

SPIO

가 MR

1

2

: MR , SPIO가 , MR 가

: SPIO 112 $\mu\text{gFe/mL}$ 2.384×10^{-7} $\mu\text{gFe/mL}$ T2*

112 $\mu\text{gFe/mL}$ SPIO 24

SPIO가 1×10^6 1/4

MR T2*

: SPIO 가 28 $\mu\text{gFe/mL}$ T2* 가 가 ,

0.219 $\mu\text{gFe/mL}$ 가 (plateau)

SPIO 가 가 , SPIO가

가 122 MR T2*

: SPIO 가 가 T2* 가 , SPIO

가 488 T2* 가

(molecular Imaging) (cellular imaging) . SPIO 가 , SPIO가 (susceptibility effect)

(magnetic resonance, MR) (1). MR (3). (iron oxide) (3),

. MR MR , SPIO가 SPIO 가

(1). (superparamagnetic iron oxide, 가 MR MR 가

SPIO) MR

(macrophage) (2). (phagocytic cell)

MR Philips 1.5 - T Gyroscan Intera (Philips, Best, the Netherlands)

T2* (T2* - weighted gradient echo)

. (Repetition time/Echo time = 313 msec/14 msec, 18 ° flip angle, 512 × 512 matrix, 1.5 - mm section thickness)

1

2

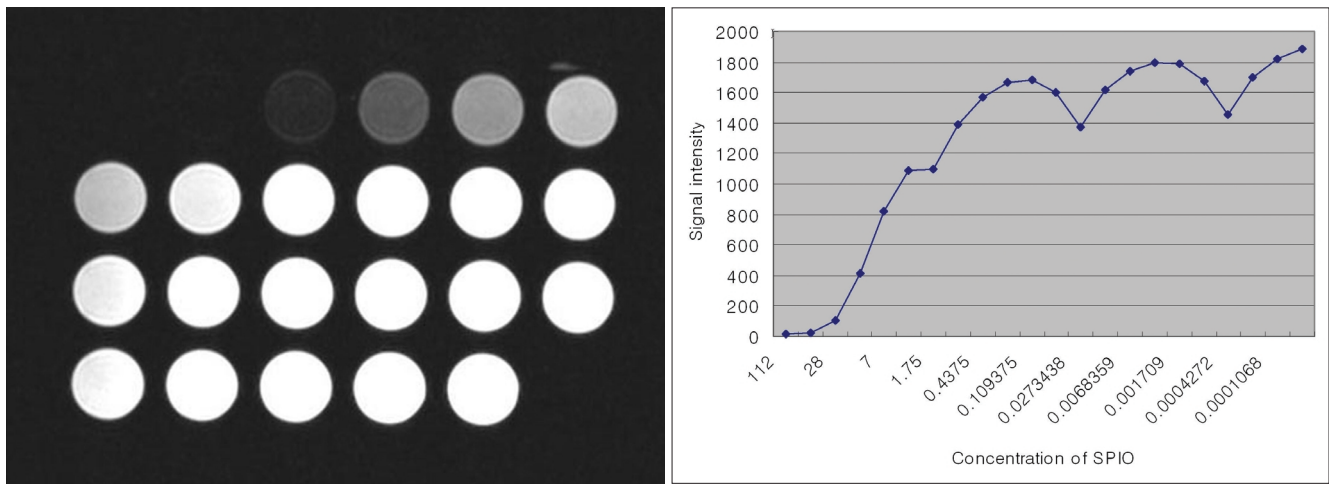
2005

2005 12 30

(05 - 384)

2006 8 11

SPIO MR
 SPIO T2* 1.5T MR
 가 , 24
 (well plate) 112 $\mu\text{gFe/mL}$ 1/2
 22 $2.384 \times 10^{-7} \mu\text{gFe/mL}$
 T2* .
 Region of Interest (ROI) 1 cm^2
 .
 3% aged Brewer's thioglycollate 1 mL
 saline, 5 (Phosphate buffered
 PBS) (peritoneal washing)
 가 (4). 60 10 mL
 0.2N , 10 mL 1.8 N
 fetal calf serum RPMI - 1640
 37 2 (tissue culture flask)
 가
 PBS 가
 SPIO
 가 112 $\mu\text{gFe/mL}$
 SPIO 25 $\mu\text{gFe/mL}$, Feridex, Berlex Laboratories)
 24
 : SPIO 가 MR
 SPIO , 37 10 mmol/L
 EDTA (ethylenediaminetetraacetic acid) 가 PBS
 10 - 15 .
 PBS
 EDTA . SPIO
 , (Prussian -
 blue staining) .
 SPIO 가 MR
 Neubauer hemocytometer (Neubauer, Marienfeld,
 Germany) Trypan blue SPIO
 . SPIO
 MR T2* (detectabi -
 ility) , 1×10^6 가
 1 10 tube 1/4
 8000 rpm 10
 , SPIO
 MR
 SPIO 112 $\mu\text{gFe/mL}$ $2.384 \times 10^{-7} \mu\text{gFe/mL}$
 T2* , SPIO
 가 112 $\mu\text{gFe/mL}$, $\mu\text{gFe/mL}$ SPIO
 T2* MR 가
 . SPIO 가 28 $\mu\text{gFe/mL}$
 가 가 , 0.219 $\mu\text{gFe/mL}$
 가 (plateau) (Fig. 1).
 1×10^6
 24 SPIO



A
 Fig. 1. T2-weighted MR image of variable concentration of iron oxide. According to the decreased concentration of iron oxide, signal intensity of MR image was increased gradually.
 B. Plotting of the relation between the concentration of iron oxide and signal intensity.

SPIO 가 (Fig. 2).
 SPIO가 T2* SPIO
 1 (1 × 10⁶ cells)
 6 (488 cells)
 7 (122 cells)
 가 MR (Fig. 3).

(targeted macromolecules)

(biological

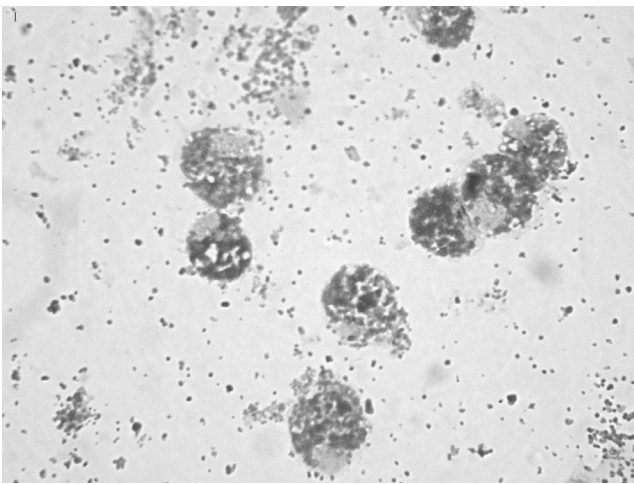


Fig. 2. Prussian blue staining of macrophages after incubation with 112 μ gFe/mL tissue culture flask for 24 hours. Compact upkake of SPIO was detected in the cytoplasm of the macrophages. (Prussian blue staining; $\times 200$)

processes)

(1).

(cellular level)

(molecular level)

MR (ultra - small super -
 paramagnetic iron oxide, USPIO)

가 USPIO

가

(5 - 15). Kooi (8)

(prospective patient trial)

USPIO

(stable

plaque)

(rupture)

(cyclosporine)

(acute tubulopathy),

(12).

(13)

(14),

(experimental allergic encephalomyelitis) (15)

MR

USPIO

, FDA SPIO, Feridex (ferumoxides
 injectable solution, Berlex Laboratories, Montville, NJ,
 U.S.A.) 가 , USPIO

product Combidex (Ferumoxtran - 10, Advanced

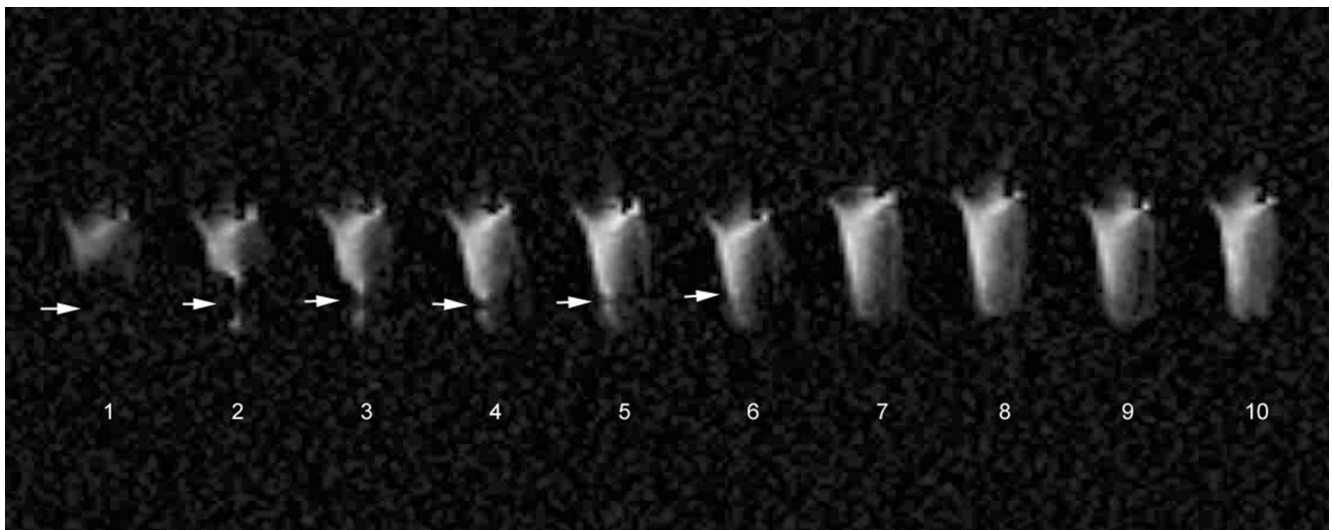


Fig. 3. T2*-weighted GRE MR image (313/14, 18 °flip angle) of micro tubes with variable number of macrophages labelled with superparamagnetic iron-oxide. There was very strong susceptibility artifact (arrows) in #1 tube with 1 × 10⁶ macrophages. The susceptibility effect could not be detected in the tubes with macrophages no more than 122 macrophages (#7 - 10 tubes).

Magnetics, Cambridge, MA, U.S.A.) Sinerem (AMI - 227, Guerbet, Paris, France) (1).
 USPIO 가 MR , USPIO 가 MR ,
 (biodegradation) 가 ,
 T2* 가 SPIO가 ,
 SPIO 가 micron-sized iron oxide particles (MPIOs)가 (16).
 가 . SPIO
 Fe₂O₃·Fe₂O₃ (17) 가 , 50 nm
 (18) (nanoparticle) (18).
 (dephasing) T2*
 가 (19). SPIO
 T2* 가
 Fleige (20) USPIO 0 μmol/L 1,000 μmol/L
 L 가 MR . USPIO
 가 0 100% , USPIO
 가 300 μmol/L 40-50%가 ,
 800 μmol/L .
 SPIO 가 0.219 μgFe/mL
 100% , SPIO 가 1.75 μgFe/mL
 50-60%가 , SPIO 가
 28 μgFe/mL , T2* 가
 MR T2* SPIO
 0.219 μgFe/mL .
 (foreign material) 가
 27가 . 가 1 μm
 (phagocytosis) ,
 (pinocytosis)
 (21). Raynal (3) SPIO 가 62.5,
 125, 250 μgFe/mL 2
 SPIO ,
 62.5 μgFe/mL 5 pg Fe , 250
 μgFe/mL 7.7 pg Fe .
 100 μgFe/mL 24, 48, 72
 , 2.5, 2.9. 6.2 pg Fe
 SPIO
 가 SPIO 가
 : SPIO 가 MR
 가 SPIO 100 μgFe/mL, 500 μ
 gFe/mL 48 ,
 가 -1 가 ,
 SPIO
 . SPIO 가 112 μ
 gFe/mL 24 ,
 SPIO가
 . SPIO MR
 SPIO MRI
 . Foster - Gareau (22)
 1.5 T MR SPIO
 . Fleige (20) neutral carboxydextran-coated
 가 1 × 10⁶ , acidic citrate-coated
 USPIO 가 0.09 × 10⁶ , MR
 USPIO
 .
 1.5 T MR SPIO 가 488
 MR 가 . Fleige
 (20) 3 mmol/L USPIO 120
 , 112 μgFe/mL SPIO 24
 , USPIO SPIO
 MR 가
 .
 MR ,
 , 가가 가 .
 (Non-phagocytic cell) SPIO
 (cell migration)
 (trafficking) 가 (19, 23-25).
 (monitor)
 (target cell) (migration)
 가 , 가 가
 (target organ) 가
 T 가
 (26, 27). SPIO , SPIO
 , SPIO (28, 29).
 ,
 SPIO 가
 MR
 (Unpublished data). SPIO
 .
 , SPIO가
 , 가
 SPIO
 SPIO
 가

		가	가
	SPIO	112 $\mu\text{gFe/mL}$	2.384
$\times 10^{-7}$ $\mu\text{gFe/mL}$		T2*	
SPIO		T2*	
	112 $\mu\text{gFe/mL}$	SPIO	24
		SPIO	
SPIO가		MR T2*	
	SPIO	가 488	
		T2*	가

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Relationship between the Number of SPIO-labeled Macrophage and MR Signal Intensity¹

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Purpose: For the in vivo imaging of macrophages using MRI, the feasibility of labeling macrophages with iron oxide and the number of SPIO-labeled macrophage detected in 1.5 T MR, were assessed.

Materials and Methods: The MR signal intensity was measured with variable concentrations of iron oxide, ranging from 112 to 2.384×10^{-7} $\mu\text{gFe/mL}$. The macrophages were incubated in SPIO solution (112 $\mu\text{gFe/mL}$) for 24 hours. The MR signal intensity was measured in variable numbers of SPIO-labeled macrophages.

Results: The MR image signal intensity gradually increased with decreasing SPIO concentration, and reached a plateau at a concentration of 0.219 $\mu\text{gFe/mL}$. After incubation with iron oxide, the compact uptake of SPIO was detected in the cytoplasm of the macrophages using Prussian blue staining. No susceptibility effect was detected in the tubes of more than 122 macrophages.

Conclusion: The MR signal intensity was dependent on the number of macrophages. No susceptibility effect due to a cluster of SPIO-labeled macrophages was detected in more than 488 cells.

Index words : Phantoms

Magnetic resonance (MR), experimental studies

Magnetic resonance (MR), contrast enhancement

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