Angiography and Venography in a Single SWI Acquisition

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Introduction: This work sought to develop a means for high resolution simultaneous MR angiography (MRA) and MR venography (MRV) using a Susceptibility Weighted Imaging (SWI) sequence. The ability to collect simultaneous MRA and MRV data is an important clinical goal for analyzing a variety of clinical diseases including stroke, trauma and multiple sclerosis.

Materials and methods: All SWI images were acquired at 4T with a resolution of 0.5x0.5x2.0mm^3. Volunteers were scanned after administration of caffeine (to help suppress the veins) and injection of a gadolinium contrast agent (Figures 1 and 2). Imaging parameters were TR=30ms, TE=20ms, and FA=10° and 30°. Volunteers were also scanned without any contrast agent (gadolinium or caffeine) but with an MT pulse (Figure 3). Imaging parameters were TR=51ms, TE=15ms, and FA=15°. While caffeine was used in the first two scans and does give a slight boost to the venography it is by no means necessary for this technique.

Results: As expected with a contrast agent the 10° flip angle does an excellent job creating a high quality MRV but due to insufficient background suppression the MRA is poor. The 30° flip angle suppresses the background much better giving a good MRA result but leads to an inhomogeneous MRV even after the SWI processing. Without any contrast agent and with an MT pulse the background is nicely suppressed giving reasonable MRA and SWI results for the MRV. The quality of the MRV is also good due to the lower flip angle used. All pairs of images shown come from a single acquisition with a maximum intensity projection (MIP) used to show the arteries (left), and a minimum intensity projection (mIP) with SWI processing used to show the MRV (right).

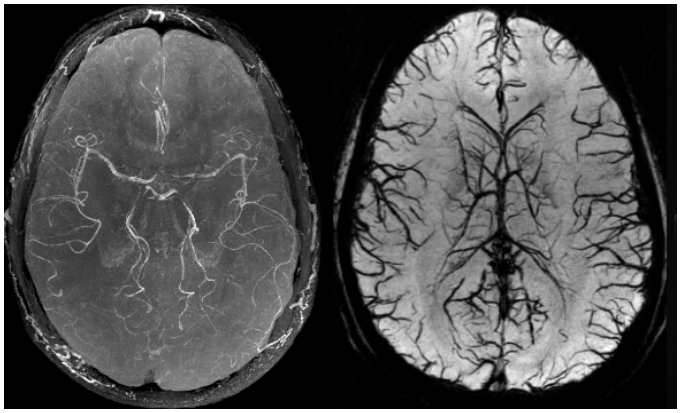

Figure 1: Imaged with gadolinium and caffeine, TE=20ms, TR=30ms, FA=10°

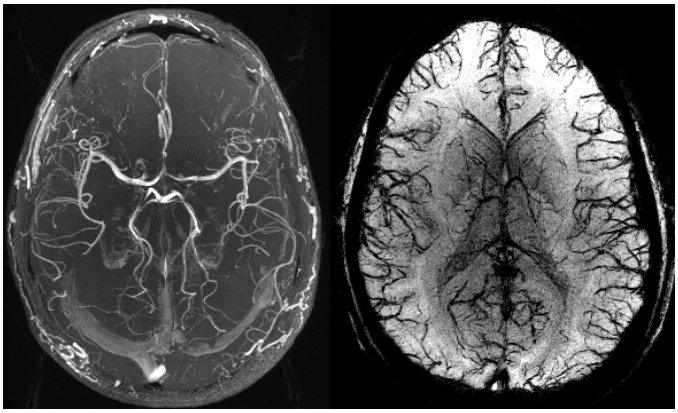

Figure 2: Imaged with gadolinium and caffeine, TE=20ms, TR=30ms, FA=30°

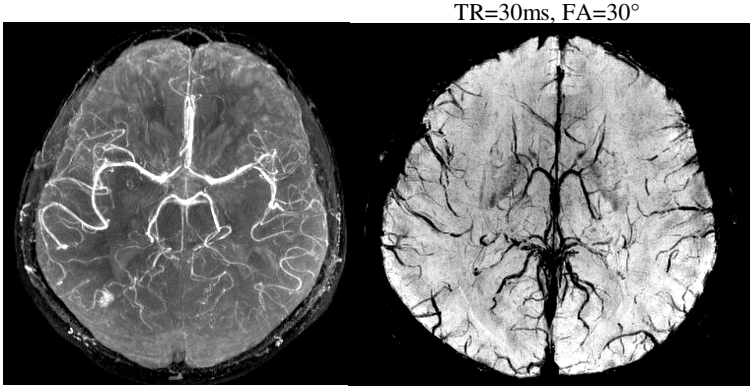

Figure 3: Imaged without contrast agent, and with MT pulse, TE=15ms, TR=51ms, FA=15°. Notice the small AVM on the MIP in the lower left.

Discussion and Conclusion: Generally, by using a long TE and short TR the veins can be suppressed and the arteries brightened allowing a very good separation of arteries and veins in a single scan. This is true even in the presence of a contrast agent, where the shortened T1 boosts the signal in the arteries and the cancellation effect helps further suppress the veins. This T1/R2* coupling makes it possible to enhance the R2*-like cancellation effect. Without a contrast agent it is still possible to get good results by using an MT pulse to help suppress the background and enhance the angiographic elements of the sequence. The arteries can be visualized using a standard maximum intensity projection (MIP), and the veins visualized with SWI processing and a minimum intensity projection (mIP). The choice of flip angle is very important for determining image quality of both the MRA and SWI data sets. Higher flip angles improve the angiography due to increased background suppression, but in turn hurt the venography by over suppressing the CSF. Choosing a medium flip angle (15-20°), a slightly longer TR, and an MT pulse appears to be optimal. The longer TR allows more inflow enhancement for the angiography and also keeps the CSF from being over suppressed, while the MT pulse maintains adequate background suppression.