Real-time and color-flow spiral MR imaging of peripheral chronic total occlusion (CTO)

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Background: Endovascular interventions on peripheral chronic total occlusions (CTO) remain challenging under X-ray-guidance because the path of occluded lumen is not visible. MRI can image the entire peripheral artery occlusion, including arterial wall, lumen content, and adjacent structures, without radiation or iodinated contrast agents. Spiral MRI techniques provide a highly efficient means of acquiring k-space data with improved spatial and temporal resolution. This study tested the feasibility of real-time spiral MRI (RT-MRI) techniques for visualizing peripheral arteries and CTO lesions *in vivo* in patients undergoing intervention.

Methods: We used the RTHawk real-time system [1] to acquire both real-time and real-time color-flow images [2]. This system was installed on a clinical 1.5-T GE scanner (40 mT/m, 150 T/m/s gradients). A 3" surface coil was used for reception. Acquisition parameters were as follows: FOV=12 to 18cm, spatial resolution=800µm to 1.2mm, 6 spiral interleaves, 150ms per full frame, sliding window reconstruction at 40 fps. For the color-flow sequence, twice the number of acquisitions are required thus reducing the frame rates to 300ms per full frame and 20-fps reconstruction.

The superficial femoral arteries were imaged in 4 subjects—1 healthy volunteer and 3 patients with 4 CTO lesions before and after percutaneous intervention with atherectomy and/or nitinol stent placement.

Results: Patient characteristics are shown in the table below. In CTO patients pre-intervention, as shown in Figure 1, RT-MRI was able to visualize the patent and CTO portions of the vessels. Inflow enhancement resulted in high, pulsatile signal in patent portions of the vessel, while CTO regions exhibited consistently low signal. Signal intensity in the patent portion was significantly higher that in either the femoral vein or CTO region (Figure 2). Similarly, RT-color-flow-MRI showed pulsatile color signal in the patent segment and absence of color flow in the CTO (Figure 3). Post-intervention, RT-MRI confirmed vessel patency in both atherectomy and nitinol stent cases (Figure 1) and the signal intensity of region increased significantly from that of pre-intervention and the pulsatile signal characteristic was restored (Figure 4).

Conclusion: This study demonstrates the capability of both RT-MRI and RT-color-flow-MRI to visualize and assess peripheral CTO lesions prior to and following interventions at 1.5 T. The signal pulsatility of patent vessel regions under RT-MRI allows easy visual identification of patent and occluded vessel segments. RT-MRI thus has the potential to aid image-guided recanalization of CTO.

References: [1] Santos JM, et al. 26th IEEE EMBS, 1048, 2004.

[2] Nayak, K.S., et al. MRM, 43:251-58, 2000.

Table. Patient Characteristics

pt #	CTO Location	Procedure
#1	Right SFA	Atherectomy
#2	Right SFA	Atherectomy
#2	Left SFA	Atherectomy + Stent
#3	Right SFA (ISR)	Balloon + Laser

Figure 1. Real-time MRI of In vivo CTO patients on 1.5-T

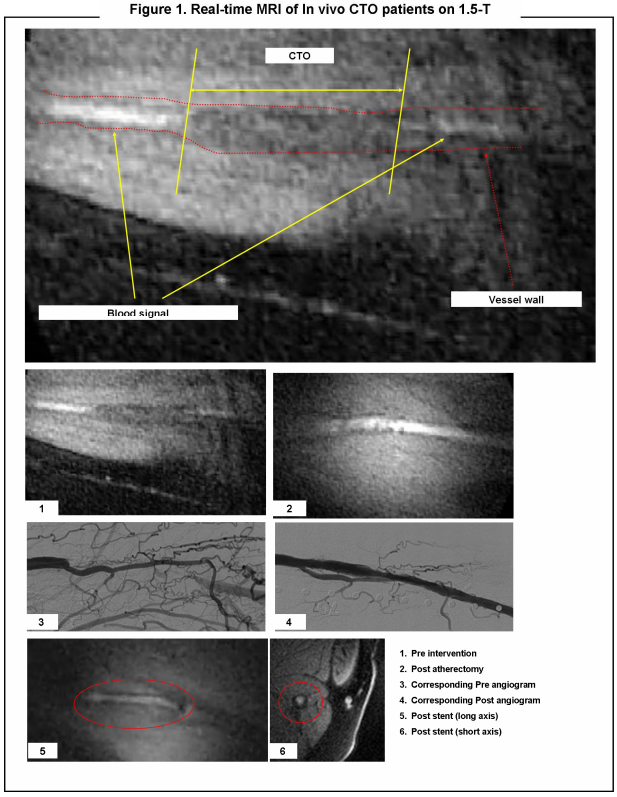

Figure 2. Signal intensity in pt#1

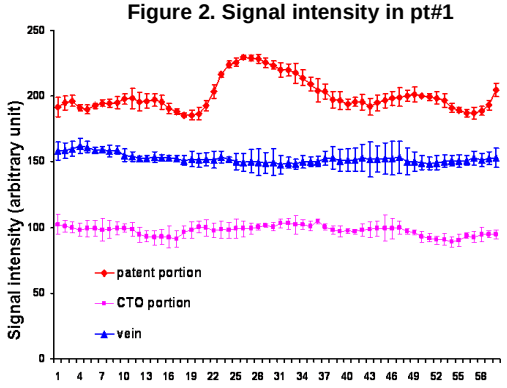

Figure 3. Real-time color flow MR imaging (pt#1)

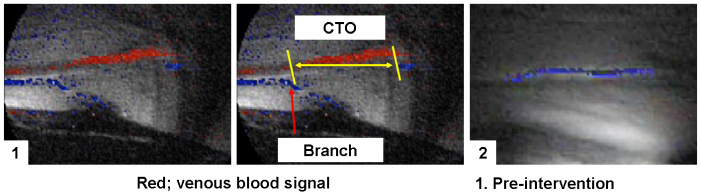

Figure 4. Signal intensity of pre/post-intervention in pt#3