Magnetic Resonance Imaging Findings in Patients with Multinodular Vacuolating Neuronal Tumors

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ABSTRACT

Objective: Multinodular vacuolating neuronal tumor (MVNT) is a rare entity that radiologists should recognize based on its unique imaging characteristics. We aimed to present the imaging findings of 26 patients diagnosed with MVNT.

Materials and Methods: The brain MRI findings of 26 patients with a pre-diagnosis of multinodular vacuolating neuronal tumor (MVNT) were retrospectively evaluated across five centers. Conventional MRI sequences were used for all patients. Additionally, diffusion MRI images were obtained for 25 patients, and contrast-enhanced sequences were performed on 19 patients.

Results: The mean age of the patients was 39.7 years. The lesion was located in the cerebrum in 25 patients (96.15%) and in the cerebellum in 1 patient (3.85%). When classified by location, the most common site was the left frontal lobe, observed in 6 patients (23.07%). In 1 patient (3.85%), the lesion was located in the left cerebellum, classified as MVNT/MV PLUS. The long axis of the lesion was measured in the axial plane, with an average size of 18.6 mm. On T1-weighted images (T1W), the lesion was isointense in 23 patients (88.46%) and hypointense in 3 patients (11.54%). On T2-weighted (T2W) and FLAIR sequences, the lesion was hyperintense in all patients. Diffusion-weighted images were obtained in 25 patients; on b1000 sequences, the lesion was hyperintense in 20 patients (80%), isointense in 4 patients (16%), and hypointense in 1 patient (4%). Contrast-enhanced sequences were acquired in 19 patients, with no enhancement observed in any case.

Conclusion: Conventional MRI is the primary imaging modality for diagnosing multinodular vacuolating neuronal tumor (MVNT), as its imaging features are characteristic. In addition to these features, diffusion imaging may aid in the diagnosis of MVNT.

Keywords: MRI, incidental radiological finding, multinodular and vacuolating neuronal tumor, mvnt

INTRODUCTION

Multinodular vacuolating neuronal tumor (MVNT) was first defined as an epilepsy-related lesion by Huse et al. in 2013 (1). It was included as a new entity in the subcategory of gangliocytomas in the 2016 World Health Organization (WHO) updated classification of central nervous system (CNS) tumors.

The lesions frequency and pathophysiology are unknown, and the described typical imaging findings and stability of the lesions during follow-up support the diagnosis (2). MVNT cases have typical imaging features. Almost all cases described in the literature are defined as hyperintense “soap bubbles” on T2W and FLAIR images in subcortical white matter areas (3).

In light of the literature, we aimed to present the magnetic resonance imaging (MRI) findings of 26 patients followed up in 5 centers with a pre-diagnosis of MVNT.
MATERIALS and METHODS

Our study was approved by the ethics committee of our institution (2023-04-47). Informed consent was obtained from all patients before the brain MRI examination.

Demographic characteristics, lesion locations, and MR images of 26 patients who were followed up by experienced neuroradiologists with a provisional diagnosis of MVNT between January 2017 and July 2022 were retrospectively evaluated. In addition to conventional sequences, diffusion MR images were obtained in 25 patients, and 19 underwent contrast-enhanced sequences.

MR imaging examinations were performed on 1.5T or 3T scanners (MagnetomVerio and Avanto Siemens, Erlangen, Germany/ SIGNA Explorer, GE Healthcare, USA/ Signa Pioneer, GE Healthcare). Scan parameters consisted of axial T2-WI (TR /TE,4000/114 ms), FLAIR (TR / TE, 8000/94), and DWI/ADC at 0,1000 b-values (TR /TE 7400/91), and pre-and post-contrast T1-WI (TR /TE,410/10 ms) in axial, coronal, and sagittal planes.

RESULTS

Patient demographic characteristics, lesion size and location, and MRI findings are summarized in Table 1.

Table 1: Demographic and MRI findings of MVNT and MVNT PLUS

<table>
<thead>
<tr>
<th>GENDER</th>
<th>AGE</th>
<th>LOCATION</th>
<th>SUBCORTICAL</th>
<th>LOCATION</th>
<th>SIZE (mm)</th>
<th>T1</th>
<th>T2</th>
<th>FLAIR</th>
<th>DWI b1000</th>
<th>ADC</th>
<th>ENHANCEMENT</th>
<th>FOLLOW UP (YEARS)</th>
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<td>I. H. H. H. I.</td>
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<td>4</td>
<td>MVNT</td>
<td></td>
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The mean age of the patients was 39.7 years (minimum 20, maximum 71). While the lesion was cerebral in 25 patients (96.15%), the lesion was cerebellar in 1 patient (3.84%). When the lesion was classified according to its location, the location of the lobes was as follows: in the right parietal lobe in 4 patients (15.38%), in the left frontal lobe in 6 patients (23.07%), in the left frontoplateral lobes in 4 patients (15.38%) in the left parietal lobe in 3 patients (11.53%), in the right frontal lobe in 2 patients (7.69%), in the left occipital lobe in 2 patients (7.69%), in the right temporal lobe in 1 patient (3.84%), in the right parietotemporal in 1 patient (3.84%), and in the left temporal lobe in 2 patient (7.69%). In 1 patient (3.84%), the lesion was located in the left cerebellum, and this patient was accepted as MV PLUS. The long axis of the lesion was evaluated in the axial plane, and the average size was 18.6 mm (longest 32 mm, shortest 11 mm). On T1W images, the lesion was isointense in 23 patients (88.46%), whereas it was hypointense in 3 patients (11.53%). Lesions were hyperintense in all patients on T2W and FLAIR sequences. Diffusion-weighed images were obtained in 25 patients, and b1000 sequences were hyperintense in 20 patients (80%), isointense in 4 patients (16%), and hypointense in 1 patient (4%). Contrast-enhanced series were obtained in 19 patients, and none of the 19 patients showed enhancement. Case examples of MVNT and MV Plus are presented in Figures 1 and 2. No significant difference in lesion sizes was detected during the follow-up periods.
**Figure 1A-B:** Axial DWI, ADC, FLAIR and T2 weighted images of two different patients with MVNT prediagnosis.

**Figure 2 (A): Initial and (B):** 2- years follow-up axial FLAIR, T2 and contrast-enhanced T1- weighted images of MVNT PLUS.
DISCUSSION

Multinodular vacuulating neuronal tumor (MVNT), which can be diagnosed radiologically based on its typical imaging findings, was first defined by Huse et al. in 2013 and included in the gangliocytoma subcategory of the World Health Organization (WHO) central nervous system (CNS) tumor classification in 2016 (1,2). Its incidence is not precisely known, and it is primarily reported in the literature as case studies.

Most multinodular vacuulating neuronal tumors (MVNTs) are discovered incidentally during imaging studies. In terms of treatment and prognosis, MVNTs appear to be benign tumors. They are biologically indolent and can often be monitored through imaging when they are asymptomatic. In symptomatic patients with epilepsy, surgical resection frequently eliminates seizures without evidence of tumor regrowth. In almost all cases reported in the literature, lesions have demonstrated stable prognoses, albeit with short follow-up periods. However, a variety of symptoms have been described, ranging from headaches to epilepsy (1-6). In their study, Bıyıklı et al. described a case of numbness in both hands, predominantly on the left, in one patient, and detected a lesion in the right parietal region (6).

MVNT cases typically present with characteristic imaging features. Almost all cases described in the literature are defined as hyperintense "soap bubbles" on T2-weighted (T2W) and FLAIR images in subcortical white matter areas (3). In our study, all cases were identified as T2W and FLAIR hyperintense lesions with the appearance of soap bubbles in subcortical white matter, consistent with the literature. Diffusion restriction on diffusion-weighted images and contrast enhancement have not been reported in the literature (1-6).

Arim et al. discussed the importance of diffusion-weighted imaging (DWI) in the differential diagnosis of MVNT and dysembryoplastic neuroepithelial tumors (DNET). They reported that the bright diffusion sign is a sensitive and specific radiological marker in differentiating these conditions (7). In our study, diffusion-weighted images were obtained for 25 cases, and no diffusion restriction was observed. However, lesions with a b-value of 1000 were observed to be hyperintense in 20 cases, which we believe will facilitate diagnosis. In 19 patients, contrast-enhanced imaging was performed, and no enhancement was observed in any of them. Given the long-term stability of the imaging findings and the clinical course of MVNT, it is noteworthy that MVNT behaves benignly and non-aggressively, more like a hamartomatous lesion than a neoplasm (3). Typical imaging findings of MVNT support the diagnosis and are often called a "leave me alone" lesion. However, in cases where the lesion causes symptoms such as epilepsy, surgical treatment may be considered. In cases where the lesion is asymptomatic or is not certain to cause symptoms, no biopsy, resection, or imaging follow-up is required 3-6.

The location of lesions varies in the literature. When Huse et al. first described MVNT, it was confined to the temporal lobes in 7 of 10 cases (1). In the study by Leclerc et al., it was reported that 20 of 64 cases were located in the frontal lobe and 24 in the parietal lobe.

In this study, the lesion was located in the posterior fossa in only 1 patient and was evaluated as MV PLUS based on its typical imaging features and stability during follow-up. In their study, Leclerc et al. used the definition of MV PLUS for 11 infratentorial lesions with very similar imaging features to MVNT (10). The study by Bıyıklı et al. reported that the lesions were located parietally in 5 of 11 cases (6). In our study, 8 lesions were located in the frontal lobe, 7 in the parietal lobe, 3 in the temporal lobe, and 2 in the occipital lobe, while extension to more than one lobe was observed in 5 patients. In 1 patient, the lesion was located in the cerebellum and was accepted as MVNT PLUS based on its typical imaging features and stability on follow-up.

Due to their similar imaging features, dysembryoplastic neuroepithelial tumors (DNETs) can be confused with focal cortical dysplasias and enlarged perivascular cerebrospinal fluid (CSF) spaces. DNETs are also lesions associated with epilepsy and are characterized as well-circumscribed solid-cystic lesions, typically accompanied by thickening of the cerebral cortex. On MRI, DNETs generally appear hypointense or isointense on T1-weighted images and hyperintense on FLAIR and T2-weighted images (7-8). Variable contrast enhancement patterns have been reported, and calcification can occur in up to 44-60% of cases, often affecting the inner table of the bone structure.

In a study conducted by Arim et al., the bright diffusion sign and the absence of cortical involvement were found to have high sensitivity, specificity, and positive predictive value (PPV) for diagnosing MVNT (7). Radiologically, the absence of cortical involvement, lack of enhancement, and clustered appearance with deep localization in the white matter help distinguish MVNT from DNET (5-8).

Focal cortical dysplasia (FCD), also associated with epilepsy, is characterized by areas of focal cortical thickening, blurring of the grey-white matter division, and, in some cases, abnormal cortical rotation. FCD on the other hand, has a high T2 signal deep to cortex in the same location, but it is generally accompanied by a radial glial band (transmantle sign) and has a thickened abnormal overlying cortex (3,9). The presence of cortical involvement and the interface between gray and white matter help distinguish it from MVNT. Enlarged perivascular Virchow-Robin spaces appear as linear or fusiform foci that follow CSF signal intensity in all sequences (7,8,10).

MV-PLUS consists of small T1WI hypointense and T2-FLAIR hyperintense nodules in the subcortical and juxtacortical areas, similar to MVNT, which was defined as a new entity by WHO in 2016 (1,5,10,11). The differential diagnosis of intraaxial lesions in the posterior fossa includes a wide variety of diseases such as ischemic lesions, inflammatory diseases such as multiple sclerosis, infectious diseases, vascular malformations, neoplastic lesions, degenerative lesions such as ataxia, toxic lesions, malformative lesions such as dysplastic cerebellar gangliocytoma, or perivascular spaces (9). However, both the location in juxtacortical or subcortical regions and typical features such as the presence of clusters of discrete or confluent high T2-FLAIR signal intensity small nodules make the diagnosis of MV-PLUS very likely (9).
In their study, Lecler et al. reported the T2 and FLAIR hypointense central dot sign and stated that it could be a criterion that can increase readers’ confidence when diagnosing MV-PLUS (10). We defined the lesion located in the posterior fossa, whose imaging features were similar to MVNT and where no significant change was observed in the 3-year follow-up, as MV PLUS.

Our study is not only one of the most comprehensive evaluations of MVNT imaging findings in the English-language literature but also the largest study conducted within the Turkish population, which enhances its significance. Knowledge of MVNT imaging findings can help radiologists avoid unnecessary additional examinations, follow-up procedures, or biopsies. Additionally, our study highlights that a hypointense appearance with a b-value of 1000 on diffusion-weighted imaging (DWI) can be a valuable finding in MVNT diagnosis. Furthermore, presenting a case of MVNT PLUS in the posterior fossa, a rare occurrence in the literature, further underscores the study’s importance.

CONCLUSION

Multinodular vacuolating neuronal tumors (MVNTs) are distinctive lesions that can be diagnosed effectively through radiological imaging due to their characteristic features. MRI plays a crucial role in identifying these tumors, with typical findings including hyperintense lesions resembling “soap bubbles” on T2-weighted and FLAIR images. Accurate provisional diagnosis based on these imaging characteristics can significantly reduce the need for additional diagnostic procedures, such as biopsies or further imaging. Our study underscores the importance of recognizing these hallmark features to streamline the diagnostic process and manage patient care more efficiently. Moreover, the observation that diffusion-weighted imaging (DWI) reveals a hypointense appearance with a b-value of 1000 further supports the utility of MRI in MVNT diagnosis. The presentation of a rare case of MVNT PLUS in the posterior fossa highlights the study's contribution to expanding the current understanding of MVNTs and their variations.

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Conflict of interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval: The present study was conducted in strict accordance with the principles outlined in the Declaration of Helsinki. Informed consent was obtained from the participant of this study. The study was approved by the ethics committee of our institution (Dr. Abdurrahman Yurtaslan Ankara Oncology Training and Research Hospital) (2023-04/47).

Authors’ Contribution

Conceptualization: ŞT, ÖÜ
Data curation: YB, AB, BTÇ, OO
Formal analysis: ŞT, EYB
Funding acquisition: -
Investigation: ŞT, EYB, ÖÜ
Methodology: ÖÜ
Project administration: ŞT, ÖÜ
Resources: WOS, Scholar Google, Scopus, Index Copernicus
Software: SPSS
Supervision: ÖÜ, YB, AB, BTÇ, OO
Validation: AB, BTÇ, OO
Visualization: ÖÜ, YB, AB, EYB, ŞT
Writing—original draft: ŞT, EYB
Writing—review & editing: ÖÜ, YB, AB, BTÇ, OO

REFERENCES


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