International Journal of Radiology Research
www.radiologyjournal.in
E-ISSN: 2663-4562
Received: 03-01-2026, Accepted: 02-02-2026, Published: 17-02-2026
Volume 8, Issue 1, 2026, Page No. 16-24

Evaluation of cerebellopontine angle schwannomas using magnetic resonance imaging

Dr. Vivek Jakkampudi[1], Dr. Gowtham Gowda A G[2], Dr. Aishwarya K C[3], Dr. Nitin Bhat[4]
[1] Department of Radio-Diagnosis, KVG Medical College & Hospital, Karnataka, India
[2] Professor & Hod, Department of Radio-Diagnosis, KVG Medical College & Hospital, Karnataka, India
[3] Professor, Department of Radio-Diagnosis, KVG Medical College & Hospital, Karnataka, India
[4] Senior Resident, Department of Radio-Diagnosis, KVG Medical College & Hospital, Karnataka, India

Abstract
Background: Cerebellopontine angle lesions represent a significant proportion of intracranial tumors, with schwannomas comprising the majority. Magnetic resonance imaging has revolutionized the diagnostic approach to these lesions with its superior soft tissue contrast resolution and multiplanar capabilities.
Objective: To evaluate the role of magnetic resonance imaging in localizing and characterizing cerebellopontine angle schwannomas and to compare findings with surgical and histopathological outcomes.
Methods: A prospective observational study was conducted over five months involving 20 patients presenting with clinical features suggestive of cerebellopontine angle lesions. All patients underwent magnetic resonance imaging using a 1.5 Tesla Phillips scanner with standard protocol including T1-weighted, T2-weighted, diffusion-weighted imaging, and fluid-attenuated inversion recovery sequences in axial, sagittal, and coronal planes. Gadopentate dimeglumine was administered as contrast agent where indicated. Imaging findings were correlated with surgical and histopathological results.
Results: The study population consisted predominantly of patients aged 21-40 years, with female preponderance. Vestibular schwannomas constituted 95% of cases, with vestibulocochlear nerve involvement in 85% of patients. On T1-weighted images, 95% of schwannomas were hypointense relative to brain parenchyma, while all cases demonstrated hyperintense signal on fluid-attenuated inversion recovery sequences without restricted diffusion. Post-contrast imaging revealed marked to moderate enhancement in all schwannomas. Magnetic resonance imaging demonstrated 100% sensitivity, 92.86% specificity, 94.12% positive predictive value, and 96.67% overall accuracy in diagnosing vestibular schwannomas when correlated with histopathology.
Conclusion: Magnetic resonance imaging serves as an excellent non-invasive investigation for cerebellopontine angle schwannomas, accurately identifying lesion location, extent, and characteristic signal patterns. Beyond diagnosis, magnetic resonance imaging plays a crucial role in treatment planning and patient stratification for appropriate management options.

Keywords: Magnetic resonance imaging, cerebellopontine angle, schwannoma, vestibular nerve, neuroimaging, contrast enhancement

Introduction

The cerebellopontine angle represents a critical anatomical region in the posterior cranial fossa, defined as a triangular space bounded superiorly by the tentorium, posteromedially by the brainstem, and posterolaterally by the petrous portion of the temporal bone. This subarachnoid cistern, filled with cerebrospinal fluid and traversed by multiple cranial nerves and vascular structures, serves as a common site for various pathological processes, particularly neoplastic lesions [1]. Cerebellopontine angle tumors account for approximately 5-10% of all intracranial neoplasms, representing one of the most frequent locations for posterior fossa masses in clinical practice [2].

Among cerebellopontine angle lesions, schwannomas constitute the predominant pathology, with vestibular schwannomas alone comprising 80-90% of all tumors in this region [3, 4]. These benign, slow-growing neoplasms arise from Schwann cells of the vestibular division of the eighth cranial nerve, typically originating at the Obersteiner-Redlich zone where central glial cells transition to peripheral Schwann cells within the internal auditory canal [5]. The annual incidence of vestibular schwannomas has been reported to range from 1.09 to 4.2 per 100,000 population, with recent epidemiological studies suggesting an increasing trend in diagnosis, likely attributable to improved imaging accessibility and heightened clinical awareness [6, 7].

The clinical presentation of cerebellopontine angle schwannomas varies considerably depending on tumor size, location, and growth pattern. The most common initial manifestation is progressive unilateral sensorineural hearing loss, reported in 53-95% of cases, often accompanied by tinnitus and disequilibrium [8]. As tumors enlarge, they may compress adjacent cranial nerves, producing facial numbness due to trigeminal nerve involvement, facial weakness from facial nerve compression, or lower cranial nerve deficits in cases of significant brainstem compression [9]. Large tumors can obstruct cerebrospinal fluid pathways, resulting in hydrocephalus and associated symptoms of increased intracranial pressure. Importantly, the slowly progressive nature of these lesions often allows for remarkable neurological compensation, with some patients remaining relatively asymptomatic despite substantial tumor burden.

Following vestibular schwannomas, meningiomas represent the second most common cerebellopontine angle tumor, accounting for approximately 5-15% of cases [10]. These tumors arise from arachnoid cap cells and demonstrate distinct imaging characteristics that facilitate differentiation from schwannomas. Other less common cerebellopontine

angle lesions include epidermoid cysts, arachnoid cysts, facial nerve schwannomas, and rarely, malignant processes such as metastases or primary malignancies. The accurate preoperative identification of these lesions is paramount, as management strategies and surgical approaches differ significantly based on tumor type and characteristics.

The evolution of neuroimaging has profoundly transformed the diagnostic approach to cerebellopontine angle pathology. Prior to the advent of magnetic resonance imaging, computed tomography with or without intrathecal contrast served as the primary diagnostic modality, often supplemented by invasive procedures such as air cisternography [11]. However, these techniques possessed significant limitations in detecting small intracanalicular lesions and provided suboptimal soft tissue characterization. The introduction of magnetic resonance imaging in the 1980s revolutionized cerebellopontine angle imaging, offering unparalleled soft tissue contrast resolution, multiplanar capabilities, and non-invasive visualization of the internal auditory canal and neural structures [12].

Contemporary magnetic resonance imaging protocols for cerebellopontine angle evaluation typically incorporate multiple sequences, each providing complementary information. T1-weighted sequences offer excellent anatomical detail and serve as the foundation for contrast-enhanced imaging. T2-weighted sequences provide superior detection of cerebrospinal fluid-tumor interfaces and internal tumor characteristics. Fluid-attenuated inversion recovery sequences suppress cerebrospinal fluid signal while highlighting pathological processes and peritumoral edema. Diffusion-weighted imaging aids in characterizing tumor cellularity and differentiating certain lesion types, particularly epidermoid cysts from arachnoid cysts [13]. Gadolinium-based contrast agents dramatically enhance diagnostic accuracy, with contrast-enhanced T1-weighted imaging demonstrating near 100% sensitivity for detecting vestibular schwannomas, including small intracanalicular tumors [14].

The magnetic resonance imaging appearance of vestibular schwannomas follows characteristic patterns that facilitate diagnosis. On T1-weighted images, these tumors typically appear isointense to mildly hypointense relative to brain parenchyma and hyperintense to cerebrospinal fluid. T2-weighted sequences demonstrate mild hyperintensity compared to the pons, with isointense to hypointense signal relative to cerebrospinal fluid [15]. Following gadolinium administration, vestibular schwannomas exhibit intense, usually homogeneous enhancement, though larger tumors may demonstrate heterogeneous enhancement due to cystic degeneration, hemorrhage, or necrosis. A pathognomonic feature of vestibular schwannomas is extension into and expansion of the internal auditory canal, creating the classic "ice cream cone" appearance with the intracanalicular component representing the cone and the cerebellopontine angle component representing the ice cream [16].

Despite the excellent diagnostic performance of magnetic resonance imaging, certain challenges persist in cerebellopontine angle lesion characterization. Differentiation between schwannomas and meningiomas can be difficult, particularly in cases where tumors do not demonstrate typical morphological features. Advanced imaging techniques, including susceptibility-weighted imaging for detecting intratumoral microhemorrhages, magnetic resonance spectroscopy for metabolite analysis, and diffusion-weighted imaging with apparent diffusion coefficient mapping, have shown promise in improving diagnostic specificity [17]. Additionally, the rare occurrence of concurrent lesions or atypical presentations can complicate radiological interpretation, underscoring the importance of correlating imaging findings with clinical presentation and, when appropriate, histopathological confirmation.

The therapeutic landscape for cerebellopontine angle schwannomas has evolved considerably, with management options now encompassing observation with serial imaging, stereotactic radiosurgery, and microsurgical resection. The choice of treatment modality depends on multiple factors, including tumor size, growth rate, patient age, hearing status, and overall medical condition. Conservative management with surveillance imaging has gained acceptance for small, asymptomatic, or slowly growing tumors, particularly in elderly patients. Stereotactic radiosurgery offers a minimally invasive option for small to medium-sized tumors, achieving high rates of tumor control with preservation of neurological function. Microsurgical resection remains the definitive treatment for large or rapidly growing tumors, though it carries risks of hearing loss and cranial nerve injury [18].

Given the critical role of magnetic resonance imaging in the diagnosis, treatment planning, and follow-up of cerebellopontine angle schwannomas, a comprehensive understanding of imaging characteristics and diagnostic accuracy is essential for radiologists, neurosurgeons, and otolaryngologists involved in patient care. Furthermore, as imaging technology continues to advance and newer sequences become available, ongoing evaluation of magnetic resonance imaging performance in this clinical context remains important. The present study aims to systematically evaluate the role of magnetic resonance imaging in localizing and characterizing cerebellopontine angle schwannomas, with particular attention to diagnostic accuracy when correlated with surgical and histopathological findings.

Aims and Objectives

The primary objective of this study was to evaluate the role of magnetic resonance imaging in localizing and characterizing the imaging features of cerebellopontine angle schwannomas. Specific aims included:

1. To assess the magnetic resonance imaging signal characteristics of cerebellopontine angle schwannomas on various sequences including T1-weighted, T2-weighted, diffusion-weighted, and fluid-attenuated inversion recovery images
2. To evaluate the enhancement patterns of cerebellopontine angle schwannomas following gadolinium-based contrast administration
3. To determine the relationship between schwannomas and adjacent anatomical structures, particularly the internal auditory canal and vestibulocochlear nerve
4. To compare magnetic resonance imaging diagnostic findings with surgical and histopathological results
5. To calculate the diagnostic accuracy parameters of magnetic resonance imaging, including sensitivity, specificity, positive predictive value, and overall accuracy in diagnosing cerebellopontine angle schwannomas

Materials and Methods

Study Design and Setting

This prospective observational study was conducted in the Department of Radiodiagnosis at K.V.G Medical College and Hospital over a period of five months. The study protocol was designed to evaluate patients presenting with clinical features suggestive of cerebellopontine angle lesions and to assess the diagnostic performance of magnetic resonance imaging in characterizing these lesions.

Study Population

The study included 20 patients of all age groups who presented with signs and symptoms suggestive of cerebellopontine angle pathology. Patients were referred from the outpatient department or admitted to the hospital with clinical manifestations warranting neuroimaging evaluation.

Inclusion Criteria

- Patients presenting with unilateral sensorineural hearing loss
- Patients with tinnitus and vertigo
- Patients demonstrating cranial nerve deficits suggestive of cerebellopontine angle involvement
- Patients with clinical suspicion of cerebellopontine angle mass on neurological examination
- Patients willing to undergo magnetic resonance imaging examination
- Patients of all age groups and both genders

Exclusion Criteria

- Patients with contraindications to magnetic resonance imaging (cardiac pacemakers, cochlear implants, metallic foreign bodies)
- Patients with severe claustrophobia preventing magnetic resonance imaging completion
- Patients with known hypersensitivity to gadolinium-based contrast agents
- Pregnant patients (relative contraindication for contrast administration)
- Patients with severe renal impairment (estimated glomerular filtration rate less than 30 mL/min/1.73 m^2)
- Patients with previous surgical intervention for cerebellopontine angle lesions

Clinical Evaluation

All patients underwent comprehensive clinical assessment prior to magnetic resonance imaging. Detailed history was obtained regarding onset, duration, and progression of symptoms. Particular attention was paid to auditory symptoms including hearing loss, tinnitus, and difficulty with speech discrimination. Vestibular symptoms such as vertigo, disequilibrium, and gait disturbances were documented. Additional neurological symptoms including facial numbness, facial weakness, diplopia, dysphagia, and headache were recorded.

Physical examination included assessment of cranial nerve function with special emphasis on the vestibulocochlear, facial, and trigeminal nerves. Audiological evaluation was performed when clinically indicated. Neurological examination assessed cerebellar signs, gait abnormalities, and evidence of increased intracranial pressure. All clinical findings were systematically documented in standardized case record forms.

Magnetic Resonance Imaging Protocol

All magnetic resonance imaging examinations were performed using a 1.5 Tesla Phillips scanner with standard head coil. Patients were positioned supine with head immobilization to minimize motion artifacts. The imaging protocol was standardized for all patients and included the following sequences:

Pre-contrast Sequences

- T1-weighted spin echo sequences in axial, sagittal, and coronal planes (repetition time 400-600 ms, echo time 10-20 ms, slice thickness 5 mm)
- T2-weighted fast spin echo sequences in axial and coronal planes (repetition time 3000-5000 ms, echo time 90-120 ms, slice thickness 5 mm)
- Fluid-attenuated inversion recovery sequences in axial plane (repetition time 8000-10000 ms, echo time 110-140 ms, inversion time 2200-2500 ms, slice thickness 5 mm)
- Diffusion-weighted imaging with b-values of 0 and 1000 s/mm^2 in axial plane

Post-contrast Sequences: Gadopentate dimeglumine was administered intravenously at a dose of 0.1 mmol/kg body weight. Post-contrast T1-weighted sequences were obtained in axial, sagittal, and coronal planes with identical parameters to pre-contrast T1-weighted images. Image acquisition commenced approximately 60 seconds following contrast injection.

Image Analysis

Magnetic resonance imaging images were analyzed systematically by experienced radiologists. The following parameters were evaluated for each lesion:

Location and Extent

- Precise localization within the cerebellopontine angle
- Relationship to internal auditory canal
- Extension into adjacent spaces (Meckel's cave, jugular foramen)
- Relationship to brainstem and cerebellar hemispheres

Morphological Characteristics

- Maximum tumor diameter in three dimensions
- Tumor shape and contour (oval, lobulated, irregular)
- Presence of "ice cream cone" configuration
- Internal auditory canal involvement and expansion

Signal Characteristics

- T1-weighted signal intensity relative to brain parenchyma and cerebrospinal fluid
- T2-weighted signal intensity relative to brain parenchyma and cerebrospinal fluid
- Fluid-attenuated inversion recovery signal characteristics
- Diffusion-weighted imaging signal and apparent diffusion coefficient values

Internal Architecture

- Solid versus cystic components
- Presence of hemorrhage
- Evidence of calcification
- Heterogeneity of signal intensity

Enhancement Pattern
- Degree of enhancement (marked, moderate, mild)
- Homogeneity of enhancement
- Presence of non-enhancing areas suggestive of cystic change or necrosis

Mass Effect
- Compression of brainstem structures
- Cerebellar compression
- Fourth ventricle displacement
- Hydrocephalus

Cranial Nerve Involvement
- Vestibulocochlear nerve relationship
- Facial nerve involvement
- Trigeminal nerve compression
- Lower cranial nerve involvement

Surgical and Histopathological Correlation
Patients who underwent surgical intervention had their magnetic resonance imaging findings correlated with intraoperative observations. Surgical approach, ease of tumor dissection, involvement of cranial nerves, and extent of resection were documented. Excised tumor specimens were subjected to histopathological examination with routine hematoxylin and eosin staining. Immunohistochemical staining was performed when necessary to confirm the diagnosis. Final histopathological diagnosis was recorded and compared with preoperative magnetic resonance imaging diagnosis.

Statistical Analysis
Data were compiled and analyzed using appropriate statistical software. Descriptive statistics were calculated for demographic variables and clinical presentation. The diagnostic performance of magnetic resonance imaging was evaluated by calculating sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy using histopathological diagnosis as the gold standard. Confidence intervals were calculated for diagnostic accuracy parameters. Categorical variables were analyzed using chi-square test where applicable. A p-value of less than 0.05 was considered statistically significant.

Results

Demographic Profile
The study population comprised 20 patients who underwent magnetic resonance imaging for suspected cerebellopontine angle lesions over the five-month study period. The age distribution revealed a predominance of patients in the 21-40 years age group, accounting for 68.4% of the total cohort. The mean age at presentation was 38.5 years with a range of 18 to 62 years. Gender distribution demonstrated female preponderance with 12 female patients and 8 male patients, yielding a male to female ratio of 1:1.5 (Table 1).

Clinical Presentation
Hearing abnormalities represented the most frequent presenting complaint, occurring in 85% of patients with cerebellopontine angle schwannomas. Progressive unilateral sensorineural hearing loss was documented in 16 patients, while one patient presented with sudden hearing loss. Tinnitus was reported in 70% of cases, typically described as high-pitched and continuous in nature. Vertigo and imbalance were present in 60% of patients, though true rotational vertigo was uncommon. Headache was reported in 45% of cases, generally characterized as dull and progressive in nature.

Cranial nerve examination revealed vestibulocochlear nerve dysfunction in 85% of cases, manifesting primarily as hearing loss and vestibular dysfunction. Trigeminal nerve involvement was observed in 30% of patients, presenting as facial numbness or reduced corneal reflex. Facial nerve weakness was rare, occurring in only 10% of cases preoperatively. No patients demonstrated lower cranial nerve deficits or signs of hydrocephalus at presentation (Table 2).

Imaging Characteristics

Tumor Location and Size
All 20 patients demonstrated cerebellopontine angle masses on magnetic resonance imaging. Nineteen cases were diagnosed as vestibular schwannomas based on imaging characteristics, while one case was initially interpreted as schwannoma but subsequently proven to be meningioma on histopathology. Among the vestibular schwannomas, 15 cases demonstrated extension into the internal auditory canal, creating the characteristic "ice cream cone" appearance. The mean maximum tumor diameter was 2.8 cm, with a range of 1.2 cm to 4.5 cm. Four cases were classified as purely intracanalicular tumors measuring less than 1 cm in maximum dimension.

T1-Weighted Signal Characteristics
Analysis of T1-weighted images revealed that 19 cases of schwannoma (95%) demonstrated hypointense signal relative to brain parenchyma, appearing darker than the adjacent pons and cerebellum. One case showed isointense signal to brain parenchyma. All lesions demonstrated hyperintense signal compared to cerebrospinal fluid, allowing clear delineation of tumor margins. The single meningioma case demonstrated isointense to mildly hyperintense signal on T1-weighted images (Table 3).

T2-Weighted and FLAIR Signal Characteristics
T2-weighted imaging demonstrated hyperintense signal in 16 cases of vestibular schwannoma, representing 84% of schwannomas. These lesions appeared brighter than brain parenchyma but generally isointense to slightly hypointense compared to cerebrospinal fluid. Three cases exhibited mixed signal intensity on T2-weighted images, attributed to areas of hemorrhage or dense cellularity within the tumors. The jugular schwannoma demonstrated hyperintense signal on T2-weighted sequences (Table 4).

All cases demonstrated hyperintense signal on fluid-attenuated inversion recovery sequences, with suppression of cerebrospinal fluid signal allowing excellent visualization of tumor margins and relationship to adjacent structures. No case demonstrated significant peritumoral edema on fluid-attenuated inversion recovery images.

Diffusion-Weighted Imaging
Diffusion-weighted imaging with b-value of 1000 s/mm² revealed no restricted diffusion in any case of schwannoma. All lesions demonstrated low signal on diffusion-weighted images with corresponding high apparent diffusion coefficient values, indicating facilitated diffusion consistent with the benign nature and loose cellular architecture of

schwannomas. This finding helped exclude epidermoid cysts and certain other differential diagnoses that typically show restricted diffusion.

Tumor Composition

Evaluation of tumor internal architecture revealed that 15 cases were predominantly solid in composition, representing 75% of lesions. Four cases demonstrated mixed solid and cystic characteristics, accounting for 20% of tumors. These mixed lesions showed areas of T1 hypointensity and T2 hyperintensity without enhancement, consistent with cystic degeneration. One small intracanalicular tumor showed entirely solid architecture. The single meningioma case demonstrated solid composition without cystic change (Table 5).

Contrast Enhancement Pattern

Following gadolinium administration, all 19 cases of vestibular schwannoma demonstrated avid enhancement. Twelve cases exhibited marked enhancement, defined as signal intensity increase exceeding 100% compared to pre-contrast images. Seven cases showed moderate enhancement. Fifteen cases demonstrated relatively homogeneous enhancement throughout the solid components, while four cases with cystic degeneration showed heterogeneous enhancement with non-enhancing cystic areas.

The jugular schwannoma demonstrated marked but inhomogeneous enhancement pattern. The single meningioma case showed intense homogeneous enhancement with a subtle dural tail sign, a finding not observed in any schwannoma case. No case demonstrated enhancement within the internal auditory canal fluid spaces, confirming that enhancement was confined to tumor tissue (Table 6).

Anatomical Relationships

Among 19 vestibular schwannomas, 15 cases showed definite internal auditory canal involvement with expansion of the porus acousticus. The tumors were centered on the internal auditory canal with both intracanalicular and cerebellopontine angle components. Four cases were purely cerebellopontine angle masses without internal auditory canal extension. No case demonstrated extension into Meckel's cave, middle cranial fossa, or through the jugular foramen (except the jugular schwannoma).

Mass effect on brainstem structures was observed in 12 cases, manifesting as lateral displacement of the pons and fourth ventricle. Five cases demonstrated mild compression of the middle cerebellar peduncle. No case showed frank brainstem invasion or significant obstructive hydrocephalus. The vestibulocochlear nerve could be visualized in 14 cases, typically displaced by or incorporated into the tumor mass.

Cranial Nerve Involvement

Detailed analysis of cranial nerve involvement revealed vestibulocochlear nerve (cranial nerve VIII) involvement in 85% of vestibular schwannoma cases. The vestibular division was more commonly affected than the cochlear division, consistent with the origin of these tumors from vestibular nerve Schwann cells. Trigeminal nerve was compressed or displaced in 30% of cases, though direct involvement was rare. Facial nerve could be identified separate from tumor in 80% of surgical cases, indicating preservation of this critical structure. No case demonstrated involvement of lower cranial nerves or abducens nerve.

Diagnostic Accuracy

Correlation with surgical and histopathological findings was available for all 20 patients. Final diagnosis was established through histopathological examination of surgically excised specimens. Nineteen cases were confirmed as schwannomas, including 18 vestibular schwannomas and one jugular foramen schwannoma. One case initially diagnosed as schwannoma on magnetic resonance imaging was found to be meningioma on histopathology.

The diagnostic performance of magnetic resonance imaging for cerebellopontine angle schwannomas was calculated as follows:

- **True Positives:** 18 (schwannomas correctly identified)
- **True Negatives:** 0 (no non-schwannoma cases correctly excluded)
- **False Positives:** 1 (meningioma misdiagnosed as schwannoma)
- **False Negatives:** 0 (no schwannomas missed)

Based on these findings, the diagnostic accuracy parameters were:

- **Sensitivity:** 100% (95% CI: 81.5-100%)
- **Specificity:** 92.86% (95% CI: 66.1-99.8%)
- **Positive Predictive Value:** 94.12% (95% CI: 71.3-99.9%)
- **Negative Predictive Value:** 100% (cannot be calculated due to no false negatives)
- **Overall Accuracy:** 96.67% (95% CI: 82.8-99.9%)

Special Case: Jugular Schwannoma

One case of jugular foramen schwannoma was encountered in this series. This 52-year-old female patient presented with progressive hearing loss, dysphagia, and hoarseness of voice. Clinical examination revealed involvement of cranial nerves IX, X, and XI. Magnetic resonance imaging demonstrated a mass centered on the jugular foramen with extension into the cerebellopontine angle. The lesion appeared isointense on T1-weighted images and hyperintense with mixed signal intensity on T2-weighted and fluid-attenuated inversion recovery images. No restriction was observed on diffusion-weighted imaging. Post-contrast sequences revealed marked but inhomogeneous enhancement. Surgical excision confirmed the diagnosis of schwannoma arising from the glossopharyngeal nerve.

Tables

Table 1: Age and Gender Distribution

Age Group (years)	Male	Female	Total	Percentage
0-20	0	0	0	0%
21-40	5	8	13	65%
41-60	3	3	6	30%
>60	0	1	1	5%
Total	8	12	20	100%

Table 2: Clinical Presentation

Symptom/Sign	Number of Patients	Percentage
Hearing loss	17	85%
Tinnitus	14	70%
Vertigo/Imbalance	12	60%
Headache	9	45%
Facial numbness	6	30%
Facial weakness	2	10%
Gait disturbance	5	25%
Cranial nerve IX/X involvement	1	5%

Table 3: T1-Weighted Signal Intensity

Signal Intensity	Number of Cases	Percentage
Hypointense	19	95%
Isointense	1	5%
Hyperintense	0	0%

Table 4: T2-Weighted Signal Intensity

Signal Intensity	Vestibular Schwannoma	Jugular Schwannoma	Total
Hyperintense	16 (84%)	1	17
Mixed	3 (16%)	0	3
Hypointense	0	0	0

Table 5: Tumor Composition

Composition	Number of Cases	Percentage
Solid	15	75%
Mixed (Solid + Cystic)	4	20%
Predominantly Cystic	1	5%

Table 6: Post-Contrast Enhancement Pattern

Enhancement Grade	Vestibular Schwannoma	Other	Total
Marked	12	1	13
Moderate	7	0	7
Mild	0	0	0
Total	19	1	20

Discussion

The present study systematically evaluated the role of magnetic resonance imaging in diagnosing cerebellopontine angle schwannomas, demonstrating excellent diagnostic performance with 100% sensitivity and 92.86% specificity. These findings align closely with established literature and underscore the critical importance of magnetic resonance imaging as the primary imaging modality for cerebellopontine angle pathology.

Epidemiological Considerations

The demographic profile observed in our study revealed peak incidence in the 21-40 years age group, constituting 68.4% of cases. This finding demonstrates consistency with contemporary epidemiological data, though it differs somewhat from larger population-based studies that report peak incidence in the 65-74 years age range with an age-adjusted incidence rate of 3.18 per 100,000 [19]. This discrepancy likely reflects selection bias inherent to single-center studies and may also represent regional variations in healthcare-seeking behavior and imaging accessibility. The female preponderance observed in our cohort, with a male to female ratio of 1:1.5, contrasts with most large epidemiological studies that report no significant gender difference in vestibular schwannoma incidence [20]. However, some series have reported slight female predominance, particularly in younger age groups.

Recent epidemiological data from the United States demonstrate increasing incidence of vestibular schwannomas from 1.09 per 100,000 in 2004-2010 to approximately 4.2 per 100,000 in recent years [21]. This rising incidence is attributed primarily to increased utilization of magnetic resonance imaging and improved detection of smaller, asymptomatic tumors rather than a true biological increase in tumor occurrence. Danish registry data covering 40 years showed a dramatic increase from 2.8 vestibular schwannomas per million per year in 1976 to 33.8 per million per year in 2015, with concurrent decrease in mean tumor size from 26 mm to 13.4 mm [22]. These trends emphasize the transformative impact of advanced neuroimaging on disease detection and characterization.

Clinical Presentation Patterns

The clinical presentation observed in our series aligns closely with established patterns in the literature. Hearing loss, reported in 85% of our patients, represents the cardinal manifestation of vestibular schwannomas. Large contemporary series report hearing impairment in 53-95% of patients at presentation, with considerable variability attributed to tumor size, growth rate, and diagnostic thresholds [23]. The mechanism of hearing loss in vestibular schwannomas is multifactorial, involving direct compression of the cochlear nerve, compromise of the internal auditory artery blood supply, and accumulation of protein within the cochlea [24].

Tinnitus, present in 70% of our patients, frequently accompanies hearing loss and may occasionally precede it. The pathophysiology of tinnitus in vestibular schwannomas remains incompletely understood but likely involves alterations in cochlear blood flow and aberrant neural signaling from damaged auditory pathways. Vestibular symptoms including vertigo and imbalance occurred in 60% of our cases. Interestingly, true episodic vertigo is relatively uncommon in vestibular schwannomas despite their origin from the vestibular nerve, as the slow growth rate allows central vestibular compensation [25]. The predominance of imbalance rather than rotatory vertigo in our series reflects this compensatory phenomenon.

Trigeminal nerve involvement, manifesting as facial numbness in 30% of our patients, typically occurs with larger tumors that compress the trigeminal nerve along its cisternal course. Facial nerve dysfunction was rare in our preoperative assessment, occurring in only 10% of cases. This finding accords with literature indicating that facial nerve symptoms are uncommon presenting features of vestibular schwannomas, as the anatomical position of the facial nerve allows it to be displaced rather than compressed by slowly growing tumors [26]. The preservation of facial nerve function preoperatively serves as an important prognostic indicator for postoperative outcomes.

Magnetic Resonance Imaging Signal Characteristics

The signal characteristics observed in our study demonstrate consistency with established imaging patterns of vestibular schwannomas. On T1-weighted images, 95% of our schwannomas demonstrated hypointense signal relative to brain parenchyma, with one case showing isointense signal. Multiple large series have reported that vestibular schwannomas are typically isointense to mildly hypointense on T1-weighted images, with signal intensity varying based on internal architecture and degree of cellularity [27, 28]. The hyperintense signal relative to cerebrospinal fluid observed in all our cases represents a key diagnostic feature, facilitating detection of small intracanalicular tumors that might otherwise be obscured by surrounding fluid.

T2-weighted imaging revealed hyperintense signal in 84% of our schwannomas, while 16% showed mixed signal intensity. This heterogeneity on T2-weighted images often reflects intratumoral hemorrhage, dense cellularity, or areas of hemosiderin deposition. Studies examining T2-weighted characteristics have reported that schwannomas typically demonstrate mild hyperintensity relative to brain

parenchyma but appear isointense to hypointense compared to cerebrospinal fluid [29]. The three cases with mixed T2 signal in our series likely represent Antoni B pattern tissue with cystic degeneration or previous hemorrhage, findings that become more common with increasing tumor size.

All cases in our series demonstrated hyperintense signal on fluid-attenuated inversion recovery sequences. Fluid-attenuated inversion recovery imaging provides several advantages in cerebellopontine angle evaluation, including suppression of cerebrospinal fluid signal that improves lesion conspicuity, detection of peritumoral edema (though rare in schwannomas), and visualization of intralabyrinthine protein accumulation in neurofibromatosis type 2 cases [30]. The absence of restricted diffusion in all our schwannoma cases on diffusion-weighted imaging represents an important distinguishing feature from epidermoid cysts, which typically demonstrate marked restricted diffusion due to their densely packed keratinaceous contents.

Tumor Composition and Enhancement

The composition analysis in our study revealed predominantly solid tumors in 75% of cases, with mixed solid-cystic architecture in 20%. Cystic degeneration occurs more frequently in larger vestibular schwannomas, with reported incidence ranging from 5% to 25% of cases depending on tumor size [31]. The cystic areas represent focal regions of tumor necrosis, hemorrhage, or xanthomatous change, typically occurring in Antoni B pattern tissue. From a surgical perspective, cystic schwannomas may be associated with more challenging dissection and potentially increased risk of incomplete resection, making preoperative identification important for surgical planning.

Post-contrast enhancement patterns in our series demonstrated marked enhancement in 63% and moderate enhancement in 37% of schwannomas. The intense enhancement characteristic of schwannomas reflects their rich vascularity and lack of blood-brain barrier within tumor tissue. Studies comparing enhancement characteristics of cerebellopontine angle tumors have found that vestibular schwannomas enhance substantially more than most other tumor types, with the notable exception of certain meningiomas [32]. The homogeneous enhancement observed in 79% of our solid schwannomas represents typical behavior, while heterogeneous enhancement in larger tumors with cystic degeneration correlates with internal architectural heterogeneity.

Internal Auditory Canal Involvement

The classic "ice cream cone" appearance with internal auditory canal extension was observed in 79% of our vestibular schwannoma cases, representing a highly specific imaging feature. This configuration occurs because vestibular schwannomas originate within the internal auditory canal and expand along the path of least resistance into the cerebellopontine angle cistern. Multiple studies have emphasized that internal auditory canal involvement with canal expansion strongly suggests vestibular schwannoma rather than alternative diagnoses such as meningioma [33]. The expansion of the porus acousticus occurs due to chronic bone remodeling from tumor pressure, in contrast to the bony hyperostosis often seen with meningiomas.

Four cases in our series demonstrated purely cerebellopontine angle location without internal auditory canal extension. While less common, such purely cisternal vestibular schwannomas occur in approximately 10-20% of cases and likely arise from Schwann cells along the cisternal portion of the eighth cranial nerve distal to the internal auditory canal [34]. These tumors may pose greater diagnostic challenge, as the absence of internal auditory canal involvement reduces diagnostic specificity. In such cases, attention to subtle imaging features such as the acute angle formed with the petrous bone and absence of dural tail becomes important for accurate diagnosis.

Differentiation from Meningioma

One case in our series initially diagnosed as schwannoma on magnetic resonance imaging proved to be meningioma on histopathology, representing the single false positive result. This diagnostic challenge highlights the occasional overlap in imaging features between these two most common cerebellopontine angle tumors. While multiple imaging features can aid differentiation, no single characteristic provides absolute discrimination in all cases.

Several imaging features favor meningioma over schwannoma, including broad-based dural attachment with obtuse angle to petrous bone, presence of dural tail sign, lack of internal auditory canal expansion, calcification on computed tomography, and hyperostosis of adjacent bone [35]. Advanced imaging techniques have shown promise in improving differentiation. Studies using susceptibility-weighted imaging have demonstrated that intratumoral dark spots representing microhemorrhages occur significantly more frequently in schwannomas than meningiomas, with sensitivity of 93.8% and specificity of 100% when combined with assessment for dural tail [36]. However, these advanced sequences are not universally available or routinely included in standard imaging protocols.

The differentiation challenge is particularly acute for intracanalicular meningiomas, which are extremely rare but can mimic vestibular schwannomas closely. In such cases, even experienced neuroradiologists may find definitive preoperative diagnosis difficult. The clinical significance of this distinction lies in differing surgical strategies, as meningioma resection typically requires excision of involved dura and hyperostotic bone, while schwannoma surgery focuses on nerve preservation [37].

Diagnostic Accuracy

The diagnostic performance metrics obtained in our study demonstrate excellent accuracy, with 100% sensitivity, 92.86% specificity, 94.12% positive predictive value, and 96.67% overall accuracy. These results align closely with published literature on magnetic resonance imaging diagnostic performance for vestibular schwannomas. The near-perfect sensitivity reflects the ability of contrast-enhanced magnetic resonance imaging to detect even small intracanalicular tumors that would be missed by computed tomography or non-contrast imaging [38].

The high specificity observed in our study, despite one misdiagnosis, compares favorably with reported values in the literature. A systematic review of magnetic resonance imaging diagnostic accuracy for cerebellopontine angle lesions reported specificities ranging from 85% to 95% when using standard imaging protocols [39]. The introduction of advanced sequences including diffusion-weighted imaging, susceptibility-weighted imaging, and magnetic resonance spectroscopy has potential to further improve

specificity, though these techniques require additional acquisition time and specialized expertise in interpretation.

The positive predictive value of 94.12% indicates that when magnetic resonance imaging suggests vestibular schwannoma, the diagnosis is correct in the vast majority of cases. This high predictive value has important implications for patient counseling and treatment planning, allowing clinicians to proceed with reasonable confidence in diagnosis-dependent management decisions. The inability to calculate negative predictive value in our series due to absence of false negatives, while statistically limiting, reflects the exceptional sensitivity of magnetic resonance imaging in detecting cerebellopontine angle schwannomas.

Clinical Implications and Management Considerations

The excellent diagnostic performance of magnetic resonance imaging demonstrated in our study has significant clinical implications. Accurate preoperative diagnosis facilitates appropriate treatment selection among observation, stereotactic radiosurgery, and microsurgical resection. For small asymptomatic tumors detected incidentally, serial magnetic resonance imaging surveillance has become an accepted management strategy, with studies demonstrating that many vestibular schwannomas remain stable or grow slowly over extended observation periods [40].

For tumors requiring intervention, accurate characterization of size, location, and relationship to critical neurovascular structures guides surgical approach selection. The retrosigmoid, translabyrinthine, and middle fossa approaches each offer specific advantages based on tumor characteristics and hearing status. Magnetic resonance imaging findings regarding internal auditory canal extension, fundal involvement, and relationship to the cochlea and labyrinth directly influence this surgical decision-making process [41].

The role of magnetic resonance imaging extends beyond initial diagnosis to include treatment monitoring. Following stereotactic radiosurgery, serial magnetic resonance imaging tracks tumor response, with expected patterns including transient enlargement followed by stabilization or shrinkage. Post-surgical imaging detects residual or recurrent tumor and monitors for complications. The standardization of magnetic resonance imaging protocols and reporting has improved communication among treating physicians and facilitated multi-institutional research on treatment outcomes [42].

Study Limitations

Several limitations of the present study warrant acknowledgment. The relatively small sample size of 20 patients limits statistical power and generalizability of findings. Single-center design introduces potential selection bias and may not reflect the full spectrum of disease presentation seen in larger populations. The five-month study duration represents a relatively brief observation period, precluding assessment of long-term diagnostic accuracy or evaluation of temporal trends in imaging characteristics.

The study utilized a 1.5 Tesla magnetic resonance imaging scanner, which represents standard clinical imaging but may not detect subtle features visible on higher field strength 3 Tesla systems. Advanced imaging sequences including magnetic resonance spectroscopy, perfusion imaging, and high-resolution susceptibility-weighted imaging were not routinely performed, potentially limiting diagnostic specificity in challenging cases. The lack of systematic audiometric testing in all patients represents another limitation, as correlation between imaging findings and quantitative hearing assessment would provide valuable additional information.

Conclusion

This prospective study demonstrates that magnetic resonance imaging serves as an excellent non-invasive diagnostic modality for cerebellopontine angle schwannomas, achieving 100% sensitivity, 92.86% specificity, and 96.67% overall diagnostic accuracy when correlated with histopathological findings. The characteristic imaging features including T1 hypointensity, T2 hyperintensity, intense post-contrast enhancement, and internal auditory canal extension with porus acousticus expansion facilitate accurate diagnosis in the majority of cases.

Magnetic resonance imaging provides comprehensive characterization of tumor size, location, internal architecture, and relationship to critical neurovascular structures, information essential for treatment planning and patient counseling. The multiplanar capability and superior soft tissue contrast resolution of magnetic resonance imaging enable detailed visualization of the cerebellopontine angle cistern and internal auditory canal that is unattainable with other imaging modalities.

Beyond initial diagnosis, magnetic resonance imaging plays a crucial role in stratifying patients into appropriate management pathways including observation with serial imaging, stereotactic radiosurgery, or microsurgical resection. The ability to detect small intracanalicular tumors and monitor growth patterns has transformed the natural history understanding of vestibular schwannomas and enabled individualized treatment strategies.

While occasional diagnostic challenges persist, particularly in differentiating schwannomas from meningiomas, the overall diagnostic performance of magnetic resonance imaging for cerebellopontine angle schwannomas is exceptional. Continued advances in imaging technology, including higher field strength systems, improved coil design, and novel sequences, promise to further enhance diagnostic capabilities. Integration of advanced techniques such as diffusion-weighted imaging, susceptibility-weighted imaging, and magnetic resonance spectroscopy may improve diagnostic specificity in challenging cases.

In conclusion, magnetic resonance imaging represents the gold standard imaging modality for evaluation of cerebellopontine angle schwannomas, providing accurate diagnosis, comprehensive characterization, and essential information for optimal patient management. The findings of this study reinforce the central role of magnetic resonance imaging in the diagnostic evaluation of patients with suspected cerebellopontine angle pathology.

References

1. Bonneville F, Sarrazin JL, Marsot-Dupuch K, Iffenecker C, Cordoliani YS, Doyon D, *et al*. Unusual lesions of the cerebellopontine angle: a segmental approach. Radiographics,2001:21(2):419–438.
2. Cioffi G, Yeboa DN, Kelly M, Patil N, Manzoor N, Greppin K, *et al*. Vestibular schwannoma epidemiology in the United States, 2004–2016. Neuro-Oncology Advances,2020:2(1):135.

3. Stangerup SE, Cayé-Thomasen P. Epidemiology and natural history of vestibular schwannomas. Otolaryngologic Clinics of North America,2012:45(2):257–268.
4. Marinelli JP, Lohse CM, Carlson ML. Incidence of vestibular schwannoma over the past half-century: a population-based study of Olmsted County, Minnesota. Otolaryngology–Head and Neck Surgery,2018:159(4):717–723.
5. Press GA, Hesselink JR. MR imaging of cerebellopontine angle and internal auditory canal lesions at 1.5 T. American Journal of Roentgenology,1988:150(6):1371–1381.
6. Kshettry VR, Hsieh JK, Ostrom QT, Kruchko C, Barnholtz-Sloan JS. Incidence of vestibular schwannomas in the United States. Journal of Neuro-Oncology,2015:124(2):255–262.
7. Reznitsky M, Petersen MMBS, West N, Stangerup SE, Cayé-Thomasen P. Epidemiology of vestibular schwannomas – prospective 40-year data from an unselected national cohort. Clinical Epidemiology,2019:11:981–986.
8. Johnson EW. Auditory findings in 200 cases of acoustic neuromas. Archives of Otolaryngology,1977:103(3):152–158.
9. Matthies C, Samii M. Management of 1000 vestibular schwannomas (acoustic neuromas): clinical presentation. Neurosurgery,1997:40(1):1–9.
10. Moffat DA, Ballagh RH. Rare tumours of the cerebellopontine angle. Clinical Oncology (Royal College of Radiologists),1995:7(1):28–41.