Noncontrast MRA using Gated 3D FSE with Hybrid Refocusing Angles

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INTRODUCTION

Noncontrast-enhanced MR angiography (NC-MRA) using gated 3D fast spin-echo (FSE) based techniques (FBI, NATIVE-SPACE, TRANCE) has been used for peripheral MRA applications [1-4]. This class of NC-MRA methods leverages the inherent sensitivity of FSE to flow-induced dephasing. In general, a dark artery (DA) scan is acquired during systole while blood velocity is highest and a bright artery (BA) scan is acquired during diastole with relatively slow arterial flow. The angiogram is generated by subtracting the DA data from the BA data thus cancelling background signal.

The sensitivity of FSE to flow can be tuned by adjusting the RF refocusing angle [5]. In general, the lower the refocusing angle, the more sensitive FSE is to flow velocity. Using a large refocusing angle (160°+) produces bright arteries in BA data, but also refocuses more arterial signal in the DA scan, especially in slower flow branch arteries. Thus the subtraction angiogram contains bright signal for larger, faster flow arteries, but weak signal for smaller, slower flow arteries (Figure 1: top row). If a low refocusing angle (<120°) is used, large artery signal is reduced in BA data, but smaller, slower flow arteries are less affected. In the DA scan, even the small arteries are dark due to the combination of faster flow and low refocusing angle. Thus, a low refocusing angle produces an angiogram with bright signal in small branch arteries, but weak signal in larger arteries (Figure 1: middle row).

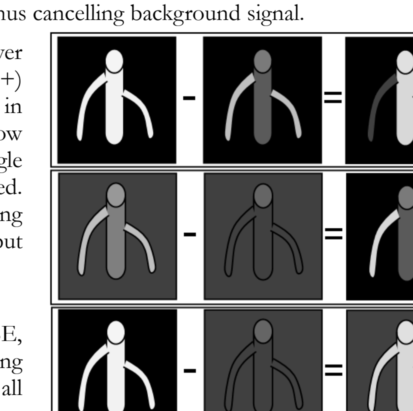


Figure 1: Illustration of effect of refocusing angle on gated 3D FSE. Left column: BA (diastole) data. Middle column: DA (systole) data. Right column: subtraction angiogram. Top row: high angle. Middle row: low angle. Bottom row: hybrid angle method (high angle in diastole, low angle in systole). The differences in background grayscale represent the effect of refocus angle on background tissue and its subsequent subtraction.

PURPOSE

All tissue signals are affected by the choice of refocusing angle, but due to the motion sensitivity of FSE, arterial signal is more sensitive to refocusing angle than venous or background signals. We propose using different refocusing angles in the DA vs. BA acquisitions to produce more uniform contrast across all arterial branches without introducing deleterious amounts of background signal (Fig 1: bottom row).

METHODS

Gated 3D FSE data were acquired on the peripheral anatomy of a male volunteer using a 3T whole-body research system under IRB approval. Coronal partial-Fourier 3D FSE was acquired with peripheral pulse gating using the following parameters: TE = 60 ms, TR = 3RR, echo space = 5.0 ms, readout BW = 651 Hz/pixel, 2 shots, ETL = 76, matrix = 256 x 256, FOV = 35 x 35 cm, and forty 3.0 mm partitions. The DA and BA data were acquired as one continuous acquisition without interruption. The 3D gated FSE data were repeated seven times for the following BA : DA refocusing angle combinations: 160°:160°, 140°:140°, 120°:120°, 100°:100°, 160°:140°, 160°:120°, 160°:100°.

RESULTS

The hybrid angle angiograms maintained vessel contrast in large arteries across the range of DA refocusing angles (100° to 160°) (Figure 2: top row). The larger the disparity between BA and DA, the greater the intrusion of background signal, especially near the edges of the FOV. The constant refocusing angle data (Figure 2: bottom row) demonstrated a monotonic reduction of femoral artery signal with decreasing refocusing angle. The background signal remained consistently near zero in the constant refocusing angle sets. The fine gauge arteries, especially branches of the peroneal and anterior tibial arteries, are more visible on the lower flip angle data sets (Figure 3). The low DA angle hybrid data sets (160°:120° and 160°:100°) depicted comparable small artery detail as the constant low angle data sets (Figure 3).

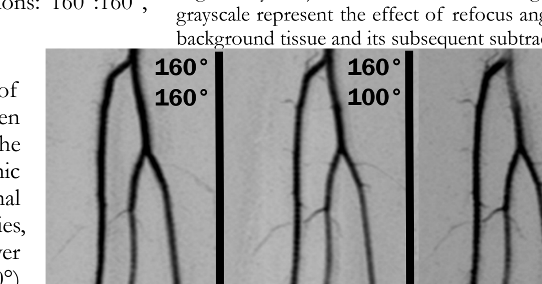


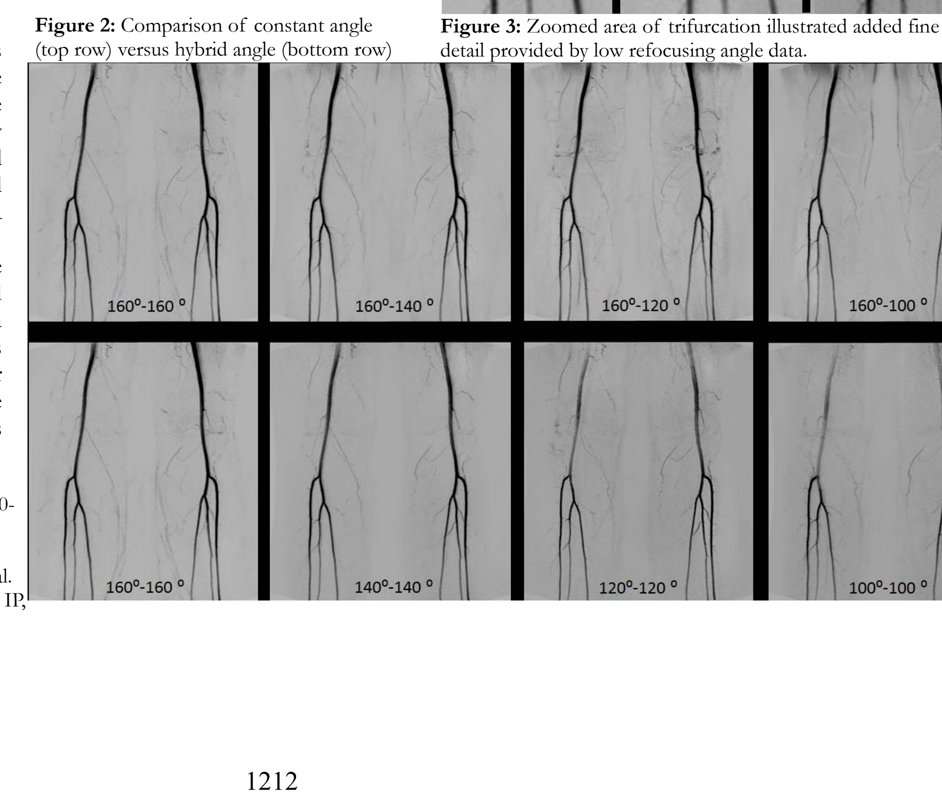
Figure 3: Zoomed area of trifurcation illustrated added fine gauge detail provided by low refocusing angle data.

DISCUSSION

The hybrid angle method produced angiograms that maintained signal in large arteries while providing the fine arterial detail of low angle gated 3D FSE. This increase in uniformity came at the modest cost of slightly increased background signal. The hybrid angle method has the added advantage of reducing SAR relative to a constant high refocusing angle.

Our preliminary study focused on the evaluation of the feasibility of using hybrid refocusing angles for gated 3D FSE. Based on our preliminary data, the 160°:120° pair offers fine arterial detail with less potential for background intrusion. We plan to use this angle pair in future quantitative evaluation studies across multiple subjects.

Figure 2: Comparison of constant angle (top row) versus hybrid angle (bottom row)



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