48 Contrast-Enhanced MRA: Peripheral Circulation

Figure 48.1A illustrates 3D contrast-enhanced MR angiography (CE-MRA) of the lower extremities in a patient with no significant stenoses or occlusions. The adjacent 3D CE-MRA examination of the femoropopliteal distribution (Fig. 48.1B) reveals, in a different patient, bilateral superficial femoral artery occlusion with development of profunda femoral artery collaterals. Figure 48.1C and Fig. 48.1D are multiphase CE-MRA images of the tibioperoneal distribution obtained during early arterial enhancement and (with a slight time delay) after substantial venous filling. In the latter image, the large vascular malformation in the left gastrocnemius is more completely visualized because of opacification of the venous component.

Peripheral MRA may be performed in three ways: time-of-flight (TOF) (see Cases 42 and 43), phase-contrast (see Case 45), and contrast-enhanced (CE). The latter technique dominates in clinical application, due to the short scan time and, more importantly, because its sensitivity and specificity approach that of traditional x-ray angiography for peripheral vascular disease. Peripheral 3D CE-MRA typically uses short TR/short TE 3D gradient echo sequences, obtained in three to four stations in the coronal plane. Automated table positioning is incorporated with image acquisition at each station. Timing is set so that the scan is acquired during passage of the gadolinium chelate bolus, or equivalently during maximal contrast concentration within the vessel of interest. Detection of T1 shortening and therefore the start of image acquisition occur via one of four methods. (1) A test bolus may be used to approximate the timing of bolus arrival during the actual examination. (2) In MR fluoroscopy, rapid 2D scans allow the technologist to monitor for arrival of the contrast bolus and thereby manually initiate the 3D CE-MRA scan (used for Fig. 48.1A, B). (3) In multiphase CE-MRA (Fig. 48.1C, D), rapid-time sequential 3D scans are acquired, permitting dynamic imaging of the passage of contrast through the arterial and venous circulation. (4) Automated bolus detection algorithms involve computer detection of bolus arrival and initiation of image acquisition.

The center of k space (see Case 7), which is the major determinant of image contrast, must be obtained when arterial enhancement is at its peak (not on the up-slope as this increases ring artifact) and venous enhancement is at a minimum. At station 1 (aortoiliac), the center of k space is obtained near either the midpoint or end of the scan to ensure that data acquisition occurs during arterial enhancement (with the scan initiated when contrast is first visualized in the proximal aorta). This order of acquisition is commonly “reversed” in station 2 (femoropopliteal) and station 3 (tibioperoneal) or in station 3 alone. The center of k space in the latter station(s) is obtained during the beginning of the scan via centric phase reordering, ensuring that this portion of the scan is acquired during peak arterial enhancement.

Recent innovations continue to improve the diagnostic quality of peripheral CE-MRA. Simplifying patient setup, image acquisition can be performed during continuous table movement, as opposed to a multistation approach (see Case 51). For the calf and foot, pulse sequences developed to provide time-resolved high-resolution MRA (see Case 49) offer improved distal arterial vessel visualization and decreased venous contamination.