (79.2%).

All the trigeminal schwannomas were classified based on the MPE classification, which divides the tumors based on location (► **Table 1**).⁷ Type M (16.1%) and Type MP (33.3%) represented the most common growth pattern in the series. Thirteen (54.2%) cases exhibited dumbbell-shaped tumors spanning multiple fossae, while 17 (70.8%) contained an “M” compartment indicative of cavernous sinus/Meckel’s cave origin.

Presentation and Symptom Resolution

Facial hypesthesia was the most common complaint in the surgical cohort at presentation (58.3%), along with headaches (33%), diplopia (33%), and facial pain (25%). Following treatment, 3 of 7 patients experienced improvement in facial hypesthesia, 1 of 7 had resolution, and 4 patients developed new facial hypesthesia. Two patients experienced improvement in facial pain, and one patient had resolution of facial pain. Additionally, 5 of 12 (41.7%) patients had atrophy of temporalis muscle on physical examination performed at last follow-up. Diplopia persisted in one patient (8.3%) attributed to partial CN VI palsy. There were no cases of hydrocephalus, changes to visual acuity, any hearing loss, or mortalities postoperatively (► **Tables 4** and **5**). One patient experienced titanium plate prominence that did not require surgical intervention, one patient had dry eyes, and there was one case of frontalis palsy.

Of the patients undergoing surgery for GTR, 10 patients underwent a frontotemporal craniotomy with an orbitozygomatic osteotomy. One patient had an endoscopic resection of the lesion, and one patient had a partial labyrinthectomy with an anterior petrosectomy. Of the 12 patients operated on by the senior author, subtotal resection with goals of tissue diagnosis and decompression of neural structures was the objective in three patients. One patient developed a recurrence 25 months following the initial GTR which has been stable on follow-up imaging. Of the three patients that underwent surgical debulking, two had subsequent stereotactic radiation leading to stable disease, while another patient had gamma knife surgery in a different center.

Patients selected to undergo radiation therapy presented most commonly with facial hypesthesia (75%), headaches (75%), and facial pain (50%). There was no headache resolution following radiation, while 2 of 4 (50%) patients developed post-treatment headaches. Two patients developed facial pain (50%) while two others experienced increased discomfort. One patient (25%) developed ataxia. Two of four patients experienced cerebral edema that required admission and steroid administration, while one patient experienced scalp pain from the frame application (25%) (► **Tables 4** and **5**). There were no mortalities associated with radiation therapy, and tumor control was achieved in all patients. Serial imaging following treatment demonstrated stability in the volume of the tumors.

Table 4 Initial clinical presentation of patients with a trigeminal schwannoma ($n = 24$)^a

Clinical presentation	Surgical resection ($n = 12$)	Radiotherapy ($n = 4$)	Observation ($n = 8$)
Incidental	3 (25.0)	1 (25.0)	5 (62.5)
Facial hypesthesia	7 (58.3)	3 (75.0)	3 (37.5)
Facial pain	3 (25.0)	2 (50.0)	0 (0.0)
Ataxia	1 (8.33)	0 (0.0)	0 (0.0)
Headache	4 (33.3)	3 (75.0)	2 (25.0)
Diplopia	4 (33.3)	0 (0.0)	1 (12.5)
Atrophy of temporalis	0 (0.0)	0 (0.0)	0 (0.0)
Hearing loss	0 (0.0)	1 (25.0)	1 (12.5)
Decreased visual acuity	1 (8.33)	0 (0.0)	0 (0.0)
Hydrocephalus	1 (8.33)	0 (0.0)	0 (0.0)
Exophthalmos	0 (0.0)	0 (0.0)	0 (0.0)

^aValues are presented as the number of patients (%) unless noted otherwise.

Those patients that had their lesions followed with serial imaging, experienced a relative stability of their symptoms over time. Most lesions were found incidentally (62.5%), with facial hypesthesia (37.5%), headaches (25%), and diplopia (12.5%) being common complaints. One patient (one-eighth) developed an improvement in their facial hypesthesia. We did not detect any significant growth in these lesions requiring intervention over a median follow-up of 7.1 years (range,

Table 5 Symptoms of patients with trigeminal schwannoma at last clinic follow-up ($n = 24$)^a

Symptom	Surgical resection ($n = 12$)	Radiotherapy ($n = 4$)	Observation ($n = 8$)
Facial hypesthesia	4 (33.3)	3 (75.0)	2 (25.0)
Facial pain	0 (0.0)	4 (100.0)	1 (12.5)
Ataxia	0 (0.0)	1 (25.0)	0 (0.0)
Headache	1 (8.33)	4 (100.0)	2 (25.0)
Diplopia	1 (8.33)	1 (25.0)	0 (0.0)
Atrophy of temporalis	5 (41.7)	0 (0.0)	0 (0.0)
Hearing loss	0 (0.0)	1 (25.0)	0 (0.0)
Decreased visual acuity	0 (0.0)	0 (0.0)	0 (0.0)
Hydrocephalus	0 (0.0)	0 (0.0)	0 (0.0)
Exophthalmos	0 (0.0)	0 (0.0)	0 (0.0)

^aValues are presented as the number of patients (%) unless noted otherwise.

2.0–13.1 years), although as previously discussed, one 19-year-old patient who initially had his lesion followed by serial imaging required surgery after growth was demonstrated 4 years after presentation, demonstrating a natural history of 11.1% chance of progression (1/9). There were no new symptoms developed during the follow-up period (►Table 5).

Evaluation of Patient Quality of Life

Patient self-reported interpretation of functional health and well-being was recorded using SF-36 scores. On this scale of 0 to 100, the lower the score, the poorer the QoL. These were obtained when available from patients preoperatively, and postoperatively at first (6 weeks) and second (≥ 3 months) visits. The response rate was 84.6% at presentation, 83.3% following treatment with surgery or radiation, and 54.2% delayed response on average 49.7 months following presentation.

There was a nonsignificant trend to better overall QoL in all cohorts at delayed follow-up (►Table 6). Preoperatively, the surgical cohort had an overall poorer interpretation of their well-being when compared with the radiotherapy and observation groups (55.9 vs. 61.1 vs. 64.4, *p* = 0.7220). This improved postoperatively to 65.7 (ΔSF-36 = +9.8) at 6 weeks, and remained durable at long-term follow-up (ΔSF-36 = +12.1) at 47 weeks when compared with presentation. In the observation cohort, the SF-36 scores improved slightly at long-term follow-up (ΔSF-36 = +6.4) at 41 weeks when compared with presentation (►Table 6). Subsequently, the subcategory component scores also demonstrated improvement in the long-term after all modality managements. The pretreatment physical component summary scores (40.6 vs. 46.1 vs. 44.5) improved to (43.8 vs. 49.5 vs. 46.0) for surgery, radiation, and observation, respectively. Similar changes were seen in mental component summary scores as 43.4 versus 42.5 versus 45.8 improved to 48.7 versus 55.5 versus 49.4.

Discussion

Advances in both microsurgery and optimization of skull base techniques have resulted in a remarkable improvement in the outcomes of patients undergoing skull base surgery, and specifically including the resection of trigeminal schwannomas. Over the course of the last half-century, the mortality rate for these lesions has dropped from over 40% to 1 to 2% in modern cohorts.^{2,3,11–13} The primary focus in the management

of trigeminal schwannoma has thus shifted to restoration of affected CN function, preservation of existing neural circuits, and improving the patient QoL. While gross total removal through a surgical resection continues to be the gold standard in treatment, challenges with morbidity, cerebrospinal fluid (CSF) leak, as well as progression of subtotally resected lesions remains a challenge.¹⁴ Management of trigeminal schwannomas remains a consideration for a multidisciplinary team approach, while tailoring the therapy regimen on an individualized basis for both the lesion and the patient.

Our surgical results are consistent with findings in the literature, where following resection, the majority of patients experience no change to their facial hypesthesia (53–72%) with a minority experiencing improvement (16–40%).^{3,15,16} This is at par with our results of improvement in facial hypesthesia in 21.4% patients with 64.3% remaining stable. Temporalis atrophy is primarily a cosmetic issue, and while in some cases is noticeable, is not necessarily bothersome for the patients. We feel that surgical resection with the goal of gross total removal with minimal morbidity should remain as the gold standard.

Radiation Therapy Outcomes

Literature is abundant for patients undergoing stereotactic radiosurgery, which remains a reasonable option for primary treatment and patients that have progression after resection given the risks of reoperation.^{17–22} The use of radiation therapy must be balanced with dose selection for these lesions as their location near the brainstem necessitates a balance of anticipated therapeutic benefit and risk of adverse radiation effect. This decision should factor in patient age, lesion volume, and pathology.²³ Additionally, it offers advantages of a high tumor control rate and a low rate of radiation-associated complications.⁸ Unfortunately, our experience remains quite sparse with just one patient in our series receiving stereotactic radiosurgery (SRS) and three patients with FSRT. The literature experience with use of FSRT for trigeminal schwannomas is quite limited.⁸ It remains as an option for patients with a large lesion who may not be candidates for microsurgical resection or stereotactic radiosurgery. We report three patients who received FSRT with acceptable results, who selected radiation by choice and were recommended for FSRT by our radiosurgery group (►Table 5).

Observation

Eight patients in the observed cohort did not progress over the follow-up period with serial imaging and did not require

Table 6 Quality of life outcomes for patients diagnosed with trigeminal schwannomas (n = 24)

SF-36 score	Surgical resection (n = 12)	Radiotherapy (n = 4)	Observation (n = 8)	p-Value
Presentation	55.9 (9 responses)	61.1 (4 responses)	64.4 (8 responses)	0.7220
Posttreatment	65.7 (11 responses)	36.8 (1 response)	—	0.2629
Delayed (49.7 mo)	68.8 (9 responses)	83.3 (1 response)	70.8 (4 responses)	0.8663

Abbreviation: SF-36, 36-Item Short Form Health Survey.

any intervention. One patient that did initially have the lesion followed with serial imaging underwent surgical resection 4 years after the initial presentation. These lesions were small and did not have a dramatic impact on patient symptomatology (►Table 3). With serial scans at a yearly basis for the first few years, and then spaced out more infrequently, these lesions were managed expectantly. Given this natural history of trigeminal schwannomas, with an 11.1% chance of progression over median of 7.1 years (range, 2.0–13.1 years), we believe observation provides a realistic option for the management paradigm of these benign lesions if followed closely, as the literature currently does not support this management strategy.

Quality of Life

The patient-perceived QoL outcomes were documented using the SF-36 during the preoperative visit, postoperatively at the first follow-up appointment (6 weeks), and in a delayed fashion. To date, while there is an abundance of studies looking into QoL outcomes in management of other skull base lesions such as vestibular schwannomas, whether by radiation, surgical resection, or observation, there are no studies including patient QoL assessments when discussing management of trigeminal schwannomas.^{24–27} Unfortunately, we were not able to collect and tabulate SF-36 scores from all the patients due to patient refusal, lost forms, or patient address change, and as such our delayed follow-up response rate was 54.1% (13/24).

Interestingly, the QoL remained durable following extended follow-up duration. The patients with trigeminal schwannomas are unlikely to experience mortality, have overall low morbidity, and the initial symptoms of pain and hypesthesia, that if improved, would stand to reason that these experiences would positively impact QoL. These values are nearing par with the SF-36 score Canadian normative data of 0.70 to 0.73.²⁸ More succinct data are needed to reliably establish pre- and postoperative QoL, but our data provide important initial insight into how patients with

trigeminal schwannomas fare after open craniotomy and microsurgical resection of their tumors, as well as radiation therapy and observation.

Management of Trigeminal Schwannomas

Microsurgical resection, radiation therapy, and observation are at the cornerstone of management of patients with trigeminal schwannomas. Unfortunately, a “one-size-fits-all” approach is no longer appropriate, with multimodal management and a multidisciplinary approach predominating to lead to better therapeutic outcomes. Radical surgical resection provides the best long-term control rates, with surgical morbidity and neurological deficits rapidly declining as microsurgical techniques and surgical equipment advance (►Table 7). The risks and benefits of each of the surgical and radiation approaches should be balanced, and we also demonstrate that those lesions that are small and incidental can be safely followed with serial imaging with 11.1% (1/9) progressing over this period. While traditionally not advocated or supported, it should be carefully considered especially keeping the QoL data in mind.

Limitations

This is a single-institution retrospective chart review. The strength of our study is limited by being a single-surgeon experience and may not be generalizable, but this is true of most of the literature on this topic. There perhaps exists a selection/referral bias and this is a relatively small cohort. Additionally, we have had a limited set of responses with regards to QoL surveys, and as such the results may not be reflective of the overall patient experience as is the case with one long-term response in patients managed by radiation therapy.

Conclusions

While GTR of trigeminal schwannomas remains the gold standard treatment, good outcomes from radiation therapy

Table 7 Recent studies surgical series with GTR, and postoperative complications in patients with trigeminal schwannomas

Author and year	n	SA	GTR (%)	MO (%)	MB (%)
McCormick, 1988 ²⁹	14	Middle fossa	43	0	78
Pollack, 1989 ³⁰	16	Frontotemporal, retromastoid	75	0	6
Goel et al, 2003	73	Middle fossa, retrosigmoid	70	3	7
Pamir, 2007 ³¹	18	Frontotemporal, retromastoid	94	0	28
Fukaya et al, 2010	57	Middle fossa	81	2	68
Wanibuchi et al, 2012	105	Mixed	82	0	9
Chen et al, 2014	55	Frontotemporal	95	0	5
Jeong, 2014 ³²	49	Frontotemporal	96	0	18
Present study					
• Planned GTR	9	Frontotemporal, middle fossa	100	0	11
• Planned STR	3		0	0	0

Abbreviations: GTR, gross total resection; MB, Morbidity; MO, mortality; SA, surgical approach.

^aValues are presented as the number of patients (%) unless noted otherwise.

as well as the option for observation with serial imaging necessitates a multidisciplinary approach for the management of these lesions with a dedicated “skull base team.” When presenting treatment options to the patient that has a trigeminal schwannoma, it is important to list the risk and benefits of each management option. While historically surgery and radiation therapy were the main treatment options, observation should be considered as a safe and reasonable option for small, asymptomatic, and incidental lesions with a characteristic appearance of a trigeminal schwannoma given they are unlikely to progress. The results of long-term QoL assessments further support that with resection, patients ultimately observe an improvement after treatment of their tumors.

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