The Puzzling Olfactory Groove Schwannoma: A Systematic Review

Eberval Gadelha Figueiredo, M.D., Ph.D.,¹ Yougi Soga, M.D.,²
 Robson Luis Oliveira Amorim, M.D.,¹ Arthur Maynart Pereira Oliveira, M.D.,¹
 and Manoel Jacobsen Teixeira, M.D., Ph.D.¹

ABSTRACT

We systematically reviewed the literature concerning the anterior cranial fossa schwannomas to understand their pathogenesis, determine their origin, and standardize the terminology. We performed a MEDLINE, EMBASE, and Science Citation Index Expanded search of the literature; age, gender, clinical presentation, presence or absence of hyposmia, radiological features, and apparent origin were analyzed and tabulated. Cases in a context of neurofibromatosis and nasal schwannomas with intracranial extension were not included. Age varied between 14 and 63 years (mean = 30.9). There were 22 male and 11 female patients. The clinical presentation included seizures ($n = 15$), headache ($n = 16$), visual deficits ($n = 7$), cognitive disturbances ($n = 3$), and rhinorrhea ($n = 1$). Hyposmia was present in 14 cases, absent in 13 cases (39.3%), and unreported in five. Homogeneous and heterogeneous contrast enhancement was observed in 14 and 15 cases, respectively. The region of the olfactory groove was the probable site in 96.5%. Olfactory tract could be identified in 39.3%. The most probable origin is the meningeal branches of trigeminal nerve or anterior ethmoidal nerves. Thus, *olfactory groove schwannoma* would better describe its origin and pathogenesis and should be the term preferentially used to name it.

KEYWORDS: Anterior cranial fossa, olfactory groove, olfactory nerve, schwannomas, subfrontal tumors

Schwannomas are benign, slowly growing nerve sheath tumors.^{1–4} They account for ~8% of all intracranial tumors and can arise from any nerve containing Schwann cells.^{4–7} The most common location is the vestibular portion of the VIIIth cranial nerve and, less commonly, the Vth, IXth, Xth, and VIIth cranial nerves.^{4–9} The occurrence of a schwannoma not related to cranial nerves is exceedingly rare, with the most common location being the anterior cranial fossa. In such instances, they have been described under different designations, such as *subfrontal*, *olfactory*, and *olfactory*

groove schwannomas,^{1–6,8–28} reflecting their enigmatic origin. However, these terminologies have contributed to the confusion concerning pathogenesis and have created a great deal of speculation about it. It is still not clear which type of cell gives rise to these schwannomas and even whether they are derived from the cerebral parenchyma.⁴ This uncertainty is partially due to the incompleteness of the previous literature reviews, which have provided only limited contribution. To address these issues, the authors performed a systematic review of the literature.

¹Division of Neurological Surgery, University of Sao Paulo, School of Medicine, Sao Paulo, Brazil; ²Department of Neurosurgery, Brain Research Institute, Nigata University, Nigata, Japan.

Address for correspondence and reprint requests: Eberval G. Figueiredo, M.D., Ph.D., Rua Oscar Freire, 1399, AP 171, CEP 05409-010, São Paulo-SP, Brazil (e-mail: ebgedelha@yahoo.com).

Skull Base 2011;21:31–36. Copyright © 2011 by Thieme Medical

Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1 (212) 584-4662.

Received: February 17, 2010. Accepted after revision: May 25, 2010. Published online: July 26, 2010.

DOI: <http://dx.doi.org/10.1055/s-0030-1262945>.

ISSN 1531-5010.

METHODS

The authors first performed a MEDLINE, EMBASE, and Science Citation Index Expanded search of the literature of the last 30 years with the use of four key words in all relevant combinations: *schwannoma*, *olfactory*, *olfactory groove*, and *anterior cranial fossa*.

Additionally, the reference lists of all retrieved publications were scrutinized. The references of the publications thus found were checked again for additional studies. This method of cross-checking was continued until no further publications were found.

Inclusion and Exclusion Criteria

Papers reporting anterior fossa schwannomas published in English, Japanese, German, Spanish, and Portuguese were reviewed. Data such as age, gender, clinical presentation, presence or absence of hyposmia, radiological features, and apparent origin were analyzed and tabulated. Site of origin was defined by radiological features coupled with surgical description, when this information was available. Studies reporting autopsy cases in a context of neurofibromatosis were excluded from the review. Papers describing nasal schwannomas with intracranial extension were also not included.

RESULTS

This systematic review is summarized in Table 1. Thirty-three cases of anterior fossa schwannomas were identified.

Age, Gender, and Clinical Presentation

Age varied between 14 and 63 years (mean = 30.9). There were 22 male (66.6%) and 11 female (33.3%) patients. Clinical presentation included seizures, the most common finding ($n = 15$; 45% of the cases); headache ($n = 16$; 48% of the cases); visual deficits ($n = 7$; 21.2% of the cases); cognitive disturbances ($n = 3$; 9% of the cases); and rhinorrhea ($n = 1$; 3% of the cases). Anosmia/hyposmia was present in 14 cases (42.4%), absent in 13 cases (39.3%), and unreported in 5 cases (15.1%). Therefore, anosmia/hyposmia was absent in 54.4% of the cases in which this information could be retrieved.

Radiological Features and Apparent Origin

Tumor was solid in 19 patients (57.5%) and cystic in 10 (30.3%). Radiological appearance was unreported in 5 cases (15.1%). Homogeneous and heterogeneous contrast enhancement was observed in 14 (42.4%) and 15 cases (45.4%), respectively. Enhancement was not reported in five patients (15.1%).

In most of the cases ($n = 31$; 93.9%), the lesion was located in the midline with close relationship with the olfactory groove. In just one case, the lesion was not clearly related with the olfactory groove. In one case, the origin could not be determined, as the author described a recurrence of the primary tumor. Therefore, the region of the olfactory groove was the apparent origin in 96.5% of all cases where the origin was clearly reported.

Olfactory Tract

Olfactory tract was identified but involved in six cases (18.1%), individualized and thinned in six (18.1%), and distant from the tumor in one (3.4%). Olfactory tract was not identified in 10 cases (34%). The involvement of the olfactory tract was unreported in 11 cases (33.3%). Olfactory tract could be identified in 39.3% ($n = 13$) of the cases that reported its status.

DISCUSSION

Intracranial schwannomas unrelated to the cranial nerves are extremely uncommon.^{5-7,16,29} They occur more frequently in the anterior cranial fossa, mainly in the midline. In these instances, they have been described as *subfrontal schwannomas*, *olfactory schwannomas*, or *olfactory groove schwannomas*.^{1-6,8-28} These different terminologies, associated with their rarity and enigmatic origin, further complicate the study of intracranial schwannomas.^{1,2,4} Schwannomas mainly arise from nerve sheaths of peripheral and cranial nerves (except for first and second cranial nerves). However, the pathogenesis of intracranial schwannomas not directly associated with cranial nerves has been puzzling.¹⁻⁷ Additionally, considerable debate exists whether these schwannomas are primarily intra- or extra-axial lesions.^{1,2,4}

There are several hypotheses concerning their probable origin. Developmental theories advocate that these lesions primarily arise from aberrant Schwann cells in the central nervous system.^{1,4} Russel and Rubinstein³⁰ have proposed that mesenchymal pial cells may transform into ectodermal Schwann cells, explaining the occurrence of intraparenchymal schwannomas. Additionally, peripheral-type myelin has been found in pathological conditions such as multiple sclerosis and cerebral infarctions, presumably originating from Schwann cells in the central nervous system.³¹ Other theories suggest an origin from multipotential mesenchymal cells or displacement of neural crest cells forming the focus of Schwann cells within brain parenchyma (schwannosis).³⁰

These developmental theories adequately explain the origin of intraparenchymal schwannomas.^{1,2,4,32} However, the subtype of schwannomas located in the base of the frontal lobe and intimately related to the

Table 1 Thirty-Three Cases of Anterior Fossa Schwannomas were Identified in the Literature

Author	Age/ Gender	Clinical Presentation	Anosmia	Radiological Features	Origin	Olfactory Tract
Figueiredo et al, 2009 ²⁸	49/M	Headache	Yes	Cystic, heterogeneous	Olfactory groove	Thinned
Choi et al, 2009 ²⁶	39/M	Headache	Yes	Cystic, heterogeneous	Olfactory groove	Involved
Adachi et al, 2007 ¹	22/F	Seizures	No	Solid, heterogeneous	Olfactory groove	Thinned
Prak et al, 2006 ²⁷	16/M	Headache, diplopia	No	Solid, heterogeneous	Olfactory groove	Not Involved
Yako et al, 2005 ⁷	14/M	Headache	Yes	Solid, heterogeneous	Olfactory groove	Not seen
Shenoy and Raja 2004 ²¹	55/M	Seizures	No	Cystic, heterogeneous	Olfactory groove	Thinned
Murakami et al, 2004 ¹⁶	30/M	Headache	No	Solid, homogeneous	Olfactory groove	Thinned
Komoriyashi et al, 2004 ⁵	37/F	Seizures	Yes	Solid, homogeneous	Olfactory groove	Not seen
Yuen et al, 2004 ²⁹	33/F	Seizures	NO	Solid, homogeneous	Olfactory groove	Involved
Prasad et al, 2004 ¹⁹	19/M	Seizures	Yes	Solid, heterogeneous	Olfactory groove	Unreported
de Souza et al, 2003 ¹²	27/M	Headache	Yes	Cystic, homogeneous	Olfactory groove	Unreported
Amador et al, 2002 ¹⁰	24/F	Hypoesthesia, visual deficit	Unreported	Cystic, heterogeneous	Olfactory groove	Not seen
Carron et al, 2002 ³	59/F	Headache, rhinorrhea	No	Solid, homogeneous	Olfactory groove	Involved
Yang et al, 2002 ²⁵	55/M	Headache	No	Solid, homogeneous	Olfactory groove	Unreported
Tsai et al, 2001 ²⁴	31/F	Seizures, headache	Unreported	Solid, heterogeneous	Olfactory groove	Unknown
Tan et al, 2001 ²²	21/M	Seizures	No	Solid, homogeneous	Olfactory groove	Unreported
Gelabert et al, 2000 ¹³	19/M	Seizures	No	Solid, homogeneous	Olfactory groove	Unreported
Timothy et al, 1999 ²³	33/F	Seizures	No	Solid, homogeneous	Olfactory groove	Not seen
Praharaj et al, 1999 ²⁴	45/M	Seizures, headache	Unreported	Solid, homogeneous	Olfactory groove	Not seen
Boyd et al, 1997 ¹¹	29/F	Seizures, headache	Yes	Cystic, heterogeneous	Olfactory groove	Involved
Huang et al, 1997 ³²	33/M	Headache, visual deficit	No	Solid, homogeneous	Olfactory groove	Unknown
Sabel and Teepen 1995 ⁴	17/M	Seizures	Unreported	Solid, homogeneous	Olfactory groove	Not seen
Harada et al, 1992 ¹⁴	33/M	Headache	Yes	Solid, heterogeneous	Olfactory groove	Thinned
Husain et al, 1992 ⁹	30/M	Headache	Yes	Unreported	Olfactory groove	Not seen
Bando et al, 1992 ⁸	55/F	Visual deficit	Yes	Mixed, homogeneous	Undefined	Not seen
Nagao et al, 1991 ¹⁷	63/F	Memory impairment	No	Cystic, heterogeneous	Olfactory groove	Unreported
Sato et al, 1985 ²⁰	22/M	Seizures	Yes	Solid, homogeneous	Olfactory groove	Thinned
Mauro et al, 1983 ³⁹	44/M	Visual and memory deficits	Unreported	Cystic, heterogeneous	Olfactory groove	Unreported
Vassilouthis and Richardson 1980 ³⁷	17/M	Visual and cognitive deficit	Yes	Cystic, heterogeneous	Olfactory groove	Unreported
Ulrich et al, 1978 ³⁸	19/M	Seizures, visual deficits	Yes	Unreported	Olfactory groove	Not seen
Harano et al, 1974 ¹⁵	26/F	Seizures	No	Cystic	Skull base	Distant
Viale et al, 1973 ³⁶	22/M	Visual deficits	Yes	Unreported	Olfactory groove	Unreported
Strum et al 1968 ⁴⁰	27/M	Headache	Yes	Unreported	Olfactory groove	Not seen

olfactory groove seems to be extra-axial rather than intra-axial lesions.¹⁻³ Even though some authors have proposed a developmental origin for explaining the occurrence of these lesions,⁴ they present several features that point the pathogenesis in another direction.

Adachi et al¹ performed an extensive review of the literature and postulated that these tumors originate from the fila olfactoria. The embryonic terminal nerve,

the nerve plexus of dural vessels, and the fila olfactoria that acquire Schwann cells ~0.5 mm beyond the olfactory bulb have also been considered as possible origins.^{1,33} Others authors^{2-4,24,26,32} have pointed out that olfactory schwannomas originate from the olfactory bulb and nerve. However, the olfactory bulbs and tracts lack Schwann cells and hence cannot give rise to the tumor. Although a kind of “ensheathing cell” that

expresses phenotypic features of both astrocyte and Schwann cell is present,³⁴ it is still an open question whether or not such a cell may generate a schwannoma.

Schwann cells are normally present within the perivascular nerve plexuses around large arteries in the subarachnoid space and in adrenergic nerve fibers of cerebral arteries.³⁵ In addition, Schwann cells are found in nerves, such as meningeal branches of trigeminal nerves and anterior ethmoidal nerves, innervating the anterior fossa and olfactory groove.³⁶

Most of the descriptions point to a lesion intimately related to the skull base, particularly to the olfactory groove (97%). Neural structures in the olfactory groove and cribriform plate include olfactory nerve and bulb, fila olfactoria, branches of trigeminal nerve, anterior ethmoidal nerves, and nerve plexus of dural vessels. Hence, they represent the probable origin of this subset of schwannomas. The absence of anosmia/hyposmia in almost half of the cases (54.4%) and the individualization of the olfactory tract in 36.3% of cases make improbable an origin from olfactory bulb and nerves and fila olfactoria and favor an extra-olfactory origin. The fact that the olfactory nerve and bulb were not seen at surgery in 55% of the cases may not necessarily corroborate these structures as the site of origin. They could just be involved by the tumor due the proximity. The predominant midline occurrence practically excludes their origin from vascular dural plexus, as they are not equally distributed in the entire extension of the anterior fossa. Considering these findings, meningeal branches of trigeminal nerve and anterior ethmoidal nerves are the most probable origin of these tumors in the olfactory groove.

CONCLUSION

Anterior cranial fossa schwannomas are very rare tumors, with 33 cases described so far. The findings of this systematic review make improbable an origin from the olfactory tract, including the fila olfactoria, as well as a developmental theory. This review has demonstrated that the most probable origin is the meningeal branches of trigeminal nerve or anterior ethmoidal nerves. Thus, *subfrontal* or *olfactory* seems to be inadequate terminology. *Olfactory groove schwannoma* would better describe its origin and pathogenesis and should be the term preferentially used to describe it.

REFERENCES

- Adachi K, Yoshida K, Miwa T, Ikeda E, Kawase T. Olfactory schwannoma. *Acta Neurochir (Wien)* 2007;149:605–610; discussion 610–611
- Ahmad FU, Gupta A, Sharma MC, Shukla G, Mehta VS. The enigmatic origin of subfrontal schwannomas: report of a case without hyposmia. *Acta Neurochir (Wien)* 2006;148:671–672; discussion 672
- Carron JD, Singh RV, Karakla DW, Silverberg M. Solitary schwannoma of the olfactory groove: case report and review of the literature. *Skull Base* 2002;12:163–166
- Sabel LH, Teepen JL. The enigmatic origin of olfactory schwannoma. *Clin Neurol Neurosurg* 1995;97:187–191
- Komoribayashi N, Arai H, Kojo T, Obonai C, Wakabayashi J, Ogawa A. [Subfrontal schwannoma: case report]. *No Shinkei Geka* 2005;33:601–605
- Sano H, Hayashi Y, Hasegawa M, Yamashita J. Subfrontal schwannoma without hyposmia—case report. *Neurol Med Chir (Tokyo)* 2004;44:591–594
- Yako K, Morita A, Ueki K, Kirino T. Subfrontal schwannoma. *Acta Neurochir (Wien)* 2005;147:655–657; discussion 657–658
- Bando K, Obayashi M, Tsuneharu F. [A case of subfrontal schwannoma]. *No Shinkei Geka* 1992;20:1189–1194
- Husain M, Mishra UK, Newton G, Husain N. Isolated olfactory groove neurilemmoma. *Surg Neurol* 1992;37:115–117
- Amador AR, Santonja C, Del Pozo JM, Ortiz L. Olfactory schwannoma. *Eur Radiol* 2002;12:742–744
- Boyd JH, Dalsaso TA Jr, Bee CS, Smith KR Jr, Martin DS. Subfrontal schwannoma with intracranial mucocoele: a case report. *Am J Otolaryngol* 1997;18:72–75
- de Souza HL, Ramos AM, Ramos CC, et al. [Olfactory groove schwannoma: case report]. *Arq Neuropsiquiatr* 2003;61:125–128
- Gelabert M, Fernández J, López E. [Schwannoma of the olfactory groove]. *Neurologia* 2000;15:404–405
- Harada T, Kawauchi M, Watanabe M, Kyoshima K, Kobayashi S. Subfrontal schwannoma—case report. *Neurol Med Chir (Tokyo)* 1992;32:957–960
- Harano H, Hori S, Kamata K, Shinohara T, Toyama K. [A case report of subfrontal schwannoma (author's transl)]. *No Shinkei Geka* 1974;2:643–647
- Murakami M, Tsukahara T, Hatano T, Nakakuki T, Ogino E, Aoyama T. Olfactory groove schwannoma—case report. *Neurol Med Chir (Tokyo)* 2004;44:191–194
- Nagao S, Aoki T, Kondo S, Gi H, Matsunaga M, Fujita Y. [Subfrontal schwannoma: a case report]. *No Shinkei Geka* 1991;19:47–51
- Praharaj SS, Vajramani GV, Santosh V, Shankar SK, Kolluri S. Solitary olfactory groove schwannoma: case report with review of the literature. *Clin Neurol Neurosurg* 1999;101:26–28
- Prasad D, Jalali R, Shet T. Intracranial subfrontal schwannoma treated with surgery and 3D conformal radiotherapy. *Neurol India* 2004;52:248–250
- Sato S, Taya S, Nakamura T, et al. [Subfrontal schwannoma: report of a case]. *No Shinkei Geka* 1985;13:883–887
- Shenoy SN, Raja A. Cystic olfactory groove schwannoma. *Neurol India* 2004;52:261–262
- Tan TC, Ho LC, Chiu HM, Leung SC. Subfrontal schwannoma masquerading as meningioma. *Singapore Med J* 2001;42:275–277
- Timothy J, Chakrabarty A, Rice A, Marks P. Olfactory groove schwannoma revisited. *Acta Neurochir (Wien)* 1999;141:671–672
- Tsai YD, Lui CC, Eng HL, Liang CL, Chen HJ. Intracranial subfrontal schwannoma. *Acta Neurochir (Wien)* 2001;143:313–314

25. Yang SH, Song SH, Kim SH, Kim Y. Olfactory grooving schwannoma: a case report. *J Korean Neurosurg Soc* 2002;32: 485–487
26. Choi YS, Sung KS, Song YJ, Kim HD. Olfactory schwannoma—case report. *J Korean Neurosurg Soc* 2009;45: 103–106
27. Prak JH, Kim TY, Park JT, Kim JM. Olfactory grooving schwannoma: case report. *J Korean Neurosurg Soc* 2006;39: 156–158
28. Figueiredo EG, Gomes MQT, Soga Y, Amorim RL, Rosemberg S, Teixeira MJ. A rare case of olfactory groove schwannoma. *Arq Neuropsiquiatr* 2009;67(2B): 534–535
29. Yuen A, Trost N, McKelvie P, Webster J, Murphy M. Subfrontal schwannoma: a case report and literature review. *J Clin Neurosci* 2004;11:663–665
30. Russel DS, Rubinstein LJ. *Pathology of Tumors of the Nervous System*. 3rd ed. London: E. Arnold; 1971:286
31. Feigin I, Ogata J. Schwann cells and peripheral myelin within human central nervous tissues: the mesenchymal character of Schwann cells. *J Neuropathol Exp Neurol* 1971;30:603–612
32. Huang PP, Zagzag D, Benjamin V. Intracranial schwannoma presenting as a subfrontal tumor: case report. *Neurosurgery* 1997;40:194–197
33. Tarlov IM. Structure of the nerve root. *Arch Neurol Psychiatry* 1937;37:555–583
34. Yasuda M, Higuchi O, Takano S, Matsumura A. Olfactory ensheathing cell tumor: a case report. *J Neurooncol* 2006;76: 111–113
35. Nelson E, Rennels M. Innervation of intracranial arteries. *Brain* 1970;93:475–490
36. Viale ES, Pau A, Turtal S. Olfactory groove neurinomas. *J Neurosurg Sci* 1973;17:193–196
37. Vassilouthis J, Richardson AE. Subfrontal schwannoma. Report of a case. *Acta Neurochir (Wien)* 1980;53:259–266
38. Ulrich J, Lévy A, Pfister C. Schwannoma of the olfactory groove. Case report and review of previous cases. *Acta Neurochir (Wien)* 1978;40:315–321
39. Mauro A, Sciolla R, Sicuro L, Ponzio R. Solitary neurinoma of the anterior cranial fossa. *J Neurosurg Sci* 1983;27: 45–49
40. Strum KW, Bohnis G, Kosmoglu V. Uber ein neurinoma der lamina cribosa. *Zentralbl Neurochir* 1968;29:217–222