Role of Magnetic Resonance Imaging in Evaluation of Cerebellopontine Angle Schwannomas

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Abstract The aim of the present study was to evaluate the role of Magnetic Resonance Imaging (MRI) to localize and characterize the MR imaging features of cerebellopontine angle schwannomas and to compare with surgical/histopathological findings. It was a prospective study which included 19 patients, who presented with signs and symptoms s/o any lesion in the CP angle and were referred to the radiology department for MRI. All patients included in the study were subjected to detailed clinical history and physical examination following which MRI was carried out on Philips Gyroscan Achieva 1.5 Tesla unit and the standard protocol consisted of T1WI, T2WI, DWI and FLAIR images in axial, sagittal and coronal planes. Hearing abnormality was the most common presenting complaint in patients with CP angle schwannoma's followed by headache and tinnitus. Vestibulocochlear nerve was the most commonly involved nerve in patients with these lesions followed by involvement of trigeminal nerve. MRI was erroneous in giving provisional diagnosis of schwannoma in one case, which on subsequent surgery and histopathology was found to be a meningioma. The sensitivity of MRI for correctly diagnosing vestibular schwannoma was 100 % and specificity was 92.86 % with a positive predictive value of 94.12 % and accuracy of 96.67 %. MRI is considered as an excellent noninvasive investigation for CP angle schwannoma's. It can identify the site and extension of the lesions as well as the characteristic signal. Apart from diagnosing, MR imaging plays an important role in stratifying patients into appropriate treatment options.

Keywords Schwannoma · Vestibulocochlear nerve · Magnetic resonance imaging

Introduction

A schwannoma is a tumor that arises from Schwann cells, named after their discoverer, Theodor Schwann (a 19th Century German histologist and physiologist). Schwann cells are cells that are derived from a primitive structure known as the neural crest. Schwann cells, like the central nervous system's oligodendrocytes, lay down the myelin sheath. Theoretically, schwannomas can arise anywhere that a Schwann cell is found. However, in the brain and spinal cord, schwannomas tend to arise mainly at the root entry zones of the following: [1].

- The VIIIth (vestibulocochlear) cranial nerve—where they are referred to as vestibular Schwannomas (or acoustic “neuromas”);
- The Vth (trigeminal) cranial nerve—where they are referred to as trigeminal Schwannomas;
- The lower cranial nerves (IX, X or XI—i.e., glossopharyngeal, vagus, or accessory) at the jugular foramen—where they are referred to as jugular foramen Schwannomas;
- The spinal cord's spinal nerve roots (especially sensory or “dorsal” nerve roots)—where they are referred to as spinal Schwannomas.

Lesions of the cerebellopontine angle (CPA) are frequent and represent 6–10 % of all intracranial tumors [2]. Acoustic neuromas, which are also called vestibular schwannomas, and meningiomas are the two most frequent lesions and account for approximately 85–90 % of all CPA tumors [3].

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Knowledge about the anatomy, pathology, clinical presentations and merits of different imaging modalities can lead to adequate diagnosis and management of the different CPA lesions [4] CT and MRI are widely used radiological methods for CPA imaging. The main radiological diagnostic goal is the description of the relation of the tumor to IAM, the brain stem and cerebellar hemispheres. The second line basic information is if the lesion is extra- or intracerebral [5].

Since the introduction of Magnetic Resonance (MR), malformations of the brain have been found with greater frequency than previously suspected. This is especially true for any lesions in the cerebellopontine angle, where the sensitivity and specificity of MR imaging with its multidimensional imaging capabilities are far superior to that of CT. The high contrast resolution and multi planar capabilities of MR helps to delineate shape and margins, extent, mass effect, intensity at MR imaging, enhancement and adjacent bone reaction [6].

The MR imaging technique described is simple and non-invasive. Therefore we evaluate the role of MRI in evaluation of cerebellopontine angle schwannomas.

Clinical Evaluation

The most common symptoms associated with vestibular schwannomas are those caused by pressure on the cochlear and vestibular divisions of the eighth cranial nerve, namely, sensorineural hearing loss, tinnitus, and dysequilibrium [7]. Frequently, patients with vestibular schwannomas have difficulty understanding speech in the affected ear. The symptoms are usually slowly progressive, evolving over months or years. Some authors have noted only tinnitus as a presenting symptom. Facial nerve manifestations such as twitching or weakness are relatively uncommon [8]. Instead, larger tumors are more likely to cause trigeminal manifestations such as facial numbness and loss of the corneal reflex. Still larger tumors may cause deficits of the lower cranial nerves, cerebellar signs and symptoms, or signs and symptoms of hydrocephalus [9].

Purpose

The present study is aimed to evaluate the role of magnetic resonance imaging (MRI) to localize and characterize the MR imaging features of cerebellopontine angle schwannomas and to compare with surgical/histopathological findings.

Materials and Methods

We prospectively studied 19 patients of all age groups over a period of 18 months starting from January 2011 who

presented with signs and symptoms s/o any lesion in the CP angle, Informed consent was taken from all patients undergoing this study. Patients excluded from the study were:

1. Those with contraindications to MRI
2. History of previous surgical intervention

All patients included in the study were subjected to detailed clinical history and physical examination.

MR Technique

MR scan in all cases included in the present study was carried out on Philips Gyroscan Achieva 1.5 Tesla unit.

MR Imaging Protocol

The standard protocol consisted of T1WI, T2WI, DWI and FLAIR images in axial, sagittal and coronal planes. Gad-opentate dimeglumine 0.1 mmol/kg was used as contrast wherever required. Each MR image was analyzed for specific features that were relevant to the evaluation of cerebellopontine angle schwannoma.

Results

In the present study, “role of MRI in evaluation of cerebellopontine angle schwannoma”, a total of 19 patients of all age groups presenting with signs and symptoms s/o any lesion in the CP angle, attending outdoor patients department or admitted to Sri Guru Ram Das Charitable Hospital attached to Sri Guru Ram Das Institute of Medical Sciences and Research, Sri Amritsar and referred to the Department of Radiodiagnosis and Imaging were included in the study. After taking relevant history and thorough clinical examination, MRI was done. The observations of this study are as follows:

In the present study, maximum number of patients were in the age group of 21–40 years (Table 1) constituting 68.4 % of patients out of which there were eight male and 11 female patients (Table 2). Hearing loss was the chief complaint in 84.2 % of patients of vestibular schwannoma (Table 3). Vestibulocochlear nerve was involved in 89.4 % of the cases of vestibular schwannoma (Table 4). Table 5 shows the distribution of the type of lesions whether solid, cystic or mixed. 84.21 % of the lesions were solid and rest 17.59 % of the lesions show mixed (solid + cystic) characteristics.

In the present study, all cases of schwannoma were hypointense to brain parenchyma on T1WI (Table 6).

Fifteen cases of vestibular schwannomas (88.2 %) showed hyperintense signal on T2WI. Only two cases

Table 1 Age incidence

Age group in years	No. of patients	Percentage
≤20	1	5.3
21–30	8	42.1
31–40	4	21.1
41–50	2	10.5
51–60	2	10.5
>60	2	10.5
Total	19	100

Table 2 Sex incidence

Sex	Number of patients	Percentage
Male	8	42.1
Female	11	57.9
Total	19	100

Table 3 Presenting complaints in patients with CP angle lesions

Symptoms	No. of patients	Percentage
Vertigo	7	36.8
Tinnitus	8	42.1
Hearing abnormalities	16	84.2
Headache	11	57.9
Vomiting	1	5.3
Facial nerve palsy	1	5.3

Table 4 Cranial nerve examination

Involvement of cranial nerves	No of patients	Percentage
Trigeminal nerve (CN V)	11	57.9
Facial nerve (CN VII)	3	15.8
Vestibulocochlear nerve (CN VIII)	17	89.4

Table 5 Distribution of lesions according to type of lesion

Lesions	Solid (n = 16)	Cystic (n = 0)	Mixed (n = 3)
Vestibular schwannoma	15	0	2
Trigeminal schwannoma	1	0	1
Total	16	0	3
Percentage (%)	84.21	0	15.79

(11.8 %) showed mixed signal intensity on T2WI. One case of trigeminal schwannoma was hyperintense on T2WI and other showed mixed signal intensity on T2WI (Table 7); (Fig. 1).

Table 6 Distribution Of Lesions According To T1wi

Lesions	Hypointense		Isointense		Total
	No	%Age	No	%Age	
Vestibular schwannoma	17	100	0	0	17
Trigeminal schwannoma	2	100	0	0	2

Table 7 Distribution of lesions on T2WI

Lesions	Hyperintense		Isointense		Mixed		Total
	No	%Age	No	%Age	No	%Age	
Vestibular schwannoma	15	88.2	0	0	2	11.8	17
Trigeminal schwannoma	1	50	0	0	1	50	2

All the cases showed hyperintense signal on FLAIR images with no restriction on diffusion-weighted images. (Table 8). None of the lesions showed restricted diffusion (Table 9).

Out of 17 cases of vestibular schwannoma, 11 showed marked enhancement and seven showed moderate enhancement.

Both the cases of trigeminal schwannoma showed marked inhomogenous enhancement (Table 10).

Final diagnosis was made by surgery/histopathology in 19 patients. MRI was erroneous in giving provisional diagnosis of schwannoma in one case, which on subsequent surgery and histopathology was found to be a meningioma. (Tables 11, 12)

Discussion

Clemis JD et al. [10] and Komatsuzaki A et al. [11] reported that schwannomas arise from the vestibulocochlear nerve (cranial nerve VIII) much more often than from any other cranial nerve, and the vestibular division is far more commonly involved than the cochlear division. Hence, for these lesions in the IAC region, vestibular schwannoma has become the preferred and most accurate term.

Valavanis A et al. [12], Brackmann DE, Bartels LJ [13] reported that vestibular schwannomas account for approximately 8 to 10 % of all intracranial tumors and approximately 60–90 % of all CPA tumors. In the present study, the most common lesion was vestibular schwannoma, which constituted 53.3 % of the total number of cases, which is consistent with the above study.

In the present study most of the vestibular schwannoma's were hypointense relative to pons on T1-weighted

Fig. 1 Axial T2W image **a** shows a hyperintense mass lesion (*arrow*) in left CP angle cistern extending into left IAC and axial T1W post contrast image **b** shows marked enhancement of the CP angle lesion

Table 8 Distribution of lesions on flair

Lesions	Hyperintense		Hypointense		Mixed		Total
	No	%Age	No	%Age	No	%Age	
Vestibular schwannoma	16	94.1	0	0	1	5.9	17
Trigeminal schwannoma	1	50	0	0	1	50	2

Table 9 Distribution of lesions on Dwi

Lesions	Restriction				Total
	Absent		Present		
	No	%Age	No	%Age	
Vestibular schwannoma	17	100	0	0	17
Trigeminal schwannoma	2	100	0	0	2

images and hyperintense to pons on T2-weighted images. Press GA, Hesselink JR [14], Tali ET et al. [15], Valvassori GE et al. [16] and Daniels DL et al. [17] reported that on T1-weighted images, schwannomas are usually isointense or mildly hypointense relative to the pons and are hyperintense to cerebrospinal fluid (CSF). On T2-weighted images they are mildly hyperintense to the pons and isointense to hypointense to CSF, which is consistent with the

present study. Intratumoral hemorrhage, at various stages of hemoglobin breakdown, may also be detected on MR imaging. [18].

Curati WL, Graif M et al. [19] reported that Vestibular schwannomas enhance intensely after intravenous administration of a gadolinium contrast agent on T1-weighted images. The sensitivity of contrast-enhanced, T1-weighted, MR imaging can approach 100 % in detecting schwannomas, especially with a small voxel size [20]. In the present study, all of the cases with vestibular schwannoma showed marked to moderate enhancement after administration of gadolinium and most of the cases showed homogenous enhancement which was consistent with the above study.

Breger RK et al. [21] found that as a group, vestibular schwannomas enhance substantially more than meningiomas, neurofibromas, or paragangliomas on contrast-enhanced T1-weighted imaging. However, enhancement varies greatly within tumors of the same type and overlaps

Table 10 Distribution of lesions according to gadolinium enhancement

Lesions	Non-enhancing	Moderate	Marked	Homogenous	Inhomogenous
Vestibular schwannoma	0	6	11	9	8
Trigeminal schwannoma	0	0	2	0	2

Table 11 Distribution of cases on MRI diagnosis

MRI diagnosis	Number of patients	Percentage
Vestibular schwannoma	17	89.5
Trigeminal schwannoma	2	10.5

Table 12 Final diagnosis based on surgical/histopathological findings

Final diagnosis	Number of patients	Percentage
Vestibular schwannoma	16	84.21
Trigeminal schwannoma	2	10.5
Meningioma	1	5.29

between different tumor types. Similar results were seen in the present study.

Vestibular schwannoma epicentered upon internal auditory canal and extended within the canal in ten out of seventeen lesions in the present study. This agrees with Mulkens et al. [22] in his study of acoustic schwannoma: MR findings in 84 tumors who concluded that this feature strongly suggests the diagnosis of acoustic schwannoma. Vestibular schwannomas, however, do not extend anterosuperiorly above the dorsum, and extremely rarely herniate into the middle cranial fossa. None of the vestibular schwannomas in the present study extended into the middle cranial fossa. The findings of the present study were consistent with the literature described.

Out of 17 cases of vestibular schwannoma, one case was diagnosed as meningioma after surgery and subsequent histopathology. Hodgson TJ et al. [23] reported that signal intensity of the masses on MR images will not contribute to

the accurate radiographic diagnosis of the intracanalicular meningioma. Both lesions are isointense to hypointense on T1-weighted MR images and are of variable signal intensity on T2-weighted MR images. They will also both brightly enhance after administration of contrast medium. Although it is very difficult to differentiate a meningioma from a vestibular schwannoma if an entirely intracanalicular type is encountered, other extension patterns may provide some information leading to the correct diagnosis (Fig. 2).

Hence, in the present study, MRI had a sensitivity of 100 % and specificity of 92.86 % with a positive predictive value of 94.12 % and accuracy of 96.67 % in the diagnosis of vestibular schwannoma. Haque S et al. [24] in their study of role of MRI in the evaluation of acoustic schwannoma and its comparison to histopathological findings in 2011 found that the overall sensitivity of MRI to diagnose Acoustic Schwannoma was 96 % with specificity of 88.2 %, positive predictive value of 92.31 % and accuracy of 92.86 % which is consistent with the above study.

Two cases of trigeminal schwannoma were encountered in this study. On clinical examination there was involvement of the cranial nerve V which was also seen in the study done by Bartels LJ and Arrington JR [13] who reported that trigeminal nerve schwannomas tend to involve the ganglion, the nerve root, or both. Therefore symptoms of nerve V tend to dominate over dysfunction of nerve VIII and the patients present with facial pain or numbness.

In the present study, one lesion was solid in nature and the other showed both solid and cystic components. On MR imaging, the lesions appeared hypointense on T1-weighted images and showed hyperintense to mixed signal intensity

Fig. 2 Axial T2W image **a** shows a large, lobulated, well-defined mass in the left CP angle cistern (*arrow*) appearing hyperintense. It is crossing the midline in the prepontine cistern towards the *right side*. There is no extension into either of the internal auditory canals. There is marked compression of the brainstem, cerebellum and left thalamus with severe obstruction of the cerebral aqueduct and posterior third ventricle. Post contrast T1W axial image **b** shows diffuse inhomogeneous enhancement of the lesion

Fig. 3 Axial T2W image (a) and FLAIR image (b) shows a hyperintense well defined rounded lesion in the right CP angle cistern (arrow), adjacent to the right IAC. Post contrast T1W axial image (c) shows marked homogenous enhancement of the lesion

on T2-weighted and FLAIR images with no restriction on DWI. Both the lesions showed marked enhancement on post contrast sequences. Similar findings were described by Valavanis A et al. [12] and Goldberg R et al. [25]; (Fig. 3).

Trigeminal schwannomas in this study harbored the Meckel's cave. Majoie et al. [26] and Rigamonti et al. [27] described dumb-bells configuration of trigeminal schwannomas due to involvement of CPA and Meckel's cave. In one patient in the present study, the trigeminal schwannoma extended through the foramen ovale as was reported by Kapila et al. [28].

Conclusions

A spectrum of usual and unusual lesions exist in the CP angle and is primarily based on the site of origin of the masses. Signal intensity at MR imaging, enhancement, shape and margins, extent, mass effect, and adjacent bone reaction are also helpful in establishing the diagnosis. MRI is considered as an excellent noninvasive investigation of the CPA lesions. It can identify the site and extension of the lesions as well as the characteristic signal. Apart from diagnosing, MR imaging plays an important role in stratifying patients into appropriate treatment options.

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