# Technical Feasibility of Three-Station Time-Resolved Bolus Chase MRA

**C. P. Johnson[1], E. A. Borisch[1], J. F. Glockner[1], T. W. Polley[2], P. M. Young[1], and S. J. Riederer[1]**
[1]MR Research Laboratory, Mayo Clinic, Rochester, MN, United States, [2]Electrical Engineering, Brigham Young University, Provo, UT, United States

**Introduction:** Imaging the extended peripheral vasculature using a single injection of contrast material poses a number of challenges. Sufficient time must be spent at each station to acquire a diagnostic angiogram, but the imaging duration at each station must also be limited so that the most distal station can be reached prior to venous enhancement. Additionally, imaging must be flexible since the speed of contrast traversal is patient-specific. State-of-the-art single-injection bolus chase methods use an estimate of the contrast bolus transit time and station-specific acquisition parameters to efficiently image each station within an allowed time window [1-3]. An alternative method using real-time 3D diagnostic time-resolved imaging was recently demonstrated in two imaging stations [4]. The method used a CAPR acquisition strategy in combination with 2D SENSE acceleration to image the thighs and calves with both high spatial (1.0 mm isotropic) and high temporal (2.5 and 5.0 sec frame times) resolution. In this work, we extend this two-station methodology to image three stations. As in [4], time frames are reconstructed in real-time to allow fluoroscopic triggering of table motion, in this case at both proximal stations.

**Methods:** The thighs, calves, and feet of two healthy volunteers were imaged using an IRB-approved protocol. Imaging was done on a 3.0T GE Signa imaging system equipped with 16 receivers. Therefore, only 16 coils total could be used to image all three stations: 6 at the thighs, 6 at the calves, and 4 at the feet. This limited the maximum 2D SENSE acceleration at each station to R=6, 6, and 4, respectively. The time-resolved MRA studies used a fast coronal GRE pulse sequence with TR/TE = 5.1/2.3 ms, $\alpha = 30^{o}$, and BW = ±62.5 kHz. Each station used specific spatial and temporal parameters, which are summarized in Table 1. Contrast material was injected using a power injector (20 mL Multihance followed by 20 mL saline at 3.0 mL/sec) after acquisition of SENSE calibration images and subtraction frames. During the exam, diagnostic quality time frames were reconstructed in real-time and displayed on the scanner console. The operator then triggered the table to move to the next station upon visualizing contrast traverse the current imaging station. The limited table speed necessitated a 5.5 sec delay between stations. The total S/I coverage was 92.5 cm.

**Results:** Maximum intensity projections (MIPs) from one volunteer are shown in Figs 1 and 2. The extended FOV MIP in Fig 1 highlights the excellent 3D diagnostic quality of this exam. Individual time frames are shown in Fig 2. Rapid frame times at the thighs and calves (2.4 and 3.0 sec, respectively) allowed precise triggering of table motion upon viewing frames #10 and #13. The results for the second volunteer were comparable at the calf and foot stations, but the thigh station had low vessel signal due to insufficient coil coverage. Triggering was precise for both studies. Minor superficial venous contamination was seen in the first frame at the foot station for both volunteers.

**Conclusion:** We have demonstrated, for the first time, three-station time-resolved stepping-table bolus chase MRA of the thighs, calves, and feet with high spatial and temporal resolution and real-time triggering of table motion. Despite significant hardware limitations (16 total receivers and slow table motion), high quality 3D arteriograms can be acquired at all three stations with minimal venous contamination. This method may allow routine high resolution CE-MRA of the peripheral vasculature with a single 20 mL contrast injection while avoiding use of a test bolus and compression cuffs.

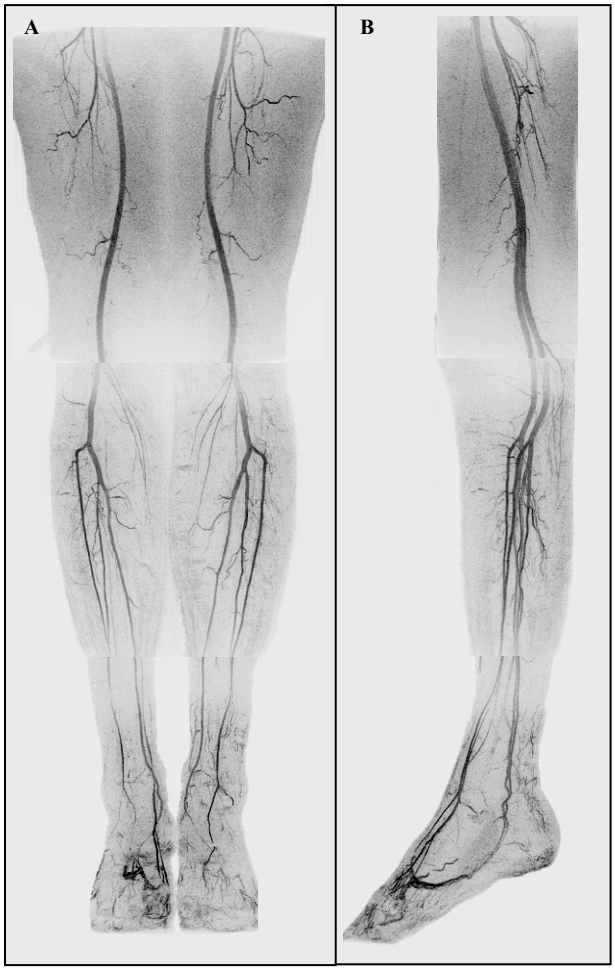


**Figure 1:** Coronal (A) and sagittal (B) extended FOV MIPs created using frames 11, 14, and 16 in Fig 2. Despite the limited imaging duration at each station, it can be seen that S/I coverage is excellent (92.5 cm), vessels are imaged with good quality, and there is only slight venous contamination at the foot station.

**References:** [1] Vogt FM, et al. Radiology (2007) 243:229. [2] Nael K, et al. Eur Radiol (2008) 18:2893. [3] Potthast S, et al. JMRI (2009) 29:1106. [4] Johnson CP, et al. MRM (2010) 64:629.

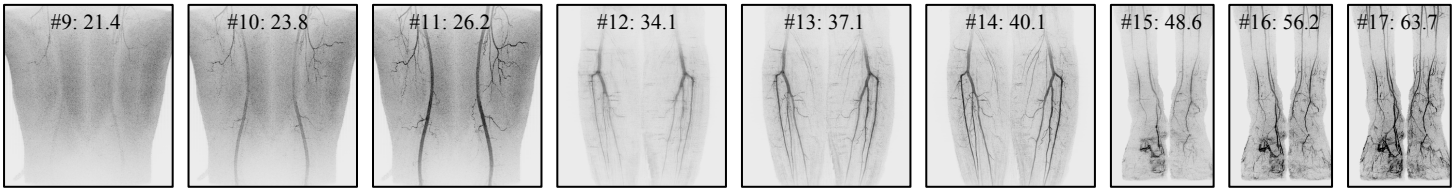


**Figure 2:** Consecutive time series coronal MIPs for the same volunteer shown in Fig 1. The time post-contrast injection is indicated in seconds.

| Station | FOV ($cm^3$): S/I x L/R x A/P | Resolution ($mm^3$): S/I x L/R x A/P | Frame Time (sec) | Temporal Footprint (sec) | Receiver Coils | 2D SENSE (L/R x A/P) | CAPR Pattern (Center Samples) |
|---|---|---|---|---|---|---|---|
| Thighs | 35 x 32.4 x 14.4 | 1.0 x 1.2 x 1.2 | 2.4 | 11.6 | 6 | 3 x 2 | N5 (60) |
| Calves | 35 x 31.8 x 13.2 | 1.0 x 1.0 x 1.0 | 3.0 | 14.7 | 6 | 3 x 2 | N5 (60) |
| Feet | 35 x 19.6 x 24 | 1.0 x 1.0 x 1.0 | 7.6 | 28.2 | 4 | 1 x 4 | N4 (400) |

**Table 1:** Three station imaging parameters.