Applying the bSSFP Dixon Method for Fat-Water Separation to Non-Contrast-Enhanced MRA in the Legs

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Introduction

Synchronizing data acquisition with the arrival of the contrast bolus in contrast-enhanced MRA can be difficult [1]. Furthermore, patients with peripheral arterial disease (PAD) are at increased risk of renal deficiency [2], and are therefore at risk of nephrogenic systemic fibrosis linked to gadolinium-based MRA contrast agents [3]. The Dixon method is capable of non-contrast-enhanced (NCE) fat-suppression [4]. Our hypothesis is that the balanced steady-state free precession (bSSFP) Dixon method [5] is capable of NCE MRA of the peripheral vasculature [6].

Methods

Images were collected using a modified 3D bSSFP sequence at multiple stations from the legs of five healthy volunteers on a 3.0 tesla clinical MR scanner (Signa VH/*i*; General Electric Healthcare, Waukesha, WI, USA) using a body transmit/receive coil. The pulse sequence parameters were TR/TE/flip angle = 3.4 ms/1.7 ms/25°, with a coronal acquisition matrix of $256 \times 256 \times N_{slices}$. Images were collected with centre frequency offsets of -100 Hz and +100 Hz to produce images where fat and water are in-phase and opposed-phase, respectively [6]. Water-only (*i.e.*, fat-suppressed) images were generated by complex addition of the ±100 Hz offset images. Maximum intensity projection (MIP) images were produced and processed for the 3D water-only image volumes. A trained vascular MR radiologist inspected both the slice-by-slice images and the MIP images for vessel conspicuity.

Results

Figure 1 displays single-slice bSSFP Dixon method images from the thigh station from one healthy volunteer. Figure 2 displays the processed MIP images generated from coronal projections in the thigh and calf stations from two different healthy volunteers. The blood vessels are clearly visible in both stations in Figure 2. Similar results were found in all stations in all volunteers. Image volumes from each station were collected in under three minutes in all volunteers. The radiologist confirmed that the blood vessels were easily identifiable in the slice-by-slice images, and in most MIP images.

Discussion and Conclusions

Because arterial blood has a higher T2/T1 ratio (intrinsic bSSFP image contrast) than venous blood and surrounding tissue, the arteries appear brighter in the water-only images. One limitation of this technique is the sensitivity to off-resonance effects inherent in bSSFP sequences, resulting in banding artifact (arrows in Figure 1c) or signal reduction (rectangle in Figure 2a). High-order shimming may help with these problems by ensuring better magnetic field homogeneity. These results show that the bSSFP Dixon method has the potential for 3D NCE MRA of the peripheral vasculature with an overall scan time of less than three minutes per station. This would have significant clinical impact for patients with PAD, who may be at risk for nephrogenic systemic fibrosis. The next step in this research is a clinical evaluation of this technique to identify vascular pathology in patients with PAD.

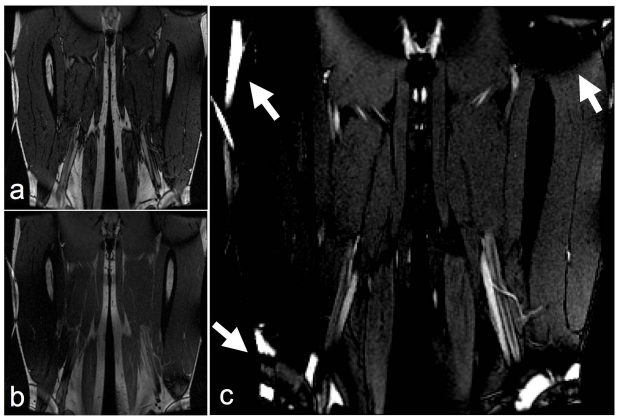

Figure 1: Single-slice images collected from the thigh station in a healthy volunteer obtained using the bSSFP Dixon method. Images a) and b) were collected at -100 Hz and +100 Hz centre frequency offsets, respectively. Image c) represents the windowed and levelled water-only image calculated from a) and b).

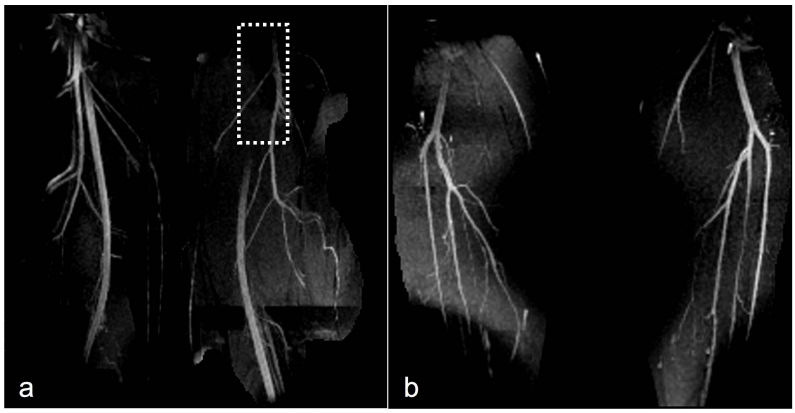

Figure 2: Maximum intensity projection (MIP) images from coronal projections through the full 3D volumes of the water-only images in a) the thigh station and b) the calf station. Image a) is from the same volunteer from Figure 1, and Image b) is from a different healthy volunteer.

References

[1] Ho VB *et al. J Magn Reson Imaging* 1999; **10**: 376.
[2] Hirch AT *et al. J Vasc Interv Radiol* 2006; **17**: 1383.
[3] Thomsen HS *et al. Eur Radiol* 2006; **16**: 2619.
[4] Dixon WT. *Radiology* 1984; **153**: 189.
[5] TY Huang *et al. Magn Reson Med* 2004; **51**: 243.
[6] Stafford RB *et al. Magn Reson Med* 2007; in-press.