

## High Temporal and Spatial Resolution Imaging of Vascular Malformations of the Extremities

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**Introduction** Treatment options for vascular malformations (VM) are relatively limited and may worsen symptoms if not appropriately applied [1]. Choice of treatment and treatment planning require accurate characterization of the vascular lesion including its structure, extent, and hemodynamics. Time-resolved contrast-enhanced MR angiography techniques with both high temporal and spatial resolution may provide structural detail of the malformation and normal vasculature as well as functional information about the feeding and draining vessels and hemodynamics of the vascular malformation. This may offer improved pre-treatment lesion characterization and aid in treatment planning. The purpose of this work is to apply a recently developed time-resolved CE-MRA technique, CAPR [2], to perform high spatial and temporal resolution imaging of peripheral vascular malformations that allows for accurate lesion characterization and treatment planning.

**Methods** The CAPR sampling pattern used for the calves [3] was adjusted for imaging of vascular malformations of the forearms, hands, thighs, and feet with approximately 1 mm isotropic spatial resolution and frame times of 3.5-7.0 sec. Acquisition parameters were TR/TE 5.68/2.54 msec, BW  $\pm$ 62.5 kHz, flip angle 30°, and 8x SENSE acceleration ( $R_y = 4$ ,  $R_z = 2$ ). The use of partial Fourier with homodyne reconstruction provides an additional acceleration of 1.8x, for a net acceleration of 14.4x. A 3T imager (GE, V20.0) with custom surface coil receiver arrays was used. Studies were generally bilateral, allowing for comparison of the flow pattern of the affected side with that of the normal contra-lateral side. For the contrast-enhanced CAPR acquisition approximately 20 ml Gd contrast agent was injected at 3 ml/sec followed by 20 ml saline at 3 ml/sec. The scan was started prior to contrast injection to acquire one full contrast-free image to be used for subtraction, and the scan was continued for 3-4 minutes post-injection. A late single phase image was acquired after the time-resolved series. Twelve patient studies in total have been performed. These patients were referred for CAPR CE-MRA for assessment of the vascular malformation and potential planning of sclerotherapy. Image evaluation was performed by one diagnostic and one interventional radiologist. The time-resolved CAPR image series was evaluated in ten categories shown in the table, with Categories 1-6 defined for assessing the image quality specific to vascular malformations, Categories 7-8 more general, and Categories 9-10 as related to the subsequent therapy. Each study was scored from 1 to 4 in each category, where 1 indicates non-diagnostic and 4 indicates excellent diagnostic image quality.

**Table: Aggregate results (mean  $\pm$  std) from radiologic evaluation  
n = 12 for all categories except n = 10 for Category 10**

<b>Category 1: Identification of feeding vessel(s)</b>	3.6 $\pm$ 0.7
<b>Category 2: Identification of filling nidus</b>	3.4 $\pm$ 0.8
<b>Category 3: Characterization of venous outflow</b>	3.7 $\pm$ 0.6
<b>Category 4: Identification of normal venous structures</b>	3.7 $\pm$ 0.6
<b>Category 5: Demonstration of malformation extent</b>	3.8 $\pm$ 0.6
<b>Category 6: Identification of tissue involvement</b>	3.9 $\pm$ 0.3
<b>Category 7: Vessel sharpness</b>	3.7 $\pm$ 0.5
<b>Category 8: Presence of artifact</b>	3.3 $\pm$ 0.5
<b>Category 9: Quality for diagnosis and treatment planning</b>	3.6 $\pm$ 0.6
<b>Category 10: Correlation with treatment images</b>	3.9 $\pm$ 0.5

**Results** All patients were successfully imaged and diagnostic image time series were obtained. The table shows the results from the image evaluation. Figure 1 (A-E) shows consecutive targeted MIPs from one patient, demonstrating high spatial resolution depiction of a slow-filling vascular malformation of the right foot. The time post-injection is noted on the images.

**Conclusion** CAPR CE-MRA has shown excellent diagnostic quality time-resolved imaging of vascular malformations of the upper and lower extremity. The time series have been shown to provide accurate lesion characterization and have been used in assessment of the malformations as well as planning of sclerotherapy.

**References** [1] Hyodoh H, RadioGraphics 25(2005); [2] Haider CR, MRM 60(2008); [3] Haider CR, Radiol 253(2009).

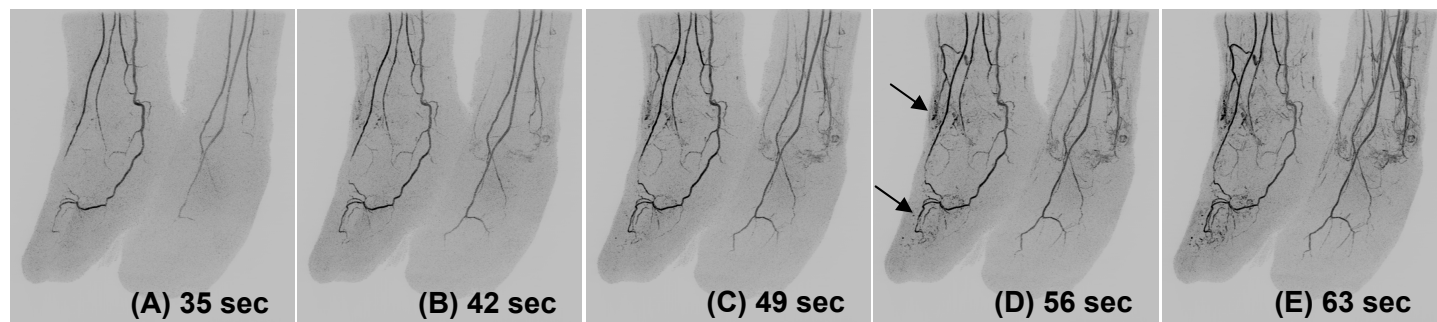


Figure 1. Consecutive oblique MIPs from the CAPR time-resolved series of a 48 year old man with a VM of the right foot (arrows).