

RARE NEUROSURGICAL DISEASE: TRIGEMINAL SCHWANNOMA - LITERATURE REVIEW

A. A. Marinescu¹, A. Mohan², G. Popescu³, A. V. Ciurea^{1,4}

¹The University of Medicine and Pharmacy “Carol Davila”, Bucharest, Romania

²Oradea University, Faculty of Medicine and Pharmacy, Oradea, Romania

²Department of Neurosurgery, Bihor County Emergency Hospital, Oradea, Romania

³Department of Neurosurgery, “Bagdasar-Arseni” University Emergency Hospital, Bucharest, Romania

⁴Department of Neurosurgery, Sanador Hospital, Bucharest, Romania

Corresponding author: Aurel Mohan

Phone no.: 0040740514636

E-mail: mohanaurel@yahoo.com

Abstract

Trigeminal schwannomas are very rare primary benign cerebral tumours. They represent less than 0,5% of all cerebral tumours and between 0.8-8% of all types of cerebral schwannomas. The main clinical features are intense neuralgia, neurasthenia, and numbness, making it difficult to diagnose without using imagistic techniques. For patients with this kind of uncommon slow-growing encapsulated tumours, surgery and/or Gamma Knife Surgery is recommended. Each case must be thoroughly analysed and its therapeutic strategy must be adapted to the patients age, associated pathology, type of tumour (cystic or solid), the status of the brain`s midline, etc. Of course, the entire neuro-imagistic arsenal must be used to obtain as much data as possible. Another important aid in operating these cases is represented by the neuronavigation module and intraoperative neurophysiological cranial nerve monitoring. Considering the rarity of the disease, the authors present a literature overview of 730 cases and analyse them considering all the criteria available (incidence, symptoms, size, localization, surgical approach and complications).

Keywords: *trigeminal schwannoma, trigeminal neuralgia, MRI, neurosurgery, neuronavigation, Gamma Knife Surgery (GKS)*

Introduction

Trigeminal schwannomas (TS) with cranial nerve origins are commonly benign, slow-growing and isolated [1-3]. They represent 0.07-0.36% of all intracranial tumours and 0.8-8% of all the intracranial schwannomas, occupying the second place in incidence. When it is associated with neurofibromatosis type 2 it tends to occupy multiple sites [4].

According to Professor Takanori Fukushima`s personal experience of 11243 cases of skull base tumours over 35 years

(1983-2016), intracranial schwannomas represent 2414 cases (21.4 %). From the total number of intracranial schwannomas, TSs have an incidence of 6.7% (Figure 1).

This type of tumour is occurring usually in patients with ages between 30 and 49 years old, women suffering more frequently from this disease, but incidence of TS is not limited to these parameters [5,6].

According to the World Health Organization (WHO) Classification of Tumours of the Central Nervous System (2016), schwannomas are recognised as tumours of the

cranial and paraspinal nerves and are either cellular or plexiform. Trigeminal schwannoma's morphology code is 9560; grade 0, according to the International Classification of Diseases for Oncology (ICD-O) - grade 0 is benign, 1

represents a borderline behavior, 2 for carcinoma in situ and grade III intraepithelial neoplasia and 3 represents malignant tumours [7].

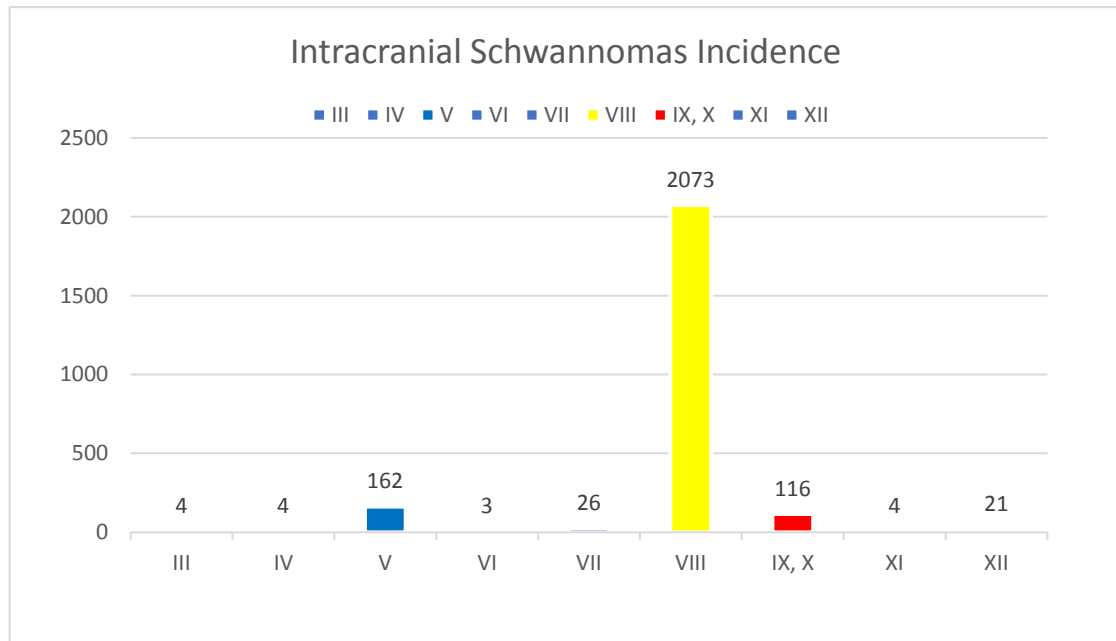


Figure 1 - Incidence of intracranial schwannomas, courtesy of Prof. Dr. Takanouri Fukushima (Red arrow indicates incidence of TS)

There are 3 types of classifications in the literature, each one of them having proposed modified versions by other authors than the original ones.

The first classification was proposed by G. Jefferson (1953). According to him, there are 3 types of TS, depending on their localization (Table 1) [8].

Tumour type	Original Jefferson Classification			Extended version
	A	B	C	
Tumour localization	Middle cranial fossa	Posterior cranial fossa	Both middle and posterior cranial fossa	Extracranial growth – related to a foramen of a trigeminal branch

Table 1 - M. Samii et al. (1995) classification – Extended Jefferson classification [8,9].

M. Samii et al. (1995) proposed an extended Jefferson classification by adding a type D which signifies an extracranial growth [9].

Lesoin et al (1986) [10]. This classification is based on the tumour origin and is meant to allow a better adaptation of the surgical approach based on the particularities of each case (Table 2).

The second classification, in chronological order, is the one proposed by F.

Tumour type	Type I	Type II	Type III
Tumour origin	Roots of the posterior fossa	Gasserian ganglion	Trigeminal branches

Table 2 - F. Lesoin et al. classification [10]

The Yoshida & Kawase (1999) classification defines 6 types of tumours, based on their location. This classification expands the Jefferson classification once more. The result is: 3 types of tumours located in a single region

(M, P, E) and their combinations (MP, ME, PE) (Table 3). For example, the “dumbbell” tumour, which is located in both the middle and posterior cranial fossa, will be classified as type MP [2].

Tumour type	M	P	E	MP	ME	PE
Tumour localization	Middle cranial fossa	Posterior cranial fossa	Extracranial extension: • Orbital fossa • Infratemporal fossa • Pterygopalatine fossa	Middle & posterior cranial fossa	Middle cranial fossa + extracranial extension	Posterior cranial fossa + extracranial exntension

Table 3 - K. Yoshida & T. Kawase (1999) trigeminal schwannoma classification [12]

SK Jeong et al. (2014) propose a modification to the Yoshida & Kawase classification by taking in consideration not only the location, but the size as well. Uppercase and lowercase letters will be used to designate the size of the tumour. For example an Mp tumour will be present in both the middle and posterior cranial fossa, but the part present in the middle fossa will be larger than the other [11].

Symptoms vary from patient to patient and a pure clinical diagnostic is impossible. The golden standard in trigeminal schwannoma is the Magnetic Resonance Imaging (MRI) technique. Still, some of the more common signs and symptoms are: trigeminal nerve dysfunction, abducent nerve paresis, trigeminal sensory and/or motor deficit, facial pain, headache, ipsilateral facial numbness, dizziness, hearing disturbance, diplopia, gait disturbance, hemiparesis, seizure, ptosis. One extremely rare symptom, which is not specific to this tumour, but significant none the less, is the pathological laughter [3,11].

Because this type of tumour is in most of the time benign, total surgical ablation is the preferred treatment choice. For type two neurofibromatose patients, elders, and patients with severe associated pathology it is recommended to first partially ablate the tumour in order to decompress the surrounding neurological structures and then follow-up with radiotherapy (Gamma Knife Surgery - GKS) on the remaining tumour [2].

Materials and methods

A total of 720 TS cases were found reported in literature since 1960. In order to obtain comparable results, we adapted the data obtained from the analyzed studies to the Samii et al. classification, regardless of the one used by the respective study’s authors (Table 4).

Discussions

According to A. Rosén et al. (2016), patients who still suffer from trigeminal nerve sensory disturbances may have a chance at rehabilitation after surgery. Tissue engineering using biodegradable synthetic material and cell-based therapies in conjunction with mesenchymal stem cell therapy represents a promising approach to nerve healing and regeneration [28].

Total ablation of some types of trigeminal schwannomas can be a challenge for the modern neurosurgery when the tumour involves complex structures such as: the brain stem, the Meckel cavum, the cavernous sinus, trigeminal foramina from the skull base

CH Frazier (1918) was the first-ever to report a case of TS and completely remove it [29].

Author	Year of publication	Number of cases					Total	Gross total ablation	Partial ablation
		A	B	C	D				
G. Schisano & H. Olivecrona[13]	1960	11	4	0	0	15	5 (33.3%)	10 (66.6%)	
de Benedittis et al.[14]	1977	5	1	3	0	9	4 (44%)	5 (56%)	
McCormick et al.[15]	1988	6	5	2	1	14	6 (43%)	8 (57%)	
V. Dolenc[16]	1994	NA	NA	NA	NA	40	40 (100%)	0 (0%)	
M. Samii et al.[9]	1995	5	1	5	1	12	10 (83%)	2 (17%)	
Konovalov et al. [17]	1996	42	26	30	13	111	86 (77%)	25 (23%)	
JD Day et al. [18]	1998	18	9	9	3	38	30 (79%)	8 (21%)	
K Yoshida & T Kawase [12]	1999	4	5	10	8	27	20 (74%)	7 (26%)	
O. Al-Mefty et al.[19]	2000	6	0	17	2	25	25 (100%)	0 (0%)	
YS. Chung et al.[20]	2001	0	0	7	0	7	6 (85.8%)	1 (14.2%)	
A. Goel et al.[3]	2003	28	7	30	7	73	51 (69.8%)	22 (30.2%)	
N. Pamir et al.[21]	2007	5	2	9	2	18	17 (94.4%)	1 (5.6%)	
R. Ramina et al.[22]	2008	7	2	6	2	17	16 (94.1%)	1 (5.9%)	
S. Alam et al.[23]	2009	2	1	3	0	6	4 (66.6%)	2 (33.3%)	
R. Fukaya et al.[2]	2010	NA	NA	NA	NA	57	46 (80.7%)	11 (19.3%)	
M. Wanibuchi et al.[24]	2012	39	22	32	14	105	86 (81.9%)	18 (17.1%)	
M. Samii et al.[25]	2014	8	1	8	3	20	15 (75%)	5 (25%)	
SK. Jeong et al.[11]	2014	20	20	9	0	49	45 (95.6%)	4 (4.4%)	
L. Chen et al.[26]	2014	13	10	21	11	55	51 (93%)	4 (7%)	
FH. Chowdhury et al.[6]	2014	NA	NA	NA	NA	30	24 (80%)	6 (20%)	
A. Mahajan et al.[27]	2016	0	0	2	0	2	2 (100%)	0 (0%)	
TOTAL	1995-2016 (12 years)	219 (30%)	116 (15.8%)	203 (27.8%)	65 (9.4%)	730	445 (84.1%)	84 (15.8%)	
		127 (17%) Unspecified							

Table 4 - Trigeminal schwannoma cases reported since 1960

According to PH Wei et al. (2016), diffusion tensor tractography (DTT) is extremely useful in planning the surgical approach. In their study of 3 patients diagnosed with TS using DTT, the tumour-adjacent Vth, VIth, VIIth and VIIIth cranial nerves location was accurately predicted, except for cranial nerve VI in a case. This technique allows the surgeons to better visualize the area of interest and prevent possible intraoperative cranial nerves lesions [30].

Depending on the tumour localization some complications are more common than others. The intracavernous part of the internal carotid artery, which is associated with large cerebral infarctions, can be damaged during surgery if the cavernous sinus is damaged. Postoperative cerebrospinal fluid fistulas represent another common complication, regardless of tumour localisation. It is recommended to suture the dura mater in a watertight fashion in order to avoid such complication.

Another complication such as large skull base post-ablation defects can be avoided or minimized by covering the lesions with fat, fascia, temporal muscles, and then surgical glue applications.

Common postoperative complications include meningitis and lesions of the IIIrd, IVth, VIth, VIIth and VIIIth cranial nerves.

The literature shows that the incidence of recurrence as well as the time necessary for the recurrence to occur is unpredictable [1].

Even though GKS is rarely and cautiously used as a treatment for trigeminal schwannomas, vestibular schwannomas cases seem to respond differently to this treatment. Stereotactic radiosurgery (GKS) seems to be a real alternative to microsurgery and can be applied as primary treatment even for large tumours. The literature presents studies where tumour control was achieved in 90% of vestibular schwannomas cases, or even 98.3% [31-33].

A very peculiar (and apparently unique) case of radiation-induced trigeminal schwannoma has been reported in a 35-year-old man who underwent aggressive radiation therapy after suffering from glioblastoma

multiforme, a primary brain tumour with known rare long-term survival rates [34].

Recently, J. Novak et al. (2017) presents a new kind of therapy for trigeminal schwannomas is currently under research and is showing promising results [35]. A 76-year-old man was diagnosed with a malignant case of schwannoma. Five years since he received one month of high dose of interferon alpha treatment the tumour shrunk. Initially, the tumour measured 25x29x26mm and in the end, the dimensions were 20x18x21mm. The tumour had to be removed due to persistence of patient's trigeminal neuralgia, but as mentioned before, treatment with interferon alpha seems to be promising for patients with schwannomas who cannot be treated through surgery or radiation therapy [35].

Conclusions

Any form of trigeminal neuralgia must be investigated with very much attention using, mainly MRI, with all facilities. The treatment method will be selected depending on the patient's age, localization, size, morphology (cyst/solid) and associated pathology.

The main goal is total removal, but in case that is not possible the goal will be improving the quality of life, even if that means partial removal (first, do no harm – *primum non nocere*).

On the remaining tumour, it is possible to use stereotactic radiosurgery (GKS). This method shall be reserved only for patients with partial ablation or nonresectable tumours, because in the case of trigeminal schwannoma, GKS doesn't represent a cure on its own.

Regardless of the treatment option, the patient must be followed-up using MRI and monitoring.

References

- [1] S. P. MacNally, S. a Rutherford, R. T. Ramsden, D. G. Evans, and a T. King, "Trigeminal schwannomas," *Br. J. Neurosurg.*, vol. 22, no. 6, pp. 729–738, Jan. 2008.

- [2]R. Fukaya, K. Yoshida, T. Ohira, and T. Kawase, "Trigeminal schwannomas: experience with 57 cases and a review of the literature," *Neurosurg. Rev.*, vol. 34, no. 2, pp. 159–171, Apr. 2011.
- [3]A. Goel, D. Muzumdar, C. Raman, K. D. Post, J. D. Day, and A. N. Konovalov, "Trigeminal neuroma: Analysis of surgical experience with 73 cases," *Neurosurgery*, vol. 52, no. 4, pp. 783–790, Apr. 2003.
- [4]I. Jusué-Torres, J. C. Martinez-Gutierrez, B. D. Elder, and A. Olivi, "Giant Trigeminal Schwannoma Presenting with Obstructive Hydrocephalus," *Cureus*, vol. 7, no. 11, p. e386, Nov. 2015.
- [5]A. Agrawal, V. Singh, A. Bhagol, P. Kumar, and A. Narwal, "Extracranial Trigeminal Schwannomas: A Retrospective Analysis," *J. Maxillofac. Oral Surg.*, vol. 16, no. 2, pp. 164–169, Jun. 2017.
- [6]F. Chowdhury, M. Haque, K. Kawsar, M. Sarker, M. Hasan, and A. Goel, "Intracranial nonvestibular neurinomas: Young neurosurgeons' experience," *J. Neurosci. Rural Pract.*, vol. 5, no. 3, p. 231, Jul. 2014.
- [7]D. N. Louis et al., "The 2016 World Health Organization Classification of Tumours of the Central Nervous System: a summary," *Acta Neuropathol.*, vol. 131, no. 6, pp. 803–820, Jun. 2016.
- [8]G. JEFFERSON, "The trigeminal neurinomas with some remarks on malignant invasion of the gasserian ganglion," *Clin. Neurosurg.*, vol. 1, pp. 11–54, 1953.
- [9]M. Samii, M. M. Migliori, M. Tatagiba, and R. Babu, "Surgical treatment of trigeminal schwannomas," *J. Neurosurg.*, vol. 82, no. 5, pp. 711–718, May 1995.
- [10]F. Lesoin et al., "Neurinomas of the trigeminal nerve," *Acta Neurochir. (Wien)*, vol. 82, no. 3–4, pp. 118–22, 1986.
- [11]S. K. Jeong, E. J. Lee, Y. H. Hue, Y. H. Cho, J. H. Kim, and C. J. Kim, "A suggestion of modified classification of trigeminal schwannomas according to location, shape, and extension," *Brain tumour Res. Treat.*, vol. 2, no. 2, pp. 62–8, Oct. 2014.
- [12]K. Yoshida and T. Kawase, "Trigeminal neurinomas extending into multiple fossae: surgical methods and review of the literature," *J. Neurosurg.*, vol. 91, no. 2, pp. 202–211, Aug. 1999.
- [13]G. Schisano and H. Olivecrona, "Neurinomas of the Gasserian Ganglion and Trigeminal Root," *J. Neurosurg.*, vol. 17, no. 2, pp. 306–322, Mar. 1960.
- [14]G. de Benedittis, V. Bernasconi, and G. Ettore, "Tumours of the fifth cranial nerve," *Acta Neurochir. (Wien)*, vol. 38, no. 1–2, pp. 37–64, Mar. 1977.
- [15]K. P. PC McCormick, JA Bello, "Trigeminal schwannoma. Surgical series of 14 cases with review of the literature," *J. Neurosurg.*, vol. 69, pp. 850–860, 1988.
- [16]V. V. Dolenc, "Frontotemporal epidural approach to trigeminal neurinomas," *Acta Neurochir. (Wien)*, vol. 130, no. 1–4, pp. 55–65, Mar. 1994.
- [17]A. N. Konovalov, A. Spallone, D. J. Mukhamedjanov, V. A. Tcherekajev, and U. B. Makhmudov, "Trigeminal neurinomas a series of 111 surgical cases from a single institution," *Acta Neurochir. (Wien)*, vol. 138, no. 9, pp. 1027–1035, Sep. 1996.
- [18]J. D. Day and T. Fukushima, "The surgical management of trigeminal neuromas," *Neurosurgery*, vol. 42, no. 2, pp. 233–40–1, Feb. 1998.
- [19]O. Al-Mefty, S. Ayoubi, and E. Gaber, "Trigeminal schwannomas: removal of dumbbell-shaped tumours through the expanded Meckel cave and outcomes of cranial nerve function," *J. Neurosurg.*, vol. 96, no. 3, pp. 453–463, Mar. 2002.
- [20]Y. S. Chung, H.-S. Gwak, H.-W. Jung, S.-H. Paek, D. G. Kim, and K.-S. Choi, "A Cranio-Orbital-Zygomatic Approach to Dumbbell-Shaped Trigeminal Neurinomas Using the Petrous Window,"
- [21]M. N. Pamir, S. Peker, F. Bayraklı, T. Kılıç, and M. M. Özek, "Surgical treatment of trigeminal schwannomas," *Neurosurg. Rev.*, vol. 30, no. 4, pp. 329–337, Sep. 2007.
- [22]N. Focus, "Surgical management of trigeminal schwannomas," *Focus (Madison)*, vol. 25, no. December, pp. 1–9, Dec. 2008.
- [23]A. S. A. Khair, Hassan R, M. Sf, and Wakil, "The surgical management of trigeminal schwannomas," *The ORION*, vol. 32, no. 2, 2009.
- [24]M. Wanibuchi, T. Fukushima, A. R. Zomordi, Y. Nonaka, and A. H. Friedman, "Trigeminal Schwannomas," *Oper. Neurosurg.*, vol. 70, no. 1 Suppl Operative, p. ons132-ons144, Mar. 2012.
- [25]M. Samii, M. Alimohamadi, and V. Gerganov, "Endoscope-Assisted Retrosigmoid Intradural Suprameatal Approach for Surgical Treatment of Trigeminal Schwannomas," *Neurosurgery*, vol. 10, pp. 565–575, Dec. 2014.
- [26]L. Chen et al., "Operative management of trigeminal neuromas: an analysis of a surgical experience with 55 cases," *Acta Neurochir. (Wien)*, vol. 156, no. 6, pp. 1105–1114, Jun. 2014.
- [27]A. Mahajan, N. P. Sable, R. Vaish, A. Moiyadi, and S. Arya, "Multicompartmental Trigeminal Schwannomas: Dumbbell Tumours Revisited," *J. Glob. Oncol.*, vol. 2, no. 6, pp. 0–4, Dec. 2016.
- [28]A. Rosén, A. Tardast, and T.-J. Shi, "How Far Have We Come in the Field of Nerve Regeneration After Trigeminal Nerve Injury?," *Curr. Oral Heal. Reports*, vol. 3, no. 4, pp. 309–313, Dec. 2016.

- [29]F. CH, "An operable tumour involving the gasserian ganglion," *Am J Med Sci*, vol. 156, pp. 483–490, 1918.
- [30]P.-H. Wei et al., "Identification of cranial nerves around trigeminal schwannomas using diffusion tensor tractography: a technical note and report of 3 cases," *Acta Neurochir. (Wien)*, vol. 158, no. 3, pp. 429–435, Mar. 2016.
- [31]M. Bailo et al., "Gamma Knife Radiosurgery as Primary Treatment for Large Vestibular Schwannomas: Clinical Results at Long-Term Follow-Up in a Series of 59 Patients," *World Neurosurg.*, vol. 95, pp. 487–501, Nov. 2016.
- [32]G. Spatola, R. Carron, C. Delsanti, J.-M. Thomassin, P.-H. Roche, and J. Régis, "Long-term results of Gamma-knife stereotactic radiosurgery for vestibular schwannomas in patients with type 2 neurofibromatosis," *Neurochirurgie*, Aug. 2016.
- [33]M. Bailo et al., "Gamma Knife Radiosurgery for Residual and Recurrent Vestibular Schwannomas After Previous Surgery: Clinical Results in a Series of 90 Patients and Review of the Literature," *World Neurosurg.*, vol. 98, pp. 60–72, Feb. 2017.
- [34]M. Al Shalchi, S. Hussain, S. Giridharan, and E. Albanese, "Rare case of radiation-induced trigeminal schwannoma occurring in a long-term glioblastoma multiforme survivor," *BMJ Case Rep.*, vol. 2016, p. bcr2016214438, Mar. 2016.
- [35]J. Novak, W. J. Sherman, and T. Vitaz, "Schwannoma response to interferon alpha," *Interdiscip. Neurosurg.*, vol. 10, pp. 1–3, Dec. 2017.