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Jugular Foramen Meningiomas: Review of the Major Surgical Series

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Abstract

Primary jugular foramen meningiomas are uncommon, with 96 previous cases published between 1992 and 2007. Exact location and extent of tumor were determined on the basis of radiologic and operative findings and used to develop a staging system. The mean age of patients was 39.4 years. The lesion was located on the right in 14 patients and on the left in 11 patients. The series identified 23 males and 58 females. The most common presenting clinical symptoms were hearing loss and tinnitus. Most clinical findings were middle ear mass and neck mass. Most meningiomas were World Health Organization grade I. The most common postoperative complications were lower cranial nerve paresis and facial nerve paresis. Surgical planning should consider that meningiomas usually invade the dura mater, cranial nerves, and surrounding bone. The surgeon should carefully collect detailed data about the tumor, and consult an otolaryngologist preoperatively for lower cranial nerve functions and hearing levels.

Key words: jugular foramen, meningioma, outcome, surgery, staging

Introduction

Jugular foramen tumors are uncommon, and are usually paragangliomas, schwannomas, or meningiomas. Primary jugular foramen meningiomas are extremely rare, accounting for approximately 0.7–4% of all posterior fossa meningiomas, and 9–10% of all intracranial meningiomas.[1,12,14] The number of case reports has been increasing. This review evaluated the cases of 96 patients previously described to assess the clinical characteristics of jugular foramen meningiomas, and to propose a staging system for these meningiomas.

Materials and Methods

I. Demographic data

Previous reports were analyzed for number of patients, age, sex, side of tumor, clinical signs and symptoms, operative procedures, range of surgical resection, tumor type, and postoperative outcome. Patients with any type of neurofibromatosis were excluded.

II. Radiological assessment

The exact location and extent of tumor as determined based on the radiological and operative findings were classified as follows: Type I, primarily within the jugular foramen; type II, primarily extension to the cerebellopontine angle (CPA)/intracranial region; type IIa, extension to the CPA/intracranial region and middle ear; type III, primarily extension to the neck; type IIIa, extension to neck and middle ear; type IV, extension to the CPA/intracranial region and neck (dumbbell shape); and type IVa, extension to the CPA/intracranial region, neck, and middle ear.

III. Surgical approaches

Various surgical approaches, depending on tumor extension and location, have been described as follows: suboccipital, infratemporal fossa, retrosigmoid, transcervical, transmastoid, middle ear exploration, petro-occipital transsigmoid, translabyrinthine, infralabyrinthine, transcondylar, transcochlear, and modified transcochlear approaches.

Results

I. Demographic data

Ninety-six patients were treated for primary jugular foramen meningioma in one or two stages between 1992 and 2007. Patients ranged in age from 7 to 65 years (mean 39.4 years). There were 23 males

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Table 1 Demographic data of the patients

Author (Year)	No. of operated patients	Mean age (yrs)	Sex		Side		Surgical approach	Tumor resection	Tumor histology	Comments
			M	F	Rt	Lt				
Molony et al. (1992)[9]	8	40	NA	NA	NA	NA	ITFA: 7, translabyrinthine/ transjugular: 1	GTR: 8, recurrence: 2	meningoendotheliomatous: 8	vocal cord medialization: 2
Tekkök et al. (1997)[15]	31	32	12	18	NA	NA	mastoidectomy: 5, cervical: 12, suboccipital: 9, ITFA: 9, far lateral: 3, middle ear exploration: 4, parotidectomy: 1	recurrence: 5	meningoendotheliomatous: 14, psammomatous: 4, anaplastic: 2, transitional: 2	NA
Vrionis et al. (1999)[16]	4	48.5	1	3	NA	NA	translabyrinthine: 2, infralabyrinthine: 1, transcochlear: 1, lateral skull base: 4	GTR: 4, recurrence: 3	NA	FN weakness: 2, LCN paresis: 4, vocal cord Teflon injection: 2, tracheostomy: 1, gastrostomy: 1
Roberti et al. (2001)[12]	7	NA	NA	NA	NA	NA	retrosigmoid: 5, transtemporal: 1, translabyrinthine: 1, ITFA: 1	GTR: 7	NA	NA
Arnautović and Al-Mefty (2002)[1]	8	49	1	7	6	2	transcondylar/supra-, trans-, retro-jugular: 8	GTR: 8, recurrence: 1	psammomatous: 1, transitional: 4, meningoendotheliomatous: 2	—
Gilbert et al. (2004)[4]	6	52	1	5	NA	NA	ITFA: 5, translabyrinthine: 2, transcochlear: 3, retrosigmoid: 1, transcondylar: 1	GTR: 5, STR: 1, recurrence: 1	NA	vocal cord medialization: 4, CSF leakages: 2, gastrostomy: 1, VP shunt: 2, aspiration pneumonia: 2, tracheostomy: 1, hydrocephalus: 1
Macdonald et al. (2004)[8]	5	52	2	3	NA	NA	NA	NA	NA	NA
Hamilton et al. (2006)[6]	4	52	1	4	3	1	NA	NA	NA	NA
Ramina et al. (2006)[11]	10	38	1	9	NA	NA	craniocervical: 10	GTR: 5, STR: 5, recurrence: 2	anaplastic: 2, papillary: 3, meningoendotheliomatous: 4, microcystic: 1	death: 2, hydrocephalus performed VP shunt: 2, LCN paresis: 3, CSF leakage: 1, vocal cord medialization: 1
Sanna et al. (2007)[14]	13	41	4	9	5	8	POTS: 8, translabyrinthine: 4, MTCA: 3, transotic: 2, ITFA: 1	GTR: 11, STR: 2	meningoendotheliomatous: 8, transitional: 1, psammomatous: 2, angiomatous: 1, mixed: 1	LCN paresis: 8, vocal cord Teflon injection: 1, FN weakness: 6

CSF: cerebrospinal fluid, FN: facial nerve, GTR: gross total resection, ITFA: infratemporal fossa approach, LCN: lower cranial nerve, MTCA: modified transcochlear approach, NA: not accepted, POTS: petro-occipital transsigmoid approach, STR: subtotal resection, VP: ventriculoperitoneal.

Table 2 Classification of the jugular foramen meningiomas

Author (Year)	No. of patients	Tumor type						
		I	II	IIa	III	IIIa	IV	IVa
Tekkök et al. (1997)[15]	24	—	1	—	5	5	11	2
Macdonald et al. (2004)[8]	5	—	—	—	—	—	—	5
Hamilton et al. (2006)[6]	4	—	—	—	—	—	—	4
Ramina et al. (2006)[11]	10	—	1	—	—	—	6	3
Sanna et al. (2007)[14]	13	2	3	2	2	1	2	1
Total (%)	56 (100)	2 (3.5)	5 (8.9)	2 (3.5)	7 (12.5)	6 (10.7)	19 (34)	15 (26)

Table 3 Tumor recurrence or regrowth

Author (Year)	Tumor removal	Regrowth	Recurrence	Mean follow up (yrs)
Molony et al. (1992)[9]	GTR: 8	—	1 (2 yrs), 1 (7 yrs)	3.5
Tekkök et al. (1997)[15]	NA	1 (4 yrs), 1 (5 yrs), 1 (2 yrs)	1 (2.5 yrs), 1 (5 yrs)	10.25
Vrionis et al. (1999)[16]	GTR: 4	—	1 (5.1 yrs), 1 (9.2 yrs), 1 (7.5 yrs)	7.3
Arnautović and Al-Mefty (2002)[1]	GTR: 8	—	1 (NA)	NA
Gilbert et al. (2004)[4]	GTR: 5, STR: 1	1 (NA)	—	NA
Ramina et al. (2006)[11]	GTR: 5, STR: 5	1 (0.4 yrs)	1 (1.8 yrs)	1
Total	GTR: 30, STR: 6	5	9	5.5

GTR: gross total resection, NA: not accepted, STR: subtotal resection.

and 58 females (male/female ratio is 0.4). The lesion was located on the right in 14 patients and on the left in 11 patients. All other findings of side, sex, and age were not given in the published series. The demographic data are shown in Table 1.

II. Clinical manifestations

The most common presenting clinical symptoms and signs were as follows: hearing loss in 45 (52.3%) patients, middle ear mass in 20 (23.2%), dysphagia in 20 (23.2%), tinnitus in 15 (17.4%), dizziness in 15 (17.4%), hoarseness in 12 (13.9%), neck mass in 10 (11.6%), ataxia in 10 (11.6%), lower cranial nerve (LCN) paresis in 5 (5.8%), shoulder weakness in 5 (5.8%), headache in 5 (5.8%), glossal atrophy in 4 (4.6%), facial nerve (FN) weakness in 3 (3.5%), otalgia in 2 (2.3%), hydrocephalus in 1 (1.1%), and hemiparesis in 1 (1.1%) patient.

III. Radiological assessment

According to the proposed staging protocol, 19 (34%) patients had type IV tumor, 15 (26%) patients had type IVa, 7 (12.5%) patients had type III, 6 (10.7%) patients had type IIIa, 5 (8.9%) patients had type II, 2 (3.5%) patients had type IIa, and 2 (3.5%) patients had type I (Table 2).

IV. Tumor subtype

The histological subtypes in 61 patients were as follows: meningoendotheliomatous in 37 patients (60.6%), psammomatous in 7 (11.4%), transitional in 7 (11.4%), anaplastic in 4 (6.5%), papillary in 3 (5.0%), microcystic in 1 (1.6%), angiomatous in 1 (1.6%), and mixed type in 1 (1.6%).

V. Surgical techniques

The surgical approaches were as follows: infratemporal fossa in 23 cases, craniocervical in 22, translabyrinthine in 10, suboccipital in 9, transcondylar in 9, petro-occipital transsigmoid in 8, retrosigmoid in 6, mastoidectomy in 5, transcochlear in 4, middle ear exploration in 4, far lateral in 3, modified transcochlear in 3, transotic in 2, infralabyrinthine in 1, transtemporal in 1, transjugular

Table 4 Postoperative complications and treatment procedures

Complication	No. of patients (%)
LCN paresis	15 (30.6)
FN weakness	8 (16.3)
Vocal cord medialization	7 (14.3)
VP shunt	4 (8.2)
Vocal cord Teflon injection	3 (6.1)
CSF leak	3 (6.1)
Hydrocephalus	3 (6.1)
Aspiration pneumonia	2 (4.1)
Death	2 (4.1)
Gastrostomy	2 (4.1)
Tracheostomy	2 (4.1)

CSF: cerebrospinal fluid, FN: facial nerve, LCN: lower cranial nerve, VP: ventriculoperitoneal.

in 1, and transparotid approach in 1 (Table 1).

VI. Tumor removal

Complete tumor removal was achieved in 48 (85.7%) patients. Subtotal tumor removal was accomplished in 8 (14.3%) patients. The tumor reappeared unexpectedly in 14 (16.1%) patients (Table 3). Other patients' findings were unreported.

VII. Postoperative complications

The most common postoperative complications were LCN paresis (30.6%) and FN weakness (transient or temporary) (16.3%), cerebrospinal fluid (CSF) leakage (6.1%), hydrocephalus (6.1%), and aspiration pneumonia (4.1%) (Table 4). Ventriculoperitoneal shunt for CSF leakage and hydrocephalus (8.2%), and vocal cord medialization (14.3%), gastrostomy (4.1%), and tracheostomy (4.1%) for LCN paresis were performed postoperatively. Two patients (4.1%) died: one of massive pulmonary embolism and other of aspiration pneumonia and infection.[10]

Discussion

I. Anatomy

The jugular foramen is a canal coursing anteriorly, inferiorly, and laterally between intracranial and extracranial openings. Classically the jugular foramen is considered to consist of the nervous part (pars nervosa) and the venous part (pars vascularis). The glossopharyngeal nerve (IXth cranial nerve), vagal nerve (Xth cranial nerve), and cranial accessory nerve (XIth cranial nerve) emerge in a path from the medulla oblongata to the jugular foramen, where they leave the posterior fossa. A fibrous or bony septum separates the pars nervosa (anteromedial compartment), which contains meningeal branches of the ascending pharyngeal artery, the inferior petrosal sinus, vena canaliculi cochlea, and glossopharyngeal nerve, from the pars vascularis (posterolateral compartment), which includes the Xth and XIth cranial nerves with the proximal part of the jugular bulb. The Xth and XIth cranial nerves have a common dural sheath, but the glossopharyngeal nerve has a separate dural covering as it passes through the foramen.[11,13] The vagus nerve is formed by multiple fascicles, and the glossopharyngeal and accessory nerves by one and two fascicles, respectively.[11] The vertical portion of the facial nerve straddles the jugular bulb.[2]

Meningiomas arising from temporal bone are rare and are likely to originate from arachnoid cells which located within the internal acoustic canal, around the greater superficial petrosal nerve, the geniculate ganglion, the jugular bulb, or arachnoid granulations that infrequently herniate through the tegmen into the middle ear.[5] However, these tumors may also originate from multipotential mesenchymal cells of meningocytic, fibroblastic, and Schwann cell lineages; and histologically seem to resemble mesenchymal lines such as fibroblastic, chondroblastic etc., and do not differentiate along glial or neural lines.[16]

II. Demographic data

Meningiomas occur with higher incidence in women and growth rate increases during pregnancy, suggesting that female sex hormones may be involved in meningioma growth. This study found tumors appeared mostly in females. This condition might be explained by progesterone/estrogen receptors, but more data is needed. Some studies show a significant correlation between high mitotic index and negative progesterone receptor or positive strogen receptor status, but the efficacy of antiprogesterone agents and the progesterone receptor status of meningiomas remains inadequately explained.[3,7] In this review, almost all meningiomas were World Health Organization grade I meningoendothelial, psammomatous, and transitional types. However, no correlation between high grade meningioma and male sex could be demonstrated by the present data.

III. Clinical manifestations

Jugular foramen meningiomas manifest as various symptoms according to size and location. Initial signs and symptoms are related to LCN deficits, hearing loss, and tinnitus. Most patients showed vestibulocochlear nerve symptoms. Specific symptoms such as dysphagia, hoarseness, dysphonia,

shoulder weakness, and glossal atrophia also occur, but are usually tolerated due to contralateral nerve functions. Some patients presented with headache or visual disturbances because of increased intracranial pressure.[14]

These tumors have slow insidious growth patterns, so the most common clinical symptoms were hearing loss, tinnitus, and LCN paresis such as dysphagia and hoarseness. On the other hand, most clinical findings were middle ear mass and neck mass. Otolaryngologic evaluation of these patients is essential for the differential diagnosis because of the nonspecific signs and symptoms of the disease, and to achieve good postoperative surgical outcome, and should include a complete history and physical examination with special attention to all cranial nerves.

IV. Radiological assessment and differential diagnosis

The diagnosis of jugular foramen tumor is based on a high index of suspicion gained from the patient's history and clinical findings.[15] Patients with suspected jugular foramen mass should be investigated by computed tomography (CT), magnetic resonance (MR) imaging, and MR angiography or selective angiography. Because of the absence of bony or air artifact, MR imaging and MR angiography are helpful for management of the tumor, and also demonstrate tumor extension, soft tissue details, vascular supply of the tumor, relationship to major vessels, patency of the jugular bulb, and other cranial nerve positions or involvements. Meningioma with large intracranial component may compress the surrounding posterior fossa structures such as the cranial nerves, brain stem, and cerebellar peduncles. Extracranial soft tissue extension is usually to the nasopharyngeal carotid space and deep space of the suprahyoid neck. Carotid artery encasement and jugular vein occlusion are common.

Jugular foramen meningiomas typically appear as isointense to hypointense on T_1-weighted MR images and intermediate intensity on T_2-weighted MR images, with no flow voids recorded and strong enhancement with gadolinium. MR imaging also reveals adjacent dural invasion namely as the dural tail sign.[4,6,8] Arteriovenous MR angiography could show jugular vein invasion and/or obstruction as well as collateral venous drainage. Schwannomas tend to compress the jugular bulb, whereas paragangliomas, meningiomas, and metastatic tumors tend to invade the vessel.[1,9,14–16] Paragangliomas, schwannomas, epidermoid tumors, chordomas, choroid plexus papillomas, chondromas, temporal bone carcinomas, salivary gland tumors, aneurysms, metastases, cerebellar hemangioblastomas, and ependymomas may be confused with jugular foramen meningiomas, even on MR images.[1]

Preoperative evaluation of the venous flow of the sigmoid sinuses, jugular bulbs, and jugular veins may prevent postoperative complications such as benign intracranial hypertension and cerebral hemorrhagic infarcts. This procedure also gives some important data for the planning of the surgical approach.[14] Selective angiography can barely detect minimal vascularity in meningiomas, despite the characteristic hypervascularity of paragangliomas, but if the tumor is hypervascular, embolization may be helpful to prevent from operative blood loss.[1,9]

Meningiomas often and schwannomas very rarely show calcification, whereas paragangliomas usually do not. CT shows meningiomas as slightly hyperdense with matrix calcification, and the jugular foramen margins appear with permeative/sclerotic appearance. However, schwannoma appears isodense or slightly hyperdense, and usually causes enlargement of the jugular foramen with smooth well defined bony margins without bone infiltration. Glomus tumors usually erode and destroy the bone, particularly the jugular spine and tubercule.[1,6,11,14]

V. Tumor staging

Jugular foramen meningiomas may compress and invade the LCNs, invade the temporal bone and jugular bulb, or extend into the CPA and middle ear fossa or extracranially into the neck. Jugular foramen meningiomas which extend to the middle ear fossa may cause conductive type hearing loss, which requires otolaryngological treatment.[1,14] The present data has suggested the proposed staging protocol. In this review, most of the tumors were described in type IV and type IVa, although reported data about the radiological assessment was sometimes inadequate, suggesting that these tumors have slow insidious growth characteristics. This staging protocol does not identify the surgical removal range, and the postoperative outcome depends on tumor type, surgical procedures, and postoperative nursing, but may help the surgeon to decide on the surgical route and may suggest the potential complications of the surgical approach.

VI. Surgical procedures

Many approaches to this region have been identified but no general consensus has been reached on the choice of surgical approach. The surgical approaches are decided based on the preoperative radiological findings, local anatomy, tumor characteristics, tumor size and extension, presenting clinical signs and symptoms, especially preoperative

hearing, and FN and LCN function status. Surgical planning should consider that meningiomas usually invade the dura mater, cranial nerves, and surrounding bone.

All authors have accepted that the ideal surgical approach should obtain wide access to the whole tumor with minimal brain manipulation and minimal morbidity related to additional cranial nerve deficits and, if possible, single stage total tumor removal.[10] Achievement of complete tumor extirpation requires careful surgical planning, because repeated operation increases the risk of LCN injuries, infection rate, and CSF leakage rate, and incomplete removal involves inevitable recurrence.[14] Total removal probably requires removal of all cranial nerves surrounded by the tumor, and resection of bone should be continued until grossly normal.

The infratemporal fossa approach type A is preferred, which provides access to the infralabyrinthine portion of the temporal bone, and is well suited for tumors of the jugular foramen. Permanent anterior transposition of the FN is required. Although not all patients have FN involvement observed at surgery, transient FN impairment may manifest in some patients postoperatively.[4] Preoperative FN dysfunction is uncommon in patients with jugular foramen meningioma, but because of the extensive manipulation of the FN in the translocation procedures of the infratemporal fossa approach type A and transcochlear approach, complete immediate postoperative paresis is frequently present, but most patients ultimately achieve better function.[4]

The transcondylar approach has been proposed with three different routes: suprajugular approach for the tumor extending primarily anteriorly, retrojugular approach for the tumor extending behind the patent jugular bulb, and transjugular approach if the jugular bulb is totally occluded by the tumor. The patency and dominance of the involved jugular bulb dictates the surgical approach.[1]

The retrosigmoid approach could provide wide exposure to the CPA and intracranial parts of the LCNs, but does not allow control of the extracranial parts of the LCN (neck) or middle ear fossa. This approach should be combined with otolaryngologic approaches (such as labyrinthine, cochlear, cervical routes) to treat cases with huge intra- and extracranial tumor.[12]

The craniocervical approach can be considered with neck dissection, mastoidectomy, sigmoid sinus ligation, and posterior fossa craniectomy. FN mobilization or resection and reconstruction with great auricular nerve graft is preferred if the nerve is infiltrated by the meningioma.[10,11]

The ideal surgical approach obtains wide access to the whole tumor with minimal brain manipulation and minimal morbidity related to additional cranial nerve deficits, and includes preservation of middle and inner ear components and FN functions. The petro-occipital-transsigmoid approach is preferred for preservation of hearing and FN functions, and no recurrence of the tumor is reported. Sigmoid sinus transection gives optimal visualization of the CPA with opening of the jugular bulb which provides control of the jugular foramen. The modified transcochlear approach is preferred for extensive meningiomas to achieve excellent control of the vertical and horizontal intrapetrous internal carotid artery and the ventral surface of the brainstem. If the preoperative hearing is unserviceable, the surgical approach can be combined with otolaryngological approaches such as the translabyrinthine approach. The infratemporal fossa approach type A has the disadvantages of postoperative conductive hearing loss due to ear canal closure and FN paresis related to anterior rerouting of the nerve, so this approach is good for significant neck extension of large tumors.[14]

Nearly all authors accept that if preoperative hearing is unserviceable, the surgical approach must be combined with otolaryngological approaches such as middle ear exploration, and infralabyrinthine, translabyrinthine, or transcochlear approaches. Subtotal tumor removal is preferred if there is a high risk of neurological deficits like absence of the surgical plane of cleavage between the tumor and brainstem or vital neurovascular structures. Subtotal tumor removal is better in elderly patients who have normal FN and/or LCNs preoperatively, because acute development of postoperative deficits cannot be compensated in patients with no deficits preoperatively, and this condition could be life threatening due to respiratory difficulties, aspiration pneumonia etc.

VII. Surgical outcome

Two factors determine the prognosis for meningioma patients, the tumor extension and amount of resection, and the histological grade. High mitotic index, malignant tumor grade, and histological subtype are significant prognostic factors for progression-free survival. Higher grade meningiomas do not receive gross total removal and still show high recurrence and mortality levels.[3,15]

Surgical morbidity and mortality are usually associated with the damage to the LCNs, FN, or brain stem. Successful surgery consists of preservation of the LCN functions, hearing, and FN status, as well as gross total tumor extirpation. A multidisciplinary

approach may be optimum, and to avoid postoperative complications, adequate surgical exposure and reconstruction of the cranial base are required. The cranial base is usually reconstructed with abdominal fat graft, rotation of local and distant pedicled muscle flaps, and free muscle flaps vascularized with microsurgical vessel anastomosis.[11,14] Most patients will require temporary assistance with swallowing, airway protection, and phonation in the form of vocal cord medialization and Teflon injection.[4] Tracheotomy and/or gastrostomy should be performed as early as possible if persistent aspirations are present.[11]

VIII. Adjuvant therapy

Recently some authors preferred postoperative stereotactic radiotherapy (such as gamma knife, linear accelerator) for residual tumors. Radiosurgery of the jugular foramen meningiomas can be considered in cases of meningiomas with atypical or malignant features, with residual tumor which shows regrowth in unresectable areas (such as the cavernous sinus); with recurrent meningiomas, and in the rare patient with single ipsilateral sigmoid sinus and jugular bulb.[1,4,10,11,14,15] However, radiotherapy is not preferred for benign meningiomas because of the increasing incidence of long-term radiation-induced glioblastoma.[11] The indications for radiosurgery include advanced age, tumor volume <20 ml, high operative risk, and refusal of surgery.[10] On the other hand, planned partial resection and postoperative radiation is not routinely used, and the efficacy of radiotherapy in long-term tumor control is still unknown, and further studies with longer follow up are necessary.[14]

IX. Conclusion

1. This study suggested that female sex hormones may be involved in the growth of meningiomas.
2. In this review, most tumors were described as type IV and type IVa although reported radiological assessments were inadequate, suggesting that these tumors have slow insidious growth pattern.
3. The choice of the surgical approach depends on tumor size, tumor location and extension, and presenting symptoms such as hearing status, and FN and LCN function. Jugular foramen meningiomas usually invade the LCNs, temporal bone and its components (such as the middle ear cavity), jugular bulb and other dural sinuses; and extend to the intra- and/or extracranial compartments. These complex pathologic conditions could be actually visualized and nearly distinguished by radiologic procedures preoperatively, and these findings and the proposed staging system may be helpful to plan the optimal surgical approach to achieve total extirpation of the tumor within a single stage operation without damage to the vital tissues (such as the brain stem, LCNs, and FN).
4. Successful surgery consists of preservation of the LCN functions, and hearing and FN functions with gross total tumor extirpation. Multidisciplinary approaches may be needed. To avoid postoperative complications, adequate surgical exposure and reconstruction of the cranial base are required.
5. Two factors determine the surgical outcome of jugular foramen meningiomas: extension of the tumor and extent of removal, and histological grade of the meningioma.
6. The efficiency of postoperative radiotherapy in long-term tumor control is still unknown, and further studies with longer follow up are necessary.
7. Jugular foramen meningiomas have prominently high morbidity and complications of LCN deficits or CSF leakage are life threatening. Therefore, the surgeon should carefully collect detailed data about the tumor and about the patient, and consult with an otolaryngologist preoperatively about LCN functions and hearing status.

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Commentary

Meningiomas with invasion or arising into the jugular foramen (JF) are unusual in neurosurgical practice, and account for less than 1% of all intracranial meningiomas. The management of meningiomas with this pattern of location should be tailored based essentially on the place of main tumor origin. We divided meningiomas of JF into tumors with the origin in the intradural compartment with secondary invasion of JF (type 1), and those with the origin in the jugular fossa surrounding the cranial nerves (type 2) with or without intradural or extradural extension. The clinical behavior of these tumors is directly related with the origin. Type 1 is generally originated in the posterior fossa, so clinical symptoms of the lower cranial nerves may be absent, however, in the operative field we can find that the main tumor dural attachment is located in the lips of JF with invasion. In this situation, an arachnoidal plane can be found separating the tumor from the nerves. In this situation, the tumor can be removed from the foramen with anatomical and functional preservation of the lower cranial nerves (Fig. 1). However, in some cases,

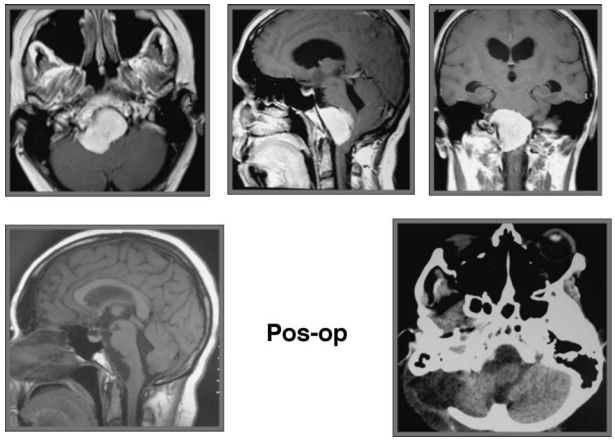

Fig 1

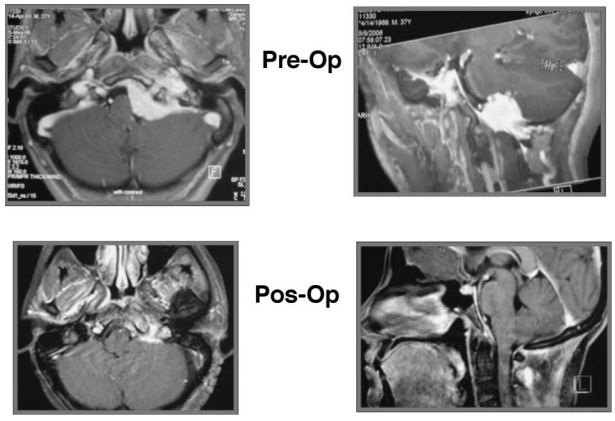

Fig 2

despite the intradural origin of the tumor, a true invasion of the foramen can be found preventing tumor removal without lower cranial nerve deficit, despite the anatomical (but not functional) preservation of nerves. For this second possibility, we prefer to leave some tumor to avoid additional deficit (Fig. 2).

Type 2 tumor originates in the JF, surrounded by the cranial nerves, so can have an intradural or extradural extension. The patient can be asymptomatic or symptomatic with lower cranial nerve deficit. In symptomatic patients, we prefer to perform radical surgical removal (Fig. 3). In asymptomatic patients, we prefer conservative treatment, because in our surgical experience any attempt to remove this tumor is associated with a high index of lower cranial nerve deficits (Fig. 4).

The surgical approach should also be tailored to the location and extension of the tumor. A retrosigmoid to extensive infratemporal with total petrosectomy may be indicated to remove these tumors. Our policy

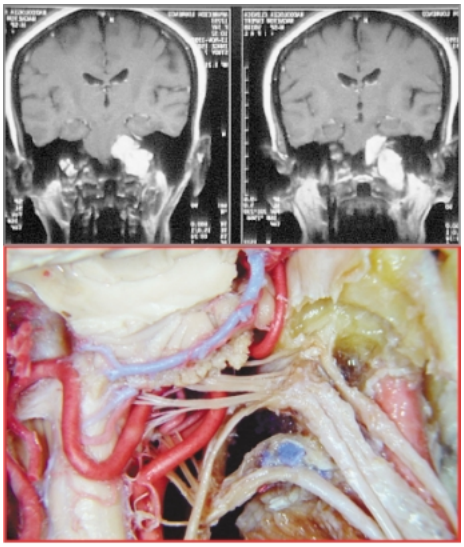

Fig 3

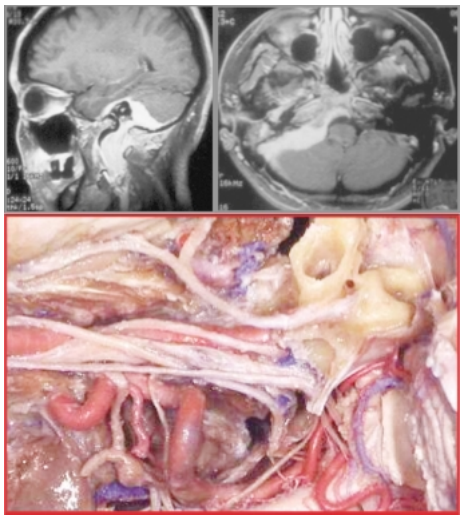

Fig 4

is not to indicate complementary radiation therapy for meningiomas. Despite remnant tumor, we prefer to wait and see the postoperative behavior.

We congratulate the authors for the excellent review of these challenging tumors.

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Meningiomas originating from the region of the jugular foramen are indeed rare. The difficulty in surgical resection emanates from the fact that the lower cranial nerves are in close proximity and damage to these nerves can create an unacceptable neurological deficit. The extension of the tumor along the lower cranial nerves into the extracranial compartment makes radical surgical resection of these tumors extremely difficult or impossible. It would have been worthwhile if the authors had presented representative images showing the nature of the tumor and their extensions, and the strategy of the surgery that will be necessary in each situation. Despite the fact that the authors have identified that majority of cases were grade 1 meningiomas, the nature of involvement of the jugular foramen and the pattern of their extensions suggests that these tumors are aggressive in their behavior. The aggressiveness of the tumor can be gauged by the extent of preoperative cranial nerve deficits. The need for surgery and the extent of tumor resection that is possible needs to be evaluated with a high degree of precision and experience. This is one case where a conservative resection of the tumor that saves the function of the lower cranial nerves may be the best form of treatment. Whenever possible, the surgery can be delayed, and the patient may be clinically observed. Even when the lower cranial nerves are preoperatively affected, surgery can worsen the function. The surgeon must realize his infinite potential to harm the patient in such cases.

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