



가 3 1

2

가 3 (3D - con -
trast enhanced - magnetic resonance angiography: 3D - CE - MRA) 가

가

3D - CE - MRA 44

1.5T MR 3

MR flu -
oroscopy , 0.2 mmol/kg Gd - DTPA 1 cc/ sec

3 (signal to noise ratio, SNR)
(contrast to noise ratio; CNR)

6 가 MRA
3 4 가 44
3D - CE - MRA 8

15 (± 5)

SNR 26.5 ± 11.6 CNR 24.6 ± 11.2

525 498 (94.9%) 가

98.5% (260/264), 89.7% (211/261) (*p* < 0.01).
가 가 1.9% (10/525)
, MRA

96%, 98.8% , 50%

82.2%, 92.9%

: 3D - CE - MRA 가

(digital subtraction angiography: (magnetic resonance angiography: MRA)
DSA) 가

가 (1, 2). 가 (3, 4). MRA
가 DSA
(5 - 10). (contrast - enhanced MRA:

1
2

2002 7 10 2002 12 17

573

가 3

CE - MRA)
T1 (Siemens, Erlagen, Germany)

MR 10 - 20 (body)
4 , 8 circularly polarized element , 95 cm
(time of flight sequence: TOF)
가 가 가
(6 - 9). 가

가 (9 - 3
(axial scout)
(phase contrast sequence)
(localizer)

11). MR
(imaging parameters) 3 (fast low angle shot: FLASH)
가 [TR/TE=3.8/1.4 msec, (flip angle) 25 °; (matrix)
TR TE 가 3 192 × 512, (field of view: FOV) 450 × 450 mm,
(autoinjector) , MR (slice thickness) 1.5 - 2 mm, (slab thickness)
fluoroscopy (automatic table moving) 3D - 40 mm, 60 - 80% k - , zero interpolation 2,
CE - MRA 가 3 cm]
가 12 , 25 가 ,
3 가
3 k -
2001 3 2002 5 (time to k - space center)
3D - CE - MRA 46 1/4 3 ,
0.5

MR 2 gadopentetate dimeglumine
44 (36 , 8) . 44 8 (Magnevist ; Schering, Berlin, Germany) 1 cc
MRA 4 DSA 가 , 2 MR fluoroscopy
5 . 9 (Care bolus technique: Siemens, Erlagen, Germany)
가 3
3 가

Fontaine (stage I, asymptomatic; stage II, intermittent claudication; stage III, pain at rest; stage IV, ulceration or gangrene of foot or toes)
gadopentetate dimeglumine 19 0.2 mmol/kg
30 cc 10 cc
(stage II) 20 , (stage III) (autoinjector: Medrad, Pittsburgh, U.S.A.) 1
12 , (stage IV) 9 , 3 cc/sec 40 20 cc
가 (subtraction)

53 - 77 (68.5) , 18 ,
15 , 1 (maximum intensity pro -
jection: MIP) (Fig. 1).
15 (± 5) ,
MRA (postprocessing) 5
MR 1.5T
(Magnetom Symphony; Siemens, Erlagen, Germany)

DSA
 44 8
 (Angiostar; Siemens,
 Erlangen, Germany)
 5 - Fr (Pigtail; Cook, Bloomington, U.S.A.)
 3
 Visipaque (Iodixanol, Nycomed, Oslo,
 Norway) 320 mg/ml 30 cc

MRA
 DSA MRA
 kappa test
 가 가
 chi - square
 p < .05

44 MRA 가
 가 (region of interest, ROI)
 (signal to noise ratio: SNR)
 (contrast to noise ratio: CNR)
 $SNR = \frac{\text{Mean Signal}}{\text{Standard Deviation of Noise}}$
 $CNR = \frac{\text{Mean Signal} - \text{Mean Background}}{\text{Standard Deviation of Noise}}$
 가
 6
 3
 : 3 - , 2 -
 , 1 -
 4 : 4 -
 , 3 - 가
 , 2 -
 가가 가 가 ,
 1 - 가 가
 , MRA DSA 4 8
 가 가
 12
) 가 : 4 - , 3 - 50% , 2 -
 50% , 1 - . DSA MRA
 DSA

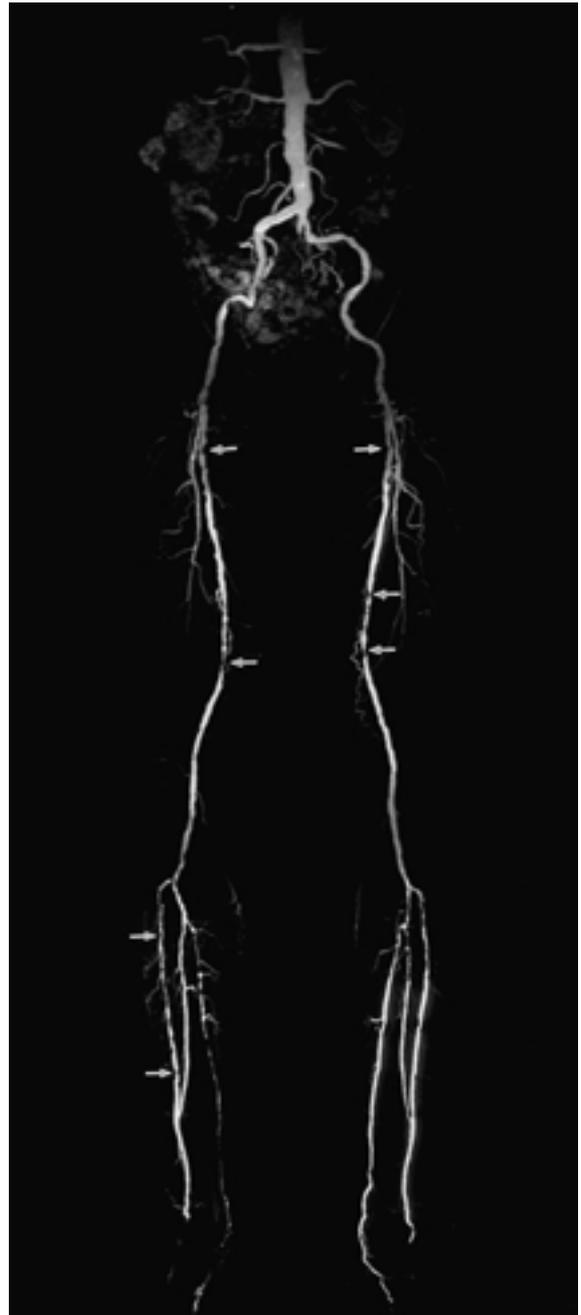


Fig. 1. Contrast-enhanced MR angiogram obtained in a 68-year-old male with intermittent claudication. Note excellent depiction of multifocal atherosclerotic changes (arrows) of the entire lower extremity arteries without venous contamination.

Table 1. Signal to Noise Ratio and Artery to Soft Tissue Contrast to Noise Ratio in 44 Patients

	Aorta	Iliac Artery	Femoral Artery	Tibial Artery	Mean
SNR (vessel)	19.8 ± 7.2	25.5 ± 11.3	35.6 ± 12.7	25.2 ± 8.7	26.5 ± 11.6
SNR (soft tissue)	1.5 ± 0.3	1.5 ± 0.3	2.4 ± 1.4	2.3 ± 1.1	2.1 ± 1.1
CNR	18.3 ± 7.0	24.0 ± 11.3	33.2 ± 11.8	22.9 ± 8.8	24.6 ± 11.2

SNRs of soft tissue are the values in the soft tissues adjacent to each arterial segments

Table 1 . 4
 (SNR)가 35.6 ± 12.7 가
 (SNR) 26.5 ± 11.6
 (SNR) 2.1 ± 1.1
 (CNR)
 24.6 ± 11.2 , 33.2 ± 11.8 가
 44 6 525
 가
 가가 가 (3) 498 (94.9%) (Fig.
 1), 가 가
 (2) 27 (5.1%) , 8
 (29.6%) 19
 (70.3%)
 (1)
 (p > 0.05).
 Table 2 . 44
 12 (27%)
 5 (11%)
 , 가
 가 (4 3
) 471 90%
 가 (2 1) 54

Table 2. Assessment of Venous Contamination with MR Angiography in Each Arterial Segment

	G4	G3	G2	G1	Total
Upper Level					
Iliac A	83 (94)	5 (6)	-	-	
Femoral A	71 (81)	13 (15)	4 (4)	-	
Popliteal A	75 (85)	13 (15)	-	-	264
Lower Level					
Anterior tibial A	43 (50)	28 (32)	13 (15)	3 (3)	
Posterior tibial A	46 (53)	25 (29)	13 (15)	3 (3)	
Peroneal A	43 (49)	26 (30)	14 (16)	4 (5)	261
Total	361 (68.8)	110 (20.9)	44 (8.4)	10 (1.9)	525

Numbers in parentheses are percentages. A: artery
 G4: good arterial imaging without venous contamination, G3: minimal venous contamination without obscuration of arteries, G2: moderate venous contamination with obscuration of arteries partially, G1: severe venous contamination with obscuration of arteries totally



Fig. 2. Contrast-enhanced MR angiogram obtained in a 45-year-old man with right lower leg swelling. There is severe venous contamination of right calf compared with left side. Right calf vessels were regarded as grade 1.

10% (Fig. 2).
 (4 3) 98.5%
 (260/264), 89.7% (211/261) ($p <$
 0.01). 가
 (1) 1.9% (10/525)
 MRA DSA 8 186
 DSA 93
 MRA 80 (Fig. 3). DSA
 93 , 50% 46 , 50%

Table 3. Assessment of Degree of Stenosis with Conventional and MR Angiography in 186 Arterial Segments

Digital Subtraction Angiography	MR Angiographic Findings			
	G4	G3	G2	G1
G4	87	3	2	1
G3	10	32	4	-
G2	8	1	13	-
G1	1	-	1	23

G4: normal, G3: stenosis with less than 50% luminal narrowing, G2: stenosis with 50% luminal narrowing or more, G1: occlusion. kappa value = 0.75



Fig. 3. 70-year-old man with resting pain of both lower legs.

A. Digital subtraction angiography reveals severe stenosis of left common iliac artery (thin arrow) and occlusion of left common femoral artery (thick arrow). Occlusion of both superficial femoral artery (open arrow) also was seen, with reconstitution of distal flow on both sides at the level of the adductor canal (large arrowheads) by collateral circulation from the deep femoral arteries (small arrowheads).

B. MR angiogram correlated well (arrows) with findings of digital subtraction angiography.

22, 50% 가 25 가 MRA 106, (16, 36, 50% 20, 24 17) , 3D - CE - MRA 가 (gadolinium chelate) , T1 가 가 (18 - 20). (subtraction) MRA 가 50% DSA 가 1 3 2 (FOV) 45 cm 100 cm SNR 가 (multistation) bolus chase (9 - 11). 98.8% (160/162) 96% (23/25), 50% 가 가 (station) 가 가 (12). 3%, 75 20% 가 가 (10). (claudication) , 가 CE - MRA (13). X - DSA 가 k - test bolus , best - guess , MR fluoroscopy , automatic triggering software [e.g., Bolus Track (Philips Medical Systems, Best, Netherlands)], MR SmartPrep (GE Medical Systems, Milwaukee, Wisconsin, U.S.A.) (21 - 25). MR fluoroscopy , 2 (14, 15). 가 가 test - bolus 가 가 (3, 가 525 4). MR 498 (94.9%) .

44 12 (27%)
 5 (11%)
 , 가 .

2 - 5 ml/sec 0.1 mmol/kg
 , 0.2 mmol/kg
 3 ml/sec 가 (5, , CE - MRA
 18, 26).

가 .

half - Fourier acquisition, partial echo acquisition, zero -
 filled interpolation, k -
 70% (28 - 30),
 (11, 27). 0.2 mmol/kg (30 cc) 10 cc
 mmol/kg k - SENSE (Sensi - tivity
 1 cc/sec 40 encoding), SMASH (simultaneous acquisition of spatial
 (circulation time) 가 harmonics) parallel acquisition technique
 가 (31, 32).
 가 3D - CE - MRA DSA
 3D - CE - MRA 가 89 - 97%, 95 - 99%
 (11, 34, 35).
 k - 1 m 가 , MR
 FOV 45 cm 3 50% 가
 1 3 82.2%, 92.9%
 k - 가 93.1%, 98.5% 66.6% 88%
 가 k - 가
 가 1 2 11 3
 12 , 9 DSA 50%
 3 . 30 mT/msec MRA
 TR TE가 2 MRA
 (interpolation) k - (partial fourier) 가 DSA
 (28 - 30). , k - 가
 가 k - 3 MRA 17 DSA
 Ruehm (33) Meaney (34)
 가 DSA
 가 가 k - 3 (bias)
 , k - MRA DSA
 가 가 DSA
 가 k - 가 CE -
 가 1 2 MRA , 가
 1/4 , 3 가
 (0.5) 3 k - 가 15 , DSA
 40 가 가
 가 CE - MRA가 가
 (screening test)

가 MRA DSA MRA
 가 , MRA
 DSA MRA
 가 (screening
 가
 3D - CE - MRA DSA
 가

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Usefulness of Three-dimensional Contrast-Enhanced MR Angiography in the Evaluation of Pelvic and Lower Extremity Arteries¹

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Purpose: To evaluate the feasibility and clinical usefulness of three-dimensional contrast-enhanced MR angiography (3D-CE-MRA) as a screening test in the evaluation of pelvic and lower extremity arterial diseases.

Materials and Methods: Forty-four patients who underwent 3D-CE-MRA were included in this study. Coronal 3-dimensional gradient-echo, pre-and post contrast image were acquired with a dedicated peripheral vascular coil and moving-bed technique on a 1.5T MR system. Timing of start of data acquisition was determined by MR fluoroscopy technique, and 0.2mmol/kg Gd-DTPA was injected into an antecubital vein, at a rate of 1cc/sec with an autoinjector. For quantitative analysis, signal to noise ratio (SNR) and artery to soft tissue contrast to noise ratio (CNR) of lower extremities arterial system including lower abdominal aorta were calculated. For qualitative analysis, arterial systems were divided into six segments, and were evaluated in terms of conspicuity of arterial systems and the degree of venous enhancement by three- and four-point scale respectively. In eight patients who underwent both MR angiography and conventional angiography, the degree of the stenosis of MR angiography was compared with conventional angiography as standard reference. Imaging analysis was done by means of consensus between two experienced radiologists.

Results: The mean time for the examination was about 15min (± 5 min). The mean SNR of arterial system was 26.5 ± 11.6 , and mean artery to soft tissue contrast to noise ratio (CNR) was 24.6 ± 11.2 . Among the total 525 arterial segments, 498 arterial segments (94.9%) could be demonstrated with good delineation of entire arterial tree. Good arterial imaging without or with minimal venous enhancement were demonstrated in 98.5% (260/264) in above knee and 89% (211/261) in below knee ($p < 0.01$). Ten of 525 segments (1.9%) demonstrated severe venous overlapping and it mostly occurred in the calf region. In comparison with DSA, the sensitivity and the specificity for MR angiography for the detection of occlusions were 96% and 98.8%, respectively, and for the detection of more than 50% stenosis, 82.2% and 92.9%, respectively.

Conclusion: 3D-CE-MRA provided adequate image for the evaluation of the lower extremity artery, and could be used as a screening test for arterial occlusive diseases.

Index words : Extremity arteries

Magnetic resonance (MR), vascular studies

Magnetic resonance (MR), contrast enhancement

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