# SWI Enhances Vein Detection Using UPSIO in Multiple Sclerosis

Li-Jie Zhang, Ye-Xiang Zheng, Ying Fu\*

Department of Neurology and Institute of Neurology, First Affiliated Hospital, Fujian Medical University, Fuzhou 350005, China. 413013752@qq.com

## INTRODUCTION

With susceptibility increased by ultrasmall superparamagnetic iron oxide (USPIO), subvoxel vessels (size < 100µm) became visible<sup>1</sup>. Among all the USPIO particles, Ferumoxytol is the one most often used in human studies as an off-label magnetic resonance imaging (MRI) contrast agent. Multiple sclerosis (MS) is an inflammatory demyelinating disease of central nervous system (CNS) usually resulting in severe and irreversible disability. Using 7T-MR, previous studies showed that the presence of central vein sign (CVS) within white matter lesions (WML) could be an imaging diagnosis marker for MS<sup>2</sup>. However, in clinical practice, 7T-MR are not routinely available. **To improve detecting capability for CVS at 3T-MR, we introduce an imaging protocol with the use of Ferumoxytol.** 

## METHOD

We enrolled 10 MS patients in total. The enrolled patients met Barkhof's Criteria<sup>3</sup> published in 1997 for MS brain imaging abnormality.



Fig.1 Inclusion and exclusion criteria for MS patients.



<sup>3</sup>T MR imaging system (Magnetom Skyra; Siemens) MRI\_Step1: 3D-T1+3D-FLAIR+SWI (post-Gd) MRI\_Step2: SWI (post-USPIO) MRI-2d: 3D-T1

Fig.2 MRI data acquisition process

# RESULT

A dose of 2mg/Kg USPIO has the highest value of contrast-to-noise ratio (CNR) and the optimal ability to detect cerebral veins. In contrast to gadolinium contrast agent, USPIO allows detection of CVS not only in the typical lesion of MS, but also in the subtentorial lesion and small lesions (diameter <3 mm).

There was a total of 531 WMLs in 10 MS patients. CVS could be observed in 435 WMLs after injection of USPIO while 305 WMLs after injection of gadolinium.

Tab.1 Clinical characteristics.

$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Onset age, y/sex	Diseas e Dura- tion, y	No. of attacks	EDSS at last flow-up	MMSE	MOCA	Other serumauto -antibodies	CSF OCB	Clinically phase	Treatment	TIV (cm³)	cortical thicken- ss (mm)
2 33/M 5 2 2 30 29 - - remission CS 1377 2.734.0.77   3 25/F 2 2 1 29 2.8 - + remission CS 1377 2.734.0.77   4 22/F 13 6 3 28 2.5 PR3 - remission CS 1393 2.494.0.68   5 27/M 9 5 3 2.8 2.4 - - remission AZA, 1556 2.422.0.66   6 25/M 3 3 2.5 2.9 2.6 - + remission C6 .44 1.50 2.422.0.66   7 31/F 2 2 1 2.8 2.9 - + remission Tc/ftunonide 1202 2.640.075 7   7 31/F 2 2 1 2.8 2.9 - + remission Tc	1	20/F	15	>10	4	30	22	ACA-IgM	7	remission	Teriflunomide	1506	2.71±0.81
3 25.7 2 2 1 29 28 - + remission Terminonic 1299 2.804.7%   4 22.7 13 6 3 28 25 PR3 - remission CS 1393 2.4910.6%   5 27/M 9 5 3 28 24 - - remission CS 1299 2.4910.6%   7 3.17 2 2 12 26 - + remission CS 2.4910.6% 2.4210.6%   7 3.17 2 2 1 28 29 - + remission Termission 1417 2.6910.75   7 3.17 2 2 1 28 29 - + remission Termission 1417 2.6910.75   8 15.57 4 4 1 30 2.99 - - remission Teriffunomide 1201 2.624	2	33/M	5	2	2	30	29	-	-	remission	CS	1377	2.73±0.77
4 22/F 13 6 3 28 25 PR3 - remission CS 1393 2.49+0.68   5 27/M 9 5 3 28 24 - - remission CS 1393 2.49+0.68   6 27/M 3 3 2.5 29 2.6 - + remission AZA 1389 2.69+0.75   7 31/F 2 2 1 28 29 - + remission Terifluromide 1402 2.69+0.75   8 15/F 4 4 1 30 2.9 - + remission Terifluromide 1405 2.76+0.80   9 22/F 8 2 1.5 29 27 - - remission Terifluromide 120 2.69+0.75   10 28/M 9 4 3 - 14 - - remission Terifluromide	3	25/F	2	2	1	29	28	-	+	remission	Teriflunomide	1299	2.80±0.79
5 27/M 9 5 3 28 24 - - remission AZA, Terimunomia 155 2.42±0.66   6 25/M 3 3 2.5 29 26 - + remission / 1356 2.42±0.66   7 3/JF 2 2 1 28 29 - + remission Terifumomide 120 2.69±0.75   8 15/F 4 4 1 30 29 - + remission Terifumomide 140 2.69±0.75   9 22/F 8 2 1.5 29 27 - - remission Terifumomide 120 2.69±0.75   10 28/M 9 4 3 2 9 27 - - remission Terifumomide 120 2.69±0.75   10 28/M 9 4 3 - 14 - - remission Ter	4	22/F	13	6	3	28	25	PR3	-	remission	CS	1393	2.49±0.68
6 25/M 3 3 2.5 29 26 - + remission / 1389 2.6940.75   7 31/F 2 2 1 28 29 - + remission Terifluomide 1407 2.6940.75   8 15/F 4 4 1 30 2.99 - + remission Terifluomide 1405 2.6940.75   9 22/F 8 2 1.5 29 27 - - remission Terifluomide 1321 2.6740.50   10 28/M 9 4 3 - 14 - - remission Terifluomide 1321 2.6740.75   10 28/M 9 4 3 - 14 - - remission NF.~Y, AZA, 1523 2.4940.64   Terifluomide 1 3 - 14 - - remission Terifluomide 1232 <t< td=""><td>5</td><td>27/M</td><td>9</td><td>5</td><td>3</td><td>28</td><td>24</td><td>-</td><td>-</td><td>remission</td><td>AZA , Teriflunomide</td><td>1556</td><td>2.42±0.66</td></t<>	5	27/M	9	5	3	28	24	-	-	remission	AZA , Teriflunomide	1556	2.42±0.66
7 31.7 2 2 1 2.8 2.9 - + remission Termfunomide 14.17 2.690.07   9 22.7 8 2 1.5 2.9 2.7 - - remission Terffunomide 14.05 2.760.50   9 22.7 8 2 1.5 2.9 2.7 - - remission Terffunomide 1321 2.6240.75   10 28.M 9 4 3 - 1.4 - - remission Terffunomide 1523 2.4940.64   Termineton 192.3 - 1.4 - - remission Terffunomide 1523 2.4940.64	6	25/M	3	3	2.5	29	26		+	remission	1	1389	2.69±0.75
8 15/F 4 4 1 30 29 - - remission Terifluomide 1405 2.7640.80   9 22/F 8 2 1.5 29 27 - - remission Terifluomide 1321 2.6240.75   10 28/M 9 4 3 - 14 - - remission Terifluomide 1321 2.6240.75   10 28/M 9 4 3 - 14 - - remission Terifluomide 1523 2.4920.64   Terifluomide	7	31/F	2	2	1	28	29	-	+	remission	Teriflunomide	1417	2.69±0.75
9 22/F 8 2 1.5 29 27 remission Teriflutonide 1321 2.62±0.75 10 28/M 9 4 3 - 14 remission INF-Y, AZA, 1523 2.49±0.64 Teriflutonide	8	15/F	4	4	1	30	29	-		remission	Teriflunomide	1405	2.76±0.80
10 28/M 9 4 3 - 14 remission INF-γ, AZA, 1523 2.49±0.64 Teriflunomide	9	22/F	8	2	1.5	29	27	-		remission	Teriflunomide	1321	2.62±0.75
	10	28/M	9	4	3	-	14	-	-	remission	INF-γ, AZA, Teriflunomide	1523	2.49±0.64

AZA = azathioprine; CS = oral corticosteroids; EDSS =Expanded Disability Status Scale score; OCB = oligoclonal bands; MMSE = Mini-mental State Examination; MOCA = Montreal Cognitive Assessment;



**Fig.3** CNR values at different time-points after injecting different doses of USPIO.





**Fig.4** Comparison of central venous signs in post-Gd SWI and post-UPSIO SWI. (A. subtentorial WML; B. Subcortical lesion; C. Lesion perpendicular to the lateral

ventricles; D. Small lesions (diameter <3 mm))

#### Tab.2 Number of lesions with CVS in 2 scanning methods.

	Lesions with CVS/total number of lesions	n (%)
Post-Gd SWI	305/531	57.4%
Post-USPIO SWI	435/531	81.9%

#### CONCLUSION

After completing evaluation of 10 MS patients with USPIO enhanced SWI, we found that USPIO improve detecting capability for CVS at 3T-MR. Specifically, it was also able to enhance the detection of CVS in subtentorial WMLs as well as small lesions (diameter <3 mm). So, this method may be valuable for MS which involve the microvasculature.

#### REFERENCES

[1] Haoyu Wang, Quan Jiang, Yimin Shen, et al. The capability of detecting small vessels beyond the conventional MRI sensitivity using iron-based contrast agent enhanced susceptibility weighted imaging. NMR in Biomedicine 2020; e4256.

[2] Pascal Sati, Jiwon Oh, R. Todd Constable, et al. The central vein sign and its clinical evaluation for the diagnosis of multiple sclerosis: a consensus statement from the North American Imaging in Multiple Sclerosis Cooperative. Nat Rev Neurol2016;12(12):714-722.

[3] Barkhof F, Filippi M, Miller DH, et al. Comparison of MR imaging criteria at first presentation to predict conversion to clinically definite multiple sclerosis. Brain 1997;120:2059–2069.