Original Research

MR Angiography of the Foot and Ankle[1]

Evan C. Unger, MD • Jolyon D. Schilling, MD • A. Nicholas Awad, MD • Kenneth E. McIntyre, MD
Mark T. Yoshino, MD • Gerald D. Pond, MD • Ammar Darkazanli, PhD • Glenn C. Hunter, MD
Victor M. Bernhard, MD

To better understand the use of magnetic resonance angiography (MRA) in evaluating peripheral vascular disease, the authors studied arteries in the foot and ankle. Twenty patients with arterial occlusive disease of the lower extremity were studied with two-dimensional time-of-flight MRA, and the results were compared with those of 10 conventional x-ray arteriograms, four digital subtraction arteriograms, and three intraoperative arteriograms. The studies were reviewed and rated by three radiologists blinded to the patients' clinical history. Also, the first 16 patients were examined with MRA before and after intravenous injection of gadopentetate dimeglumine. The mean confidence levels for the reviewers' interpretations of the MRA studies were significantly higher than those for the conventional arteriograms for the medial plantar, lateral plantar, and plantar arch arteries of the feet ($P \leq .005$). Postcontrast MRA images were inferior to precontrast images because of overlapping of veins and arteries. Time-of-flight MRA without gadolinium can serve as a useful complementary study for evaluating patients with peripheral vascular disease in the foot and ankle.

Index terms: Ankle, MR, 929.12942 • Arteries, extremities, 929.12942 • Arteries, MR, 929.12142 • Arteries, stenosis or obstruction, 929.721, 929.724 • Comparative studies • Diabetes mellitus, complications • Foot, MR, 929.12942

JMRI 1995; 5:1–5

Abbreviations: DSA = digital subtraction angiography, MRA = MR angiography, TOF = time of flight, 2D = two-dimensional.

MAGNETIC RESONANCE (MR) angiography (MRA) has already been evaluated in the central nervous system (1–5). Comparatively little work has been published regarding the role of MRA in evaluating peripheral arterial occlusive disease (6). Unlike previous reports that have addressed the role of MRA in the large vessels of the lower extremity (6), this study prospectively evaluated this modality for imaging of the foot and ankle vasculature, placing particular emphasis on the arterial circulation of the foot in patients with suspected distal arterial occlusive disease. It is often difficult to obtain high-quality images of the foot and ankle in patients with lower extremity occlusive disease with x-ray angiography because of multiple levels of atherosclerotic disease and slow flow, which frequently make visualization of foot and ankle vessels suboptimal. Visualization of arterial anatomy in the foot is critically important in planning operative treatment for these patients. Accordingly, we performed a study to evaluate the use of MRA in peripheral vascular disease.

• MATERIALS AND METHODS

In a preliminary study of six healthy volunteers, we compared two-dimensional (2D) and three-dimensional, time-of-flight (TOF) and phase-contrast MRA, with and without saturation pulses. After review of images by the authors (E.C.U., A.N.A.), it was determined that 2D TOF MRA provided the best and most consistent image quality within a reasonable imaging time. Accordingly, 2D TOF MRA was used in the subsequent phase of the study. Twenty patients (nine men, 11 women; mean age, 64 years) with lower extremity arterial occlusive disease were studied with 2D TOF MRA. Twelve of the patients were diabetic and had chronic foot ulcers. A knee coil (GE Medical Systems, Milwaukee, Wis) was used to obtain spoiled gradient-echo vascular TOF images of the foot and ankle in the axial plane at 128 section locations (80 in the ankle) with the following parameters: TR msec/TE msec = 45/15, 20-cm field of view, 60° flip angle, 256 × 128 matrix, 1.5-mm section thickness, one signal acquired, and an imaging time of 12 minutes 53 seconds. Frequency encoding was in the anteroposterior direction, and saturation slabs were applied inferiorly outside the imaging volume.

[1] From the Departments of Radiology (E.C.U., A.N.A., M.T.Y., G.D.P., A.D.) and Vascular Surgery (J.D.S., K.E.M., G.C.H., V.M.B.), University of Arizona Health Sciences Center, 1501 N Campbell Avenue, Tucson, AZ 85724. Received March 15, 1994; revision requested May 12; revision received May 27; accepted June 6. Supported in part by a grant from the General Electric Company. **Address reprint requests to** E.C.U.

Mean Confidence Levels for Interpretations of Angiographic Studies of Arteries of the Foot and Ankle

Imaging Method	Anterior Tibial	PTA	Peroneal	Dorsal Pedal	PTF	Medial Plantar	Lateral Plantar	Plantar Arch	Digital
CAG	2.79	2.89	2.57	2.30	2.08	1.94	1.77	1.83	1.58
MRA	2.91	3.00	2.88	2.77	2.72*	2.32†	2.47†	2.65‡	1.60
DSA	3.00	2.92	2.83	2.50	2.70	2.60	2.50	2.44	2.13
OAG	2.67	3.00	3.33	3.00	3.50	2.67	2.67	3.00	3.00

Note.—A value of 4.0 is the highest possible confidence level. CAG = conventional arteriography, OAG = intraoperative arteriography with intra-arterial injection of contrast material, PTA = posterior tibial artery in ankle, PTF = posterior tibial artery in foot (distal ankle).
*P = .051 (not significant) for comparison of MRA and CAG.
†$P \leq .005$ for comparison of MRA and CAG.
‡$P \leq .001$ for comparison of MRA and CAG.

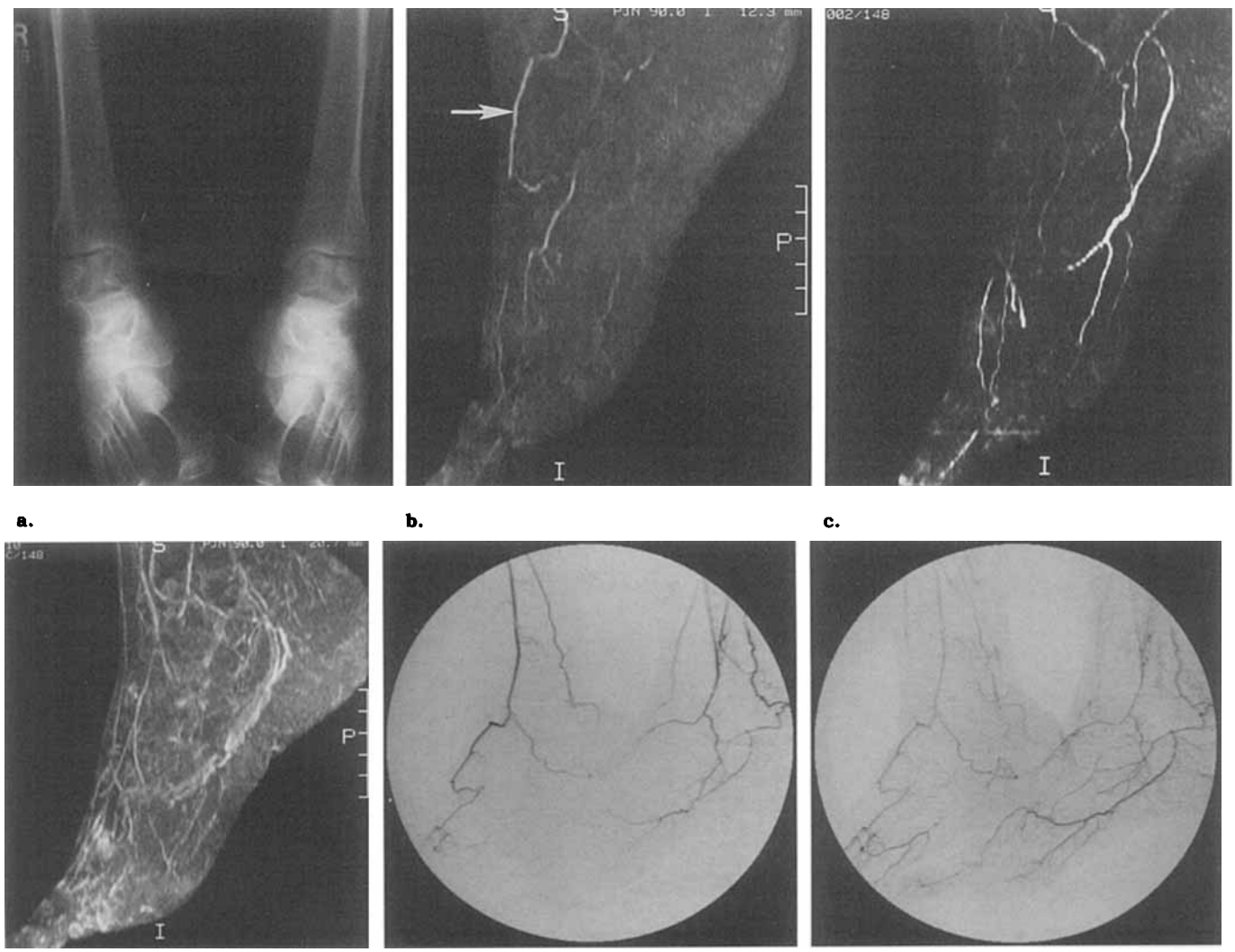

Figure 1. Images of 58-year-old woman with blue toe syndrome. **(a)** Conventional arteriogram shows poor visualization of flow to both distal extremities. **(b)** MRA image (45/15) of right foot shows improved visualization of flow compared with conventional study. Flow is seen in the proximal dorsal pedal artery (arrow), with distal occlusion. Flow to plantar vessels is poor. **(c)** MRA image of left foot shows flow in plantar vessels, with nonvisualization of the dorsal pedal artery. **(d)** MRA image of left foot after injection of gadopentetate dimeglumine shows enhancement of soft tissues and veins and arteries. Overlapping of signals from venous and arterial structures hinders appreciation of arterial anatomy. **(e, f)** Two images from DSA study show improved visualization of arterial anatomy compared with the conventional arteriogram and confirm the MRA findings.