# Time Resolved 3D Spiral MR Angiography of the Popliteal Artery Trifurcation

H. Zhang[1], H. Zhu[2], Y. Wang[2], B. Ho[1], M. Chao[1], M. R. Prince[1]

[1]Radiology, Weill Medical College of Cornell University, New York, NY, United States, [2]MR Research Center, University of Pittsburgh, Pittsburgh, Pennsylvenia, United States

**Synopsis:** MR Angiography with high temporal resolution is increasingly recognized to be important for peripheral vascular disease, particularly in the calf where differential flow rates, early venous filling, and retrograde filling of arteries represent significant features. Spiral 3D Gd MRA samples central k-space data with every TR, thereby allowing high temporal resolution MRA using sliding window reconstruction. These data in 15 patients using both spiral and conventional 3D MRA demonstrate that compared to 45ml Gd bolus chase MRA, spiral 3D MRA with 6ml Gd shows better depiction of pure arterial phase, demonstration of differential flow and comparable branch order visualization.

**Materials and Method:** Fifteen patients with claudication were examined on a 1.5 Tesla imaging system using head coil for signal transmission and reception and a fast gradient echo sequence with 3D spiral k-space acquisition. The scanning parameters were: TR/TE/flip angle = 11.1/1.1/60°; matrix = 256 x 256; field-of-view (FOV) = 36 cm; slab thickness = 64 mm, NEX = 1, bandwidth = $\pm$ 200 kHz. Six ml of Gadolinium:DTPA contrast was injected rapidly by hand at 2-3 ml/sec. After the spiral MRA, routine 3-station bolus chase was performed using 45 ml of Gd:DTPA. Data were analyzed for ability to capture pure arterial phase without venous contamination, differential flow between right and left legs or among arteries in the same leg, ability to visualize 3$^{rd}$ order branches (popliteal = 1$^{st}$ order), scan time, anatomic coverage, image quality, popliteal artery SNR and CNR, background tissue SNR and compared to the calf station of the bolus chase 3D peripheral MRA.

**Results:** Time-resolved 3D MRA data were acquired in 50 seconds, which included 3 seconds for phase correction before and after dynamic scanning as well as 9 seconds to collect a complete pre-contrast mask for subtraction. Popliteal arteries and trifurcations were covered with a 64 mm slab thickness, which was thin enough to avoid excessive off-resonance artifact. Pure arterial phase data were obtained in all patients (100%) on 3D spiral MRA while 33% of the calf stations of 3D bolus chase MRA had venous contamination. Differential flow rates between two legs or between the arteries of the same leg were shown in 8 patients (53%) with 3D spiral MRA (Figure 1) but this could not be discerned in any of these patients on the 3D bolus chase MRA. Visualization of 3$^{rd}$ order branches were identified in 80% of the imaged legs with 3D spiral MRA compared to 83% with 3D bolus chase MRA ($p = 0.99$). 3D spiral showed better suppression of the background tissues (lower tissue SNR of 1.3 vs. 3.4, $p < 0.001$). However, 3D Gd bolus chase MRA images had significantly higher arterial SNR and CNR ($p < 0.01$). Arterial occlusive disease was demonstrated similarly on 3D spiral and bolus chase MRA in 7 patients (Figures 2 and 3).

**Discussion:** Time-resolved 3D **s**piral MRA combines high spatial and temporal resolution into a single, easy to perform low dose (6ml) 3D Gd MRA evaluation that does not require bolus timing yet yields pure arterial phase data in every patient and also assesses flow dynamics. Multiple peak arterial phases may be summed to improve SNR in a final composite MRA. We found the flow information to be useful for planning subsequent 3D bolus chase MRA which has higher spatial resolution and slightly higher SNR and CNR. In this way time-resolved MRA and high spatial resolution bolus chase MRA are complementary and together provide a comprehensive assessment of peripheral vascular disease. Gradient warping may be taken into consideration to correct for blurring near FOV edge.

**Table 1.** Comparison of 3D spiral and bolus chase MRA

| | 3D spiral | Bolus chase | p value |
|---|---|---|---|
| Pure arterial phase | 100% | 67% | 0.20 |
| Differential flow rate | 53% | none | |
| 3$^{rd}$ order branches | 80% | 83% | 0.99 |
| SNR | 77 $\pm$ 33 | 108 $\pm$ 33 | 0.001 |
| CNR | 76 $\pm$ 34 | 104 $\pm$ 34 | 0.003 |

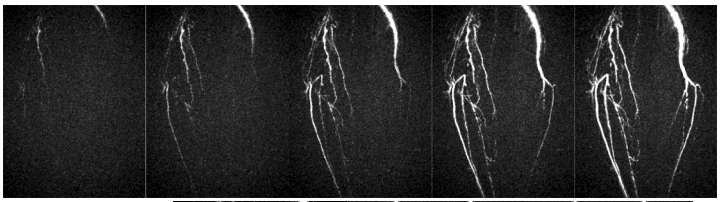

**Figure 1**. Time-resolved images (2 seconds/frame) show differential flow rates between right and left legs.

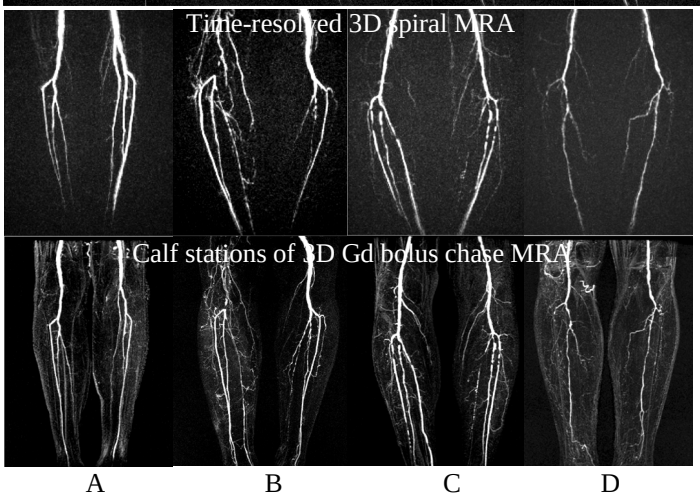


**Figure 2**. Comparison of time-resolved 3D spiral MRA with 6ml Gd (top) and 3D Gd MRA with 45ml Gd (bottom) of the trifurcation. Patient A: normal variation; Patient B: right popliteal artery occlusion; Patient C: severe stenoses of runoff vessels bilaterally; Patient D: occlusion of anterior tibial arteries bilaterally. Time-resolved 3D spiral MRA shows better background suppression and is comparably diagnostic to 3D Gd MRA.

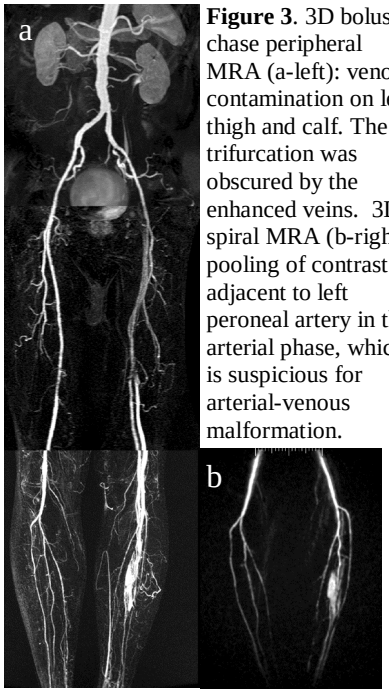


**Figure 3**. 3D bolus chase peripheral MRA (a-left): venous contamination on left thigh and calf. The trifurcation was obscured by the enhanced veins. 3D spiral MRA (b-right): pooling of contrast adjacent to left peroneal artery in the arterial phase, which is suspicious for arterial-venous malformation.

**References: 1**. Wang Y, et al. Invest. Radiol. 2001;36:170-177. **2**. Yang PC, et al. J Am Coll Cardiol. 2003;41:1134-1141. **3.** Knuesel PR, et al. JMRI. 2002;16:660-667. **4.** Amann M, et al. MRM. 2002;48:290-296. **5**. Mistretta CA, et al. MRM. 1998;40:571-581. **6**. Korosec FR, et al. MRM. 1996;36:345-351.