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Meningiomas Involving the Internal Auditory Canal: A Diagnostic and Surgical Challenge

ABSTRACT—Meningiomas are the second most common lesion encountered within the cerebello-pontine angle (CPA) and rarely project into or originate from the internal auditory meatus (IAM). It is important to distinguish between meningiomas and acoustic neuromas preoperatively as the choice of surgical approach may differ depending on the tumour type. Fortunately, most lesions can be accurately diagnosed with gadolinium-enhanced magnetic resonance imaging (MRI). We report six cases of meningioma involving the IAM, often leading to an incorrect preoperative MRI diagnosis. We highlight the challenges these tumors present to radiologists and surgeons.

Meningiomas account for 6.5% of cerebello-pontine angle (CPA) tumors¹ making them the second most common lesion in this site with only acoustic neuromas being more prevalent.² Accurate preoperative identification of both these types of tumor is important as the optimal surgical approach³ and preservation prognosis of the seventh and eighth cranial nerves⁴⁻⁶ differs between the two patient groups. Fortunately, in almost all cases, acoustic neuromas and CPA meningiomas can be accurately diagnosed by Magnetic Resonance Imaging (MRI).^{3,4} Although the vast majority of meningiomas do

not involve the internal auditory meatus (IAM), a CPA lesion may occasionally protrude into it. These lesions have a broad petrous base, usually making the exact site of origin impossible to identify. Meningiomas restricted to or clearly originating from the IAM are rare indeed.⁷⁻⁹ We report six cases of meningioma with extensive involvement of the IAM, including four where the site of origin was clearly from the porus or the meatus. We also describe one case where a tiny meningioma was found within a larger but still entirely intracanalicular acoustic neuroma, a phenomenon not previously described.

METHODS

A retrospective theater book, personal database, and/or pathology search was performed on all patients admitted to the Neurosurgical Units at Queen's Medical Centre, Nottingham and Frenchay Hospital, Bristol during a 10-year period from 1987 to 1997. Computed Tomography (CT) and/or MRI scan reports of patients with a diagnosis of CPA meningioma were studied and six patients were identified who had tumor with extensive involvement of the IAM. These cases were retrospectively reviewed for their clinical, radiological, and audiological features.

RESULTS

Summaries of the six cases are shown in Table 1. Original and follow-up MRI scanning was always performed with gadolinium enhancement. Hearing-preservation approaches were as described previously with acoustic and facial monitoring.¹⁰ Where necessary, the tumor base was coagulated with monopolar diathermy. All postoperative complications are mentioned in the text and reported audiometry is 500, 1K, 2K, and 4K, four-tone average unless otherwise specified.

Case 1

A 44-year-old lady presented with a 3-year history of left-sided deafness (30-dB four-frequency average) and tinnitus. A CT scan discovered a lesion in the left CPA, 4 cm in maximum diameter. A gadolinium-enhanced MRI scan showed the lesion to have a significant intracanalicular element with dilation of the IAM, but with a broad petrous base (Fig. 1). Although the possibility of this being a meningioma was raised, it was felt that it was more likely to be an acoustic neuroma because of the extensive dilation of the IAM and the intensity of the T2 signal. A left retro-sigmoid craniotomy was performed and a meningioma, clearly originating from the roof and outer lip of the auditory meatus, was completely excised along with as much of the underlying bone as safely possible to preserve hearing. The seventh and eighth nerves were identified and protected throughout the procedure. Postoperatively she retained audible hearing at the 50-dB level on the operative side, her facial nerve function remained intact at House-Brackmann¹¹ Grade 1, and her tinnitus resolved. She remains well with no signs of recurrence on MRI 6 years later.

Case 2

A 61-year-old gentleman presented with right-sided deafness, audiology confirming the presence of a dead ear. An MRI scan (Fig. 2), showed a tumor, presumed to be an acoustic neuroma, completely occupying the IAM. Despite the audiometric findings, because of the preference of the surgeon involved, a suboccipital approach was utilized. Intraoperative frozen sections confirmed the lesion as a meningioma. A complete macroscopic removal was performed with limited bone resection, the only complication being a temporary postoperative facial weakness (Grade 2). At 6-month follow-up, his facial nerve function had fully recovered to Grade 1. One year MRI follow-up revealed no evidence of tumor recurrence.

Case 3

A 23-year-old lady with neurofibromatosis type II and bilateral IAM lesions had undergone a right-sided trans-labyrinthine resection of an acoustic neuroma 2 years previously. Initially, a conservative approach was taken, the left-sided lesion being closely monitored with MRI scans (Fig. 3). When her left-sided hearing loss suddenly worsened to 50-dB (four-tone average), she was admitted for a posterior fossa craniotomy to preserve any residual hearing on that side. Initially, the tumor appeared to be an intracanalicular acoustic neuroma, but while exploring the deep margin of the tumor close to the canal fundus, a patch of granular tissue was encountered. Frozen section biopsy of this area showed the presence of psammoma bodies, formal pathological examination revealing this to be a tiny meningioma within an intracanalicular acoustic neuroma (Fig. 4). Postoperatively, she retained normal facial nerve function at Grade 1, but pure tone audiometry revealed the presence of a dead ear on the left. One-year follow-up MRI scans confirm complete resection of both tumors.

Case 4

A 51-year-old lady presented with an 11-year history of left-sided deafness. Over the previous year she had developed trigeminal neuralgia and a facial palsy on the left. Her audiogram revealed a dead left ear. A CT scan identified a large CPA mass with a broad base against the petrous temporal bone, with a large extension of tumor into the IAM. A provisional diagnosis of meningioma was made. After discussing the options, the patient elected to undergo a subtotal excision of the lesion with postoperative external beam radiotherapy. Six

Table 1. Details of Patients with Meningiomas of the Internal-Auditory Meatus

No.	Age	Sex	Origin	Size Surgery (cm)	Symptoms*			Signs†			Post-op Results				
					Deaf.	Tinn.	Vert.	PTA	VII	Other	PTA	VII	Tumor	F/U (yr)	Comps.
1	44	F	IAM/PA	4 PF	Yes	Yes	No	30 dB	1	Nil	35 dB	1	Clear	6	Nil
2	61	M	IAM/PA	1.5 PF	Yes	No	No	D/E	1	Nil	D/E	1	Clear	1	Nil
3	23	F	IAM	1 PF	Yes	No	No	50 dB	1	Nil	D/E	1	Clear	1	Nil
4	51	F	CPA	4.5 PF	Yes	Yes	No	D/E	3	ACR	D/E	3	1 × 2 cm	6	Nil
5	46	F	CPA	3.5 PF	Yes	No	Yes	5 dB	1	Nil	5 dB	1	Clear	9	CSF leak
6	55	F	IAM	1 TL	Yes	Yes	No	D/E	1	HFS	D/E	1	Clear	1	Nil

Note. IAM = internal auditory meatus; CPA = cerebello-pontine angle; F/U = follow-up in years; PA = porus acusticus; PF = posterior fossa; TL = trans-labyrinthine; and Comps = other complications.
 *Deaf. = deafness; Vert. = vertigo; and Tinn. = tinnitus.

†PTA = pure tone audiogram; VII = facial nerve (House grade); D/E = dead ear; ACR = absent corneal reflex; and HFS = hemi-facial spasm.

Figure 1. Gadolinium-enhanced MRI showing left cerebellopontine angle lesion involving the internal auditory meatus. At surgery the lesion was found to be a meningioma originating from the edge of the meatus.

years postsurgery she remains with a slowly expanding 1- × 2-cm mass of recurrent tumor within the CPA and IAM on MRI scanning. Her facial function has remained at Grade 3 and her hearing is unchanged.

Case 5

A 46-year-old lady presented with a 2-year history of left-sided deafness and vertigo. Despite her symptoms, her audiogram was symmetrical and normal. A contrast-enhanced CT scan identified the presence of a 4.5-cm left CPA mass with a broad petrous base and ex-

Figure 2. Right-sided meningioma predominantly located within the IAM.

Figure 3. Left sided intracanalicular lesion. This patient had neurofibromatosis type II and had undergone previous trans-labyrinthine surgery for excision of a right sided acoustic neuroma. The left-sided lesion turned out to be a tiny meningioma within an intracanalicular acoustic neuroma.

tension deep down into the IAM. A radiological diagnosis of a CPA meningioma was made and a posterior fossa exploration was performed. The tumor was completely excised with a limited amount of bone resection around the porus to remove the intracanalicular part of the tumor. Postoperatively, she required a second procedure to close a CSF leak. Nine years postoperatively she has normal facial nerve function, a normal audiogram (5-dB, four-tone average) and no evidence of recurrence on MRI scanning.

Case 6

A 55-year-old female presented with a 7-year history of sensorineural deafness and tinnitus. Her hearing loss rapidly progressed to a dead ear in the 6 months prior to surgery. This was associated with the onset of periods of hemi-facial spasm lasting between 20 and 30 sec. In between these attacks, her facial function was normal. An MRI scan demonstrated an enhancing mass filling the IAM up to the porus (Fig. 5), preoperatively diagnosed as an intracanalicular acoustic neuroma. In view of her dead ear, a trans-labyrinthine approach was undertaken. The tumor appeared atypical and intraoper-

Figure 4. Histopathologic photographs of the lesions excised from patient 3. (A) Vestibular schwannoma showing classical spindle cells ($\times 350$ magnification). (B) Section of deep tissue illustrating a Psammoma body, typical of a meningioma ($\times 250$ magnification).

ative cytology confirmed its nature as a meningioma. Complete excision with bone removal was achieved. Postoperatively, her hemi-facial spasm resolved and facial nerve function remained at Grade 1. Her recent first

annual postoperative MRI scan reveals no evidence of recurrent tumor.

DISCUSSION

Meningiomas account for 3–13% of CPA tumors, the incidence being exactly 6.5% in two recent large British series.^{1,2} They arise from the cells lining arachnoid villae, which predominantly lie adjacent to intracranial veins and dural sinuses.¹² CPA meningiomas usually grow from the areas adjacent to the sigmoid sinus, jugular foramen, torcula, or the superior and inferior petrosal sinuses,⁴ although arachnoid villae are also found where the IAM nerves pierce the dura at their foramina and hence meningiomas can also theoretically originate from the IAM.^{1,8} The vast majority of CPA meningiomas do not penetrate the IAM, but occasionally they may either partially or totally fill it.^{1,7,8,13,14} However, meningiomas that possess an intracanalicular component usually also have a broad base along the petrous bone making it impossible to determine their exact point of origin.^{8,9} Entirely intracanalicular meningiomas are extremely rare, with only a few cases having ever been convincingly described.^{7–9,15} There have also been reports of “intracanalicular meningiomas,” where tumor has also been found in the inner and/or middle

Figure 5. Intracanalicular meningioma extending up to the porus. This patient had a dead ear preoperatively and the lesion was excised via a trans-labyrinthine approach with complete preservation of facial nerve function.

ear.^{16,17} Although it seems likely that these tumors spread laterally from an intracanalicular primary site, a theoretical origin from ectopic tissue elsewhere in the temporal bone cannot be excluded, especially as arachnoid granulations have been found in the middle ear in randomly examined temporal bones.¹⁸

In the CPA it is valuable to distinguish acoustic neuromas from meningiomas preoperatively as it may alter the operative approach. Preservation of hearing and facial nerve function is better following meningioma resection^{3,19,20} and hearing may occasionally improve or even return to normal postoperatively.^{1,5,21} Destructive approaches for meningioma resection should therefore be used with caution, whereas a significant proportion of patients with acoustic neuromas will have extremely poor or no hearing, making a trans-labyrinthine approach more appropriate.³ In addition, bone needs to be drilled away from the tumor base to prevent meningioma recurrence, whereas this is not essential during the removal of acoustic neuromas.^{4,6} Information obtained from preoperative angiography may also aid the surgeon during meningioma resection²² and large feeding vessels are occasionally found, which may be suitable for embolization.³ Eighth nerve symptoms are reported as being less frequently encountered in patients with meningiomas²³ (in common with other nonacoustic tumors of the CPA^{2,6,19}), although in our series all six patients complained of subjective hearing loss. Where hearing preservation is attempted, others have found that useful postoperative hearing can be retained in up to 50% of patients with CPA meningiomas.¹⁹ Statistics for meningiomas involving the IAM have not generally been available, largely because the surgical approach has been via the translabyrinthine route.¹ Where hearing preservation was attempted in our series, two out of the three retained useful aidable hearing with normal postoperative hearing in one case.

It is claimed that failure to resect 5–10 mm of petrous bone at the site of a meningioma's origin leads to an increased risk of tumor recurrence,⁴ which can occur in approximately 13% of cases following resection of CPA meningiomas.⁶ Where the meningioma has an origin from within the IAM, removal of this amount of bone would result in damage to the otic capsule and a dead ear. As meningiomas involving the IAM are so rare, the rate of recurrence where hearing preservation is attempted is not known but despite fairly limited bone removal in cases 1, 3 and 5, no tumor recurrences have been identified to date. The only recurrence in our series was when a planned subtotal resection was performed (case 4). The vast majority of CPA meningiomas can be correctly diagnosed preoperatively,¹² although experience with intracanalicular lesions is relatively limited. In a study of 30 CPA meningiomas, all were sessile and enhanced with gadolinium. Seventy percent were extrinsic to the IAM, 93% being eccentric in orientation

toward it. Where the canal was involved, only a third exhibited any radiological evidence of dilation. Over half showed an area of enhancement at the edge of the tumor, tapering away along the meninges (a "dural tail") and 70% exhibited hyperostosis of the underlying bone.⁴ In contrast, acoustic neuromas are usually globular, centered on and often dilating the IAC, in which the tumor is usually prominent.³ Although modern imaging techniques are improving constantly, there remain lesions which are difficult to diagnose.²⁴ Acoustic neuromas with a "dural tail" have been described^{25,26} and haemorrhagic acoustic neuromas produce a signal that can be often be confused with that of a meningioma.²⁷ Primary brain tumors may even penetrate the IAM and cause confusion with preoperative diagnosis.²⁸ MRI appearances can be so odd that in a recent British series of unusual CPA lesions, 8 cases out of 30 meningiomas had an incorrect preoperative diagnosis.⁶ For intracanalicular lesions, diagnosis is even more difficult and in the past it has often been impossible to distinguish meningiomas from acoustic neuromas preoperatively,⁸ as in four out of the six cases in our series. It must be remembered that the classical T2 enhancement seen with acoustic neuromas can also occur in meningiomas, something that confused radiological diagnosis in case 1. It should also be noted that other lesions within the IAM are also difficult to distinguish from an acoustic neuroma, most notably facial neuromas that also enhance with gadolinium.²⁹ The use of advanced techniques such as Constructive Interference in the Steady State (CISS) MRI protocols^{30,31} allows three-dimensional (3D) reconstructions of the neurovascular structures of the IAM to be performed. Such methodology can detect whether a small lesion in the IAM is originating from the wall of the canal (meningiomas) or from neuronal structures (facial or acoustic neuromas).³² Such techniques are likely to be invaluable in the future preoperative investigation of complex lesions, such as meningiomas involving the IAM.

We believe this is the first reported case of a meningioma occurring within an intracanalicular acoustic neuroma (case 3). The two pathological lesions occasionally occur together in the CPA, both in patients with neurofibromatosis type II³³ and with unilateral lesions.³⁴ In previously reported cases, however, the meningioma is usually larger and found external to the IAM with a broad petrous base, making the diagnosis relatively straightforward. In case 3, both lesions were entirely intracanalicular and preoperative diagnosis of both tumors was not possible.

Although making an exact diagnosis of a meningioma involving the IAM is not absolutely essential preoperatively, a high index of suspicion should be aroused if the history or radiology of a lesion is atypical in any way⁴ (e.g., case 6). An approach that does not sacrifice eighth nerve function can then be considered. Intraoper-

ative cytology or frozen section is mandatory if there is any doubt about histologic diagnosis so that an appropriate amount of bone can be removed to prevent recurrence.⁴

The uncommon cases where meningiomas originate from or extensively involve the IAM are poorly described in the literature¹ and this is probably due to the fact that they were diagnosed and managed prior to the establishment of detailed databases that now exist in large skull-base centers.⁶ Because of their rarity, it is essential that, in the future, when such lesions are described that:

1. clinical findings;
2. pre- and postoperative audiological findings; and
3. the exact location of the tumor and its origin are clearly documented.

Meningiomas involving the IAM not only present a diagnostic challenge to neuroradiologists, but are also a difficult management problem for the neurotologist. A posterior or middle fossa approach is preferable for their resection because this always allows the possibility for hearing preservation. This is especially important for the resection of nonacoustic tumors because, even when relatively large (e.g., cases 1 and 5), hearing can be conserved because these lesions do not involve the acoustic nerve and its blood supply in the same way as schwannomas. These approaches are not without their problems as in patients with hearing, it is impossible to resect 5–10 mm of bone from the sides and fundus of the IAM without entering the labyrinth and causing a dead ear. The surgeon therefore has to balance the risks of recurrence with the chances and benefits of preserving hearing.¹ These patients need to be carefully counselled prior to surgery as individuals must be aware that, despite our encouraging findings, there may still be an increased risk of tumor recurrence if an attempt is to be made to preserve hearing. In lesions where the tumor has penetrated into the otic capsule, as hearing will be lost as a consequence of removing the tumor from the ear, a trans-labyrinthine approach is most likely to be the approach of choice (allowing extensive bone removal from a tumor originating from the IAM), although a more extensive posterior fossa exposure may be necessary, depending on the degree of spread medial to the IAM. With such lesions, there should be no problem in obtaining adequate bone removal by either route, thus minimizing the risk of recurrence unless the tumor is very large and/or involving other cranial nerves and their foraminae.

CONCLUSIONS

Meningiomas involving or originating from the IAM present a diagnostic challenge to the neuroradiolo-

gist. As the outcome for VII and VIII nerve function is good, posterior fossa approaches are ideal if patients have encouraging preoperative audiology (even with relatively large tumors), although the benefits of hearing preservation may need to be offset against a theoretical increased risk of tumor recurrence.

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