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Primary Angiitis of the CNS with Unremarkable Vessel Wall MR Imaging: How the "T1 Shinethrough" Effect on SWI Adds to the Detection of Gadolinium Enhancement of Small Intraparenchymal Brain Vessels

The article published by Suthiphosuwan et al[1] in the September 2020 edition of *AJNR* made a strong impression on us. The authors elaborate on the clinical, histopathologic, and imaging findings of biopsy-proved cases of primary central nervous system vasculitis (PCNSV).

One of the major difficulties in the diagnosis of tumefactive primary CNS vasculitis (t-PCNSV) is the differentiation of this condition from malignant neoplasms.[1,2] The absence of abnormalities in large- and medium-sized vessels on CTA, MRA, and high-resolution vessel wall imaging makes it even more unlikely for this entity to be included in the list of differential diagnoses for expansive-appearing lesions of the brain.[1] The main reason for the unremarkable angiographic studies might be the preferential involvement of small-sized vessels with relative sparing of medium and large arteries in this PCNSV subtype.[1,2]

An imaging pattern that has been associated with cerebral small-vessel inflammatory disease is that of linear or punctuate enhancement in the brain parenchyma identified in postgadolinium T1-weighted imaging.[1,2] That pattern of enhancement mimics the location of perivascular spaces, suggesting a distribution along the axis of small vessels in the brain, and has therefore been termed perivascular enhancement.[2] However, on most conventional gadolinium-enhanced T1-weighted imaging sequences, this perivascular distribution can only be presumed because most clinically available MR imaging equipment does not offer enough spatial resolution to visually identify the gadolinium enhancement actually surrounding the vessels. Even vessel wall imaging, which can clearly demonstrate gadolinium enhancement in large- and medium-sized artery walls, fails to visually depict the perivascular nature of linear and punctuate enhancement in the brain (**Fig 1**).

SWI is a relatively recent technique of MR imaging that combines both phase and magnitude signal to produce high-resolution images that provide higher sensitivity than T2*-weighted imaging to detect brain hemorrhage and calcification.[3] It is also useful to acquire intracranial venography (venous bold imaging).[3] Although in that sequence the T2* and phase effects are dominant, the signal intensity is also a function of molecular transverse relaxation time for gradient-echo imaging; therefore, T1 effects are still present.[4] This phenomenon is termed the "T1 shinethrough" effect and can be exploited for the detection of pathologic gadolinium enhancement in the brain tissue with several applications, ranging from neuro-oncology to demyelinating diseases.[4] The strong contrast resolution provided by gadolinium-enhanced SWI caused by the combination of its T2* intracranial venographic effect and T1 shinethrough effect might prove itself helpful in the characterization of perivascular gadolinium enhancement in small-sized vessel vasculitis (**Fig 2**). The strong T2* effect in SWI sequences allows the identification of the very low-intensity signal of small vessels within the brain parenchyma, surrounded by a hyperintense background determined by a T1 shinethrough effect caused by the highly paramagnetic gadolinium in the vessel walls and adjacent tissues. In some studies, it is possible to identify a perivascular annular area of enhancement surrounding the vessels, which we coined the "silver ring sign" (**Fig 2*D***). This high-contrast resolution obtained between small vessels and the surrounding tissue gadolinium enhancement is the same principle that allows the visualization of a small-sized central medullary vein in demyelinating lesions in MS.[4]

The applications of the gadolinium-enhanced SWI sequence have been growing recently. Therefore, we believe this sequence might also have the potential to add information on the currently difficult issue of diagnosing t-PCNSV. Further research is necessary to determine whether it can add to the sensitivity and specificity of such diagnosis. Also, we encourage the study of postgadolinium SWI for

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other potential applications in this scenario, such as biopsy guidance and treatment follow-up.

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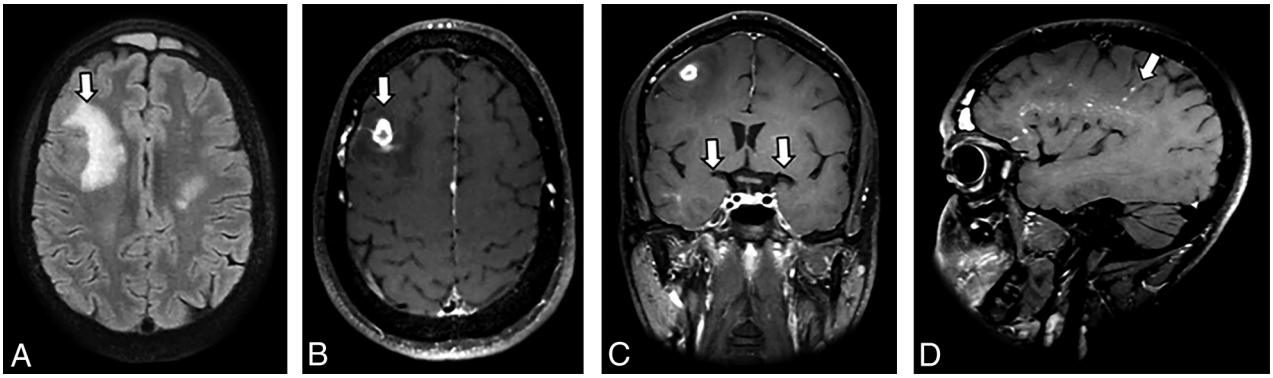

FIG 1. MR imaging findings in a 42-year-old man with biopsy-confirmed t-PCNSV. Axial fluid-attenuated inversion recovery (*A*) and postgadolinium T1-weighted imaging (*B*) demonstrate an expansive-appearing lesion (*arrows*) with ring enhancement in the right frontal lobe surrounded by an area of vasogenic edema. Coronal reformat 3D CUBE T1-weighted vessel wall image (*C*) at the internal carotid bifurcation shows no large- or medium-sized artery wall enhancement (*arrows*). Sagittal reformat of the 3D CUBE T1-weighted vessel wall image (*D*) depicts multiple linear or nodular foci of enhancement (*arrow*) within the right hemisphere white matter, with a striking radial distribution attributable to a perivascular location.

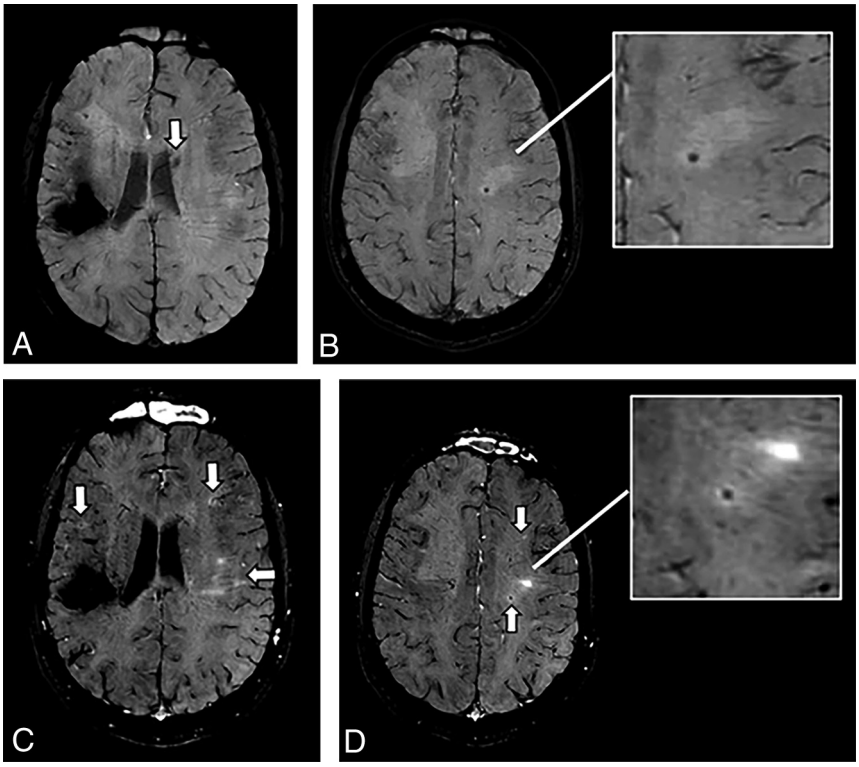

FIG 2. SWI findings of the same patient. Axial pregadolinium SWI (*A* and *B*) shows a large hemorrhage in the right brain hemisphere and a smaller hematic focus in the body of left caudate nucleus (*arrow*). Postgadolinium SWI (*C* and *D*) shows selective perivascular gadolinium enhancement along the parenchymal small-sized vessel walls (*arrows*). The "silver ring sign" is depicted in the amplified image in *D*.