

**A Unique Stroke Case with Contralateral Sulcal Hyperintensity  
on Fluid-Attenuated Inversion Recovery Image  
Changed to Linear Serpiginous Structures**

**Yosuke Osakada, MD, Yoshiaki Takahashi, MD, Kota Sato, MD, PhD,  
Jingwei Shang, MD, PhD, Mami Takemoto, MD, PhD, Nozomi Hishikawa, MD, PhD,  
Yasuyuki Ohta, MD, PhD, Toru Yamashita, MD, PhD, and Koji Abe, MD, PhD**

Department of Neurology, Graduate School of Medicine, Dentistry and Pharmaceutical Sciences,  
Okayama University, 2-5-1 Shikata-cho, Kita-ku, Okayama 700-8558, Japan.

Running title: A unique sulcal hyperintensity on FLAIR

Address correspondence and reprint requests to: Prof. Koji Abe

Department of Neurology, Graduate School of Medicine, Dentistry and Pharmaceutical Sciences,  
Okayama University, 2-5-1 Shikata-cho, Kita-ku, Okayama 700-8558, Japan.

Tel: +81-86-235-7365; Fax: +81-86-235-7368;

E-mail: osakada.yosuke.n.1990@gmail.com

**Abbreviations used:** FLAIR, fluid-attenuated inversion recovery; GCS, Glasgow coma scale; CT, computed tomography; DWI, diffusion-weighted image; MRI, magnetic resonance imaging; MCA, middle cerebral artery; MRA, Magnetic resonance angiography; ACA, anterior cerebral artery; CBC, complete blood count; ESR, erythrocyte sedimentation rate; CSF, Cerebrospinal fluid; T1WI, T1 weighted imaging

## **Abstract**

An 83-year-old man developed acute ischemic stroke. Brain magnetic resonance imaging (MRI) showed ischemic stroke in the left parietal lobe gyri, but fluid-attenuated inversion recovery (FLAIR) showed hyperintensity in the contralateral right temporal-occipital lobe sulci. Follow-up FLAIR image showed the gradual disappearance of the sulcal hyperintensity in the sulci and changed to linear serpiginous structures. This is a unique stroke case showing transitioned FLAIR findings suggesting that the sulcal hyperintensity findings are more severe and an earlier ischemic condition than the linear serpiginous structures.

## **Keywords**

Cerebrovascular Disease, Imaging, Linear Serpiginous Structure, FLAIR, Sulcal Hyperintensity

## **Introduction**

Stroke occasionally shows sulcal hyperintensity on FLAIR in some cases of moyamoya disease, ischemic stroke and subarachnoid hemorrhage<sup>1-4</sup>. These findings include diffuse sulcal surface hyperintensity and linear serpiginous structures<sup>1,4</sup>. However, these findings are often confused in many reports, and relationship of them is unclear. Here, we report an unusual case of acute ischemic stroke, presented FLAIR hyperintensity on the contralateral lobe sulci (sulcal hyperintensity) which later changed to linear serpiginous hyperintensity.

## **Case report**

An 83-year-old man who had a long history of vascular risk factors such as hypertension, hyperlipidemia, smoking history (30 cigarettes/day for 25 years), and a past ischemic stroke suddenly presented consciousness disturbance (Glasgow coma scale (GCS); E4V2M5), dysarthria, and right hemi-paresis at 11:50 a.m.. His blood pressure was mildly high (145/82 mmHg) with a regular rhythm (62 /min). Although brain computed tomography (CT) showed no early ischemic signs (Fig. 1 A) at 1:00 p.m., a brain diffusion-weighted image (DWI) of MRI at 1:30 p.m. showed an acute stroke pattern on the left parietal lobe gyri (Fig. 1 B, arrowhead), and FLAIR showed hyperintensity in the contralateral temporal-occipital lobe sulci (Fig. 1 C, D, arrowheads) with diffuse right middle cerebral artery (MCA) sulci's enhancement by Gadolinium (Gd) (Fig. 1 G, H, arrowheads). Magnetic resonance angiography (MRA) showed the complete occlusion of the right MCA (Fig. 1 I, arrowhead) which was later confirmed by cerebral angiography (Fig. 1 J, arrowhead). Leptomeningeal collaterals

were observed from the right anterior cerebral artery (ACA) to the right MCA region (Fig. 1 K, arrowheads). His consciousness disturbance and hemiparesis gradually improved, and he reached a normal state at around 2:00 p.m. Laboratory data and cerebrospinal fluid (CSF) examination showed no abnormal findings.

A follow-up MRI showed the gradual disappearance of the FLAIR hyperintensity, changing to linear serpiginous structures (Fig. 1 L). Since there was no second ischemic attack, the patient was discharged, and he walked home with the assistance of a cane on day 25.

## **Discussion**

FLAIR hyperintensity in the sulcus is usually caused by abnormal CSF composition such as subarachnoid hemorrhage<sup>3</sup> and leptomeningeal metastasis<sup>4</sup>. Sulcus FLAIR hyperintensity was also found in ischemic stroke with the ipsilateral internal carotid or MCA stenosis, in which a vascular hemodynamic change was accompanied by a high concentration of deoxyhemoglobin due to venous blood pool congestion at pial-to-arachnoid (arterial capillary and venous) levels<sup>4,5</sup>. As for ischemic stroke cases, this finding was reported in ipsilateral sulcal spaces<sup>4,5</sup>. However, the present case is the first report of contralateral side sulci (Fig. 1C and D, arrowheads).

The linear serpiginous structures of the sulci on FLAIR imaging are associated with the appearance of an enlarged leptomeningeal collateral<sup>5</sup>, and intravascular slow flow<sup>6</sup>. Similar FLAIR findings are also called “ivy sign” in children with moyamoya disease<sup>2,6</sup>. In the present case, leptomeningeal collaterals of the right MCA region show like these linear serpiginous structures on FLAIR (Fig. 1L). Despite the similarity between FLAIR sulcus hyperintensity and this kind of linear serpiginous structure, there are no reports that discuss the relationship between them.

In the present case, sulci FLAIR hyperintensity on right parietal lobe at the onset (Fig. 1C and D, arrowheads) may be induced by severe ipsilateral MCA stenosis (Fig. 1I, arrowhead), which changed to linear serpiginous structures within several days after stroke treatment, but eventually did not develop a stroke. Therefore, FLAIR sulcus hyperintensity may reflect a more severe ischemic

condition and blood congestion than linear serpiginous structures at the moment of an acute ischemic stroke.

In summary, this is a rare case showing transitioned MRI findings from the FLAIR hyperintensity in the contralateral lobe sulci (sulcal hyperintensity) to linear serpiginous structures during an acute ischemic stroke, suggesting that the sulcal hyperintensity findings are a more severe ischemic condition than the linear serpiginous structures.

## References

1. Maeda M, Tsuchida C. "Ivy sign" on fluid-attenuated inversion-recovery images in childhood moyamoya disease. *Am. J. Neuroradiol.* 1999; 20: 1836–38.
2. Kamran S, Bates V, Bakshi R, Wright P, Kinkel W, Miletich R. Significance of hyperintense vessels on FLAIR MRI in acute stroke. *Neurology.* 2000; 55: 265-69.
3. Noguchi K, Ogawa T, Inugami A *et al.* Acute subarachnoid hemorrhage: MR imaging with fluid-attenuated inversion recovery pulse sequences. *Radiology.* 1995; 196: 773-77.
4. Haccin-bey L, Mukundan G, Shahi K, Chan H, Tajlil AT. Hyperintense ipsilateral cortical sulci on FLAIR imaging in carotid stenosis: ivy sign equivalent from enlarged leptomeningeal collaterals. *Clinical Imaging.* 2014; 38: 314-17.
5. Taoka T, Yuh WT, White ML, Quets JP, Maley JE, Ueda T. Sulcal hyperintensity on fluid-attenuated inversion recovery MR images in patients without apparent cerebrospinal fluid abnormality. *Am J Neuroradiol.* 2001; 176: 519-24.
6. Sanossian N, Saver J.L, Alger R *et al.* Angiography Reveals That Fluid-Attenuated Inversion Recovery Vascular Hyperintensities Are Due to Slow Flow, Not Thrombus. *Brain.* 2009; 30: 564-68.
7. Shimoda M, Hoshikawa K, Shiramizu H, Oda S, Matsumae M. Problems with diagnosis by fluid-attenuated inversion recovery magnetic resonance imaging in patients with acute aneurysmal subarchnoid hemorrhage. *Neurol. Med. Chir.* 2010;50 530-37.

**Conflict of interest**

The authors state that they have no conflicts of interest.

**Acknowledgments**

We appreciate the cooperation of the patient. This work was partly supported by the Okayama Prefecture Intractable Disease Medical Council, a Grant-in-Aid for Scientific Research (B) 17H0419619, (C) 15K0931607, 17H0419619 and 17K1082709, and Grants-in-Aid from the Research Committees (Kaji R, Toba K, and Tsuji S) from the Japan Agency for Medical Research and Development (AMED) 7211700176, 7211700180 and 7211700095.



## Figure legends

Fig. 1: A) Computed tomography showed no early ischemic signs. B) Diffusion-weighted image (DWI) showed an acute stroke pattern. C, D) Fluid-attenuated inversion recovery (FLAIR) showed hyperintensity on the right temporal-occipital lobe sulci (arrowheads). E) T2 \*. F) Typical FLAIR sulcus hyperintensity on subarachnoid hemorrhage. G, H) T1 weighted imaging (T1WI) showed diffuse right middle cerebral artery (MCA) sulci enhancement by gadolinium (arrowheads). I) Magnetic resonance angiography (MRA) and J) cerebral angiography showing the complete occlusion of the right MCA (arrowheads). K) Leptomeningeal collaterals were found from the right anterior cerebral artery (ACA) to the right MCA territory (arrowheads). L) Time course of FLAIR hyperintensity in the sulci at days 4, 12, and 40, which gradually changed to linear serpiginous structures from day 4.