Three-Station Fluoroscopic Tracking 3D Bolus Chase MRA with Optimized Accelerations

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Purpose: Bolus chase peripheral MRA was first described over 15 years ago [1]. Fundamental and oftentimes competing challenges are to (i) dwell at a station long enough to allow data accumulation for sufficient spatial resolution; (ii) move the table sufficiently quickly to avoid venous contamination in distal stations; and (iii) synchronize table motion to the patient-specific bolus transit. Means to address these have included 1D parallel imaging to reduce scan time [2], and use of multiple contrast injections or external cuffs to reduce venous contamination [3-4]. Recently the method of fluoroscopic tracking [5-6] has been described in which contrast bolus transit is imaged in real time at each station, allowing the operator to trigger a table move as the contrast reaches the end of the FOV of that station. This method utilized a 32-channel receiver array enabling R=8 2D SENSE acceleration at each station to achieve 1.5 mm^3 spatial resolution at the two proximal stations with a 2.5 second image update time. Initial results identified specific challenges in each of the three stations. In the pelvis and particularly in the thigh station the bolus transit is rapid, with the leading edge typically traversing the 40 cm S/I FOV in less than 10 seconds.

The purpose of this current work is to utilize an improved receiver coil array with 48 channels and acceleration optimization techniques [7-8] enabling R = 8, 10, and 12 fold parallel imaging at the proximal, middle, and distal stations respectively allowing even shorter frame times.

Methods: The technique described in Ref. [6] is used but with improved receiver coil arrays and parallel imaging techniques. First, prior to injection, the fully sampled calibration data is acquired. Next, each station's optimal acquisition parameters are calculated according to the methods described in Refs. [7-8]. The two proximal stations make use of R = 8 and R = 10 optimal CAIPIRINHA [9] acceleration, and the distal station R = 12 Acceleration Apportionment [7]. This results in frame times of 2.5s, 2.12s, and 4s for the proximal, middle and distal stations with 1.5, 1.5 and 1mm isotropic resolution respectively covering a 122 cm longitudinal field-of-view (FOV). Next, the pre-contrast reference frames are acquired, and finally the contrast bolus is imaged with the reconstruction being done in real time with coronal MIPs displayed on the scan console. All acquisitions were done on a 3.0T GE MRI system with a coronal GRE acquisition. One 20 mL injection of gadobenate dimeglumine contrast agent was administered per exam.

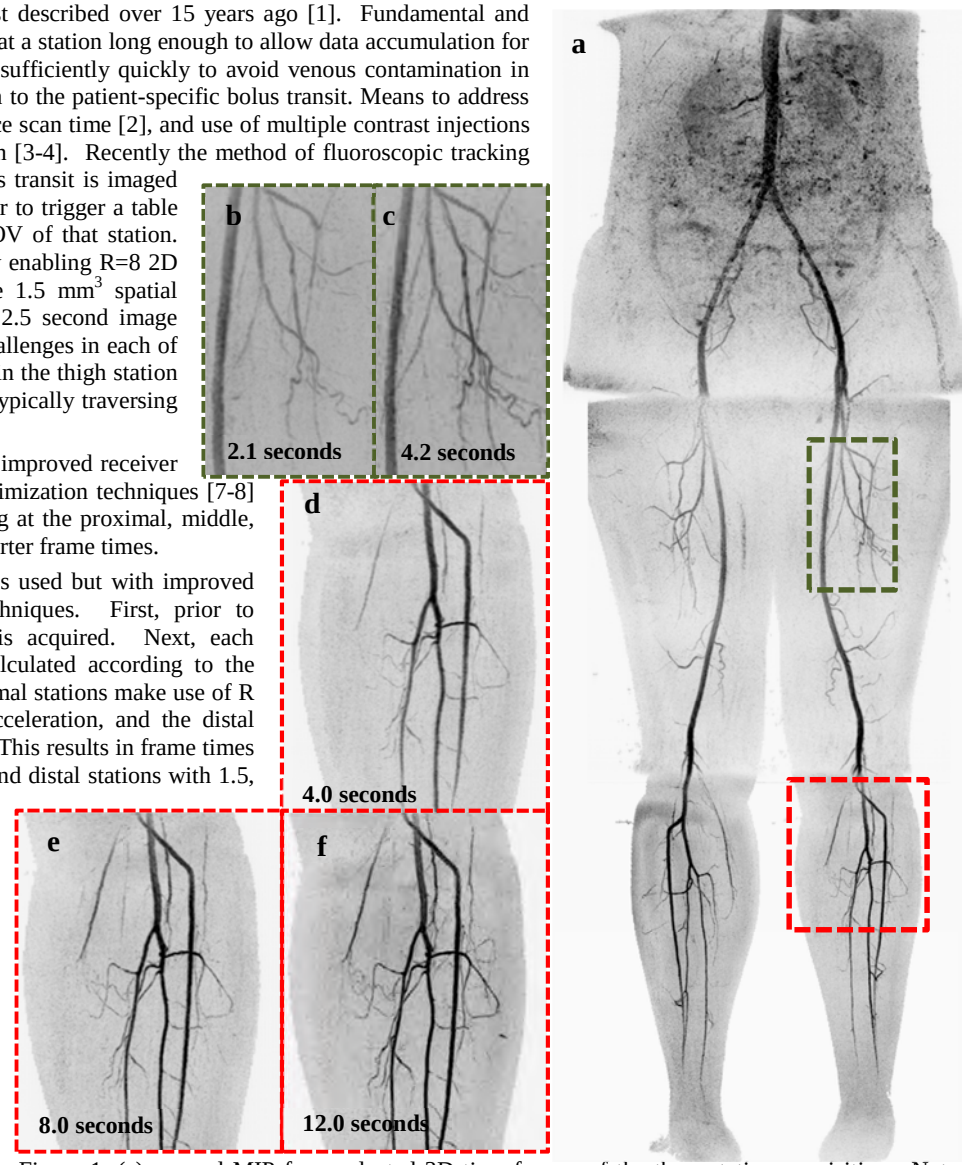

Figure 1: (a) coronal MIP from selected 3D time frames of the three-station acquisition. Note some subtraction artifact in the second station, but sharp depiction of the vasculature throughout. (b,c) show zoomed targeted MIPs of the thigh station, and (d-f) show the targeted MIPs of the first three updates of the calf station. Note high conspicuity of small vessels and avoidance of venous contamination in the early frames.

Results: A coronal maximum intensity projection from an initial volunteer is shown in Figure 1. This healthy volunteer exhibited fast flow through the thigh station, resulting in only two frames being acquired there before table move. The second frame of the distal station is used in (a), exhibiting sharp delineation of vessels. Zoomed targeted MIPs of the two thigh station frames (b,c) and the first three calf frames (d-f) are also shown. Even with the short acquisition times indicated the images have very high spatial resolution.

Discussion: Application of improved receiver coil arrays and patient-specific prescription of acceleration parameters has yielded reduced image update time for an otherwise identical bolus chase MRA protocol, reducing the chance of venous contamination in the distal station. This additional parallel imaging acceleration could be used instead to increase spatial resolution if so desired.

Conclusion: Improved receiver coils and implementation of optimized parallel imaging has resulted in faster image updates for three-station fluoroscopic tracking in peripheral CE-MRA.

References: [1] Ho KY, Radiol 1998. [2] Maki JH, JMRI 2002. [3] Berg F, Invest Radiol 2008. [4] Voth M, Invest Radiol 2009. [5] Johnson CP, MRM 2010. [6] Johnson CP, Radiol 2014. [7] Weavers PT, MRM 2014. [8] Weavers PT, Proc. ISMRM 2013 #0129. [9] Breuer FA, MRM 2006.