Comparative Assessment of Carotid and Vertebral Arteries by FSE IDEAL Black Blood Sequence with and without Diffusion Preparation: A Low Refocusing Flip Angle and Strong T1-weighted Approach

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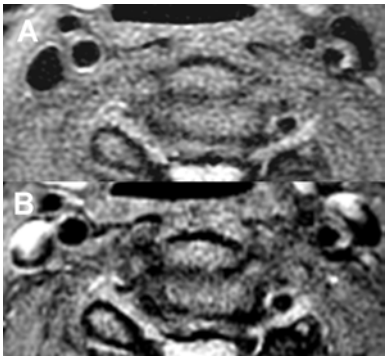
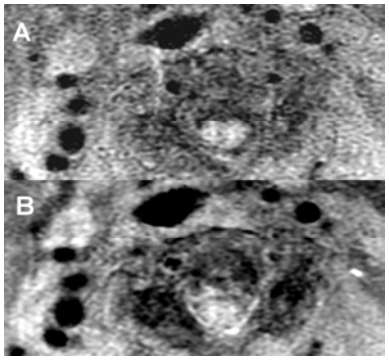
PURPOSE: Diffusion prepared gated black blood sequences or 3D FSE T1 techniques for assessing arterial wall abnormalities require significant scan time[1], custom made surface coils, high-field magnets[2] and cooperative patients. Hence it is difficult to implement black blood sequences for atherosclerotic plaque or arterial dissection in acute settings using routine general purpose spine coils at lower field magnets. Here we have developed a water-fat separated high SNR black blood sequence for acute or emergency situations without gating or diffusion preparation using low refocusing flip angle (low RFA) 2D FSE as a clinically feasible alternative to bright blood as well as to offer the same advantages as diffusion prepared or gated black blood sequences.

MATERIALS AND METHODS: We optimized a low refocusing flip angle 2D FSE T1 sequence without gating or diffusion based preparation and with no discarded echoes to achieve low TE to minimize lumen signal while increase signal from vessel walls and adjacent muscles by means of a strong T1 weighting. Also the signal acquisition was done to separate fat and water components by iterative decomposition or IDEAL reconstruction to specifically visualize the water only image. Under a prospective IRB we also optimized a diffusion based double inversion recovery (DIR) prepared 2D FSE T1 sequence at 1.5T for comparison. Both the sequences were applied using general purpose cervical spine array coils on 7 symptomatic patients, 4 for assessing atherosclerotic plaques and 3 with suspected vertebral or carotid arterial dissections and were assessed by 2 readers for subjective lumen signal comparison. The quantitative assessment of lumen SNR was done by placing an ROI within the lumens of common carotids and in air background. Similarly the carotid lumen CNR was estimated by dividing the signal from adjacent muscle by the signal from "nulled carotid lumen". The scan parameters were: 2-4 mm thick 8-24 axial slices, FOV = 12 x 10 (matrix 256x128) or 14x11 cm2 (matrix 256x160), bandwidth = ±16-31 kHz, 6-10 echo trains, TR/TE 500-700ms/10-16 ms, scan time = 45 sec/slice for diffusion prepared, 15 sec/slice for low RFA non-diffusion based FSE. Low RFA sequence employed RFA =100-120º, 0 - 2 discarded echoes and total scan times = 3-4 min for assessment of bifurcation and 7-8 min for cervical dissection.

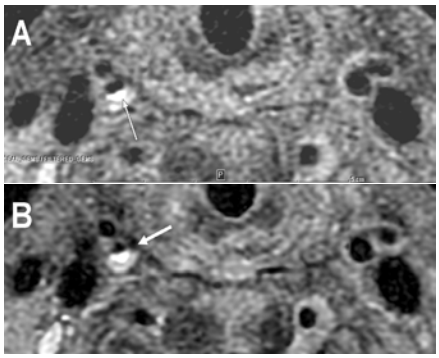
RESULTS: Three typical examples are shown below (cases 1-3) depicting equivalence of diffusion and non-diffusion prepared approaches and the sensitivity of the low RFA black blood FSE to minute wall abnormalities, particularly in the water selective images. The computed mean SNR(Carotid Lumen) was slightly more favorable for diffusion prepared FSE black blood sequence although it was very close to the mean SNR for low RFA non-diffusion sequence (Fig 1) while the lumen/adjacent muscle contrast was superior for non-diffusion sequence (Fig 2).



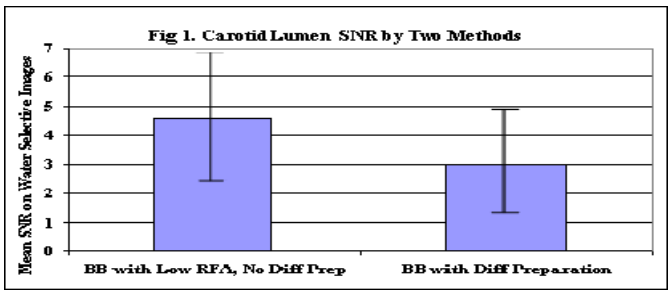
Case 1. 56 y/o female, 1.5T, spine array. Equivalent arterial lumen blood nulling by (A) diffusion prepared, 45s/section and (B) low RFA non-diffusion based, 15s/section FSE T1 IDEAL images. Venous blood was accepted in (B) to maximize tissue/lumen contrast..

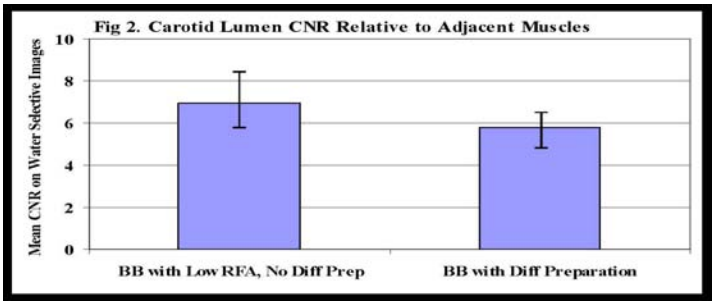


Case 2. 97 y/o female, 1.5T, spine array. Note equivalent arterial and venous blood nulling by (A)diffusion prepared, 39s/slice and (B) low RFA, non-diffusion based, 18s/slice FSE T1 IDEAL images. Here additional saturation bands and longer TE was used to suppress venous blood.



Case 3. Right ICA plaque (arrow) that is well seen equally on (A) diffusion based black blood FSE T1 as well as in (B) low RFA black blood FSE T1 method without diffusion preparation. The lumen SNR and CNR are comparable in both although (B) has slightly higher overall SNR and CNR in spite of being 3 times faster.





DISCUSSION: Low RFA FSE sequence can offer strong T1 weightings and consequently imaging speed by including early echoes as demonstrated in this work. One can obtain in-plane sub-millimeter resolution and thin slice black blood images for bifurcations (2-3mm) or full length neck vessels (4-5mm) using routine spine array coils that could be useful for assessing carotid plaques or dissections in 3-8 minutes.

CONCLUSION: Utilizing low refocusing flip angle FSE sequences and minimal discarding of echoes we have demonstrated strong T1 weighted black blood imaging of neck vessels, and with fat-water separation reconstruction, have obtained results equivalent to diffusion gradient preparation and custom-built coils with almost three times time savings that make it feasible for outpatient screening or assessment of carotid plaques or dissections in acute settings using routine clinical hardware.

REFERENCES: (1) Mihai et al. JMRI 2012:449-455. (2) Edjlali et al. AJNR 2013:34:E103-106.