

# High resolution non contrast enhanced MRA of the hand arteries at 3 Tesla using an ECG-triggered variable flip angle 3D fast spin echo (SPACE) sequence

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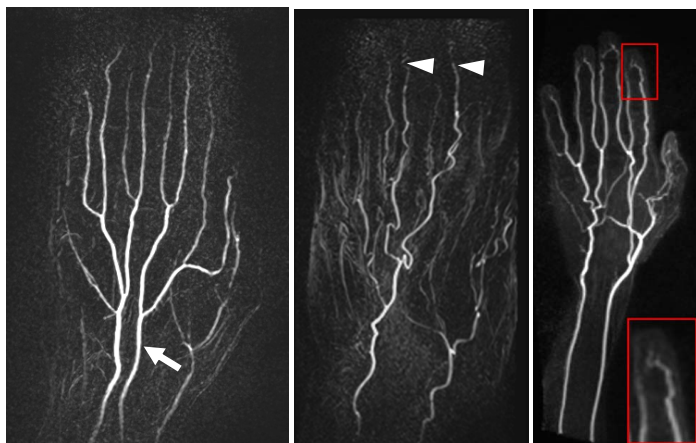
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## Purpose:

Hand MRA is challenging, with small caliber vessels, slow arterial flow and short arteriovenous transit times hampering visualization with contrast enhanced techniques<sup>1</sup>. A non-contrast MRA technique is desirable, particularly in patients with vasculitides where renal function may be compromised, and Nephrogenic Systemic Fibrosis becomes a potential concern<sup>2</sup>. Time of flight and phase contrast MRA are difficult in the hand<sup>3</sup>. ECG-gated single shot fast spin echo (SSFSE) MRA<sup>4</sup> and a time-spatial labeling inversion pulse have been reported<sup>5</sup>. We present our initial experience with an ECG gated turbo spin echo SPACE (Sampling Perfection with Application optimized Contrasts using different flip angle Evolutions) sequence<sup>6</sup> that has been described for lower extremity MRA<sup>7,8</sup>. Selective RF excitation and non-selective variable flip angle refocusing pulses facilitate short interecho spacing and readout duration at 3Tesla within SAR limits, minimizing vessel blur that hampers SSFSE MRA<sup>7</sup>. High flow sensitivity of variable flip angle MRA (VFA-MRA) enables separation of slow arterial flow from venous signal. As intravenous contrast is not required, images can be repeated, providing functional assessment of vascular reactivity in patients with connective tissue disease.

## Methods:

ECG-gated VFA-MRA was performed on 11 hands in 7 volunteers (M=4, mean 43.4y, range 26-62y) and 2 patients (both F, ages 66 and 67) at 3T (Trio, Siemens). Both patients had a history of limited scleroderma. Imaging was performed lateral decubitus, or prone with arms above the head if both hands were acquired simultaneously, with foam wedges and a custom-made hand holder to minimize motion. Imaging parameters were tailored to hand size and surface coil employed (8 channel knee, 12 channel head, or 6 element surface phased array coils): TR=2 R-R intervals, TE 10 ms, variable flip angle, voxel size: 0.7 x 0.8 x 1-2 mm, TA = 3±1min, FOV 240-280 x 156-252 mm, acceleration factor 2-3, 2 echo trains per slice, 43 echoes per train, interecho spacing 3.3ms (echo train duration 73 ms, half Fourier phase encoding). With VFA-MRA, systolic arterial flow voids are subtracted from diastolic bright signal, resulting in an arteriogram. Systolic trigger delays were based on a 2D phase contrast "scout" with 0ms trigger delay for diastolic images. Two of the volunteers with a history of cold sensitivity were imaged following temperature challenge to evaluate vascular reactivity, with images acquired following cooling with ice packs and warming with heated saline bags. Images were assessed by 2 radiologists in consensus for overall image quality (0=non-diagnostic, 1=poor, 2=satisfactory, 3=excellent), factors limiting evaluation, including motion artifact (0=severe; 1=present, affecting image interpretation; 2=present, not affecting interpretation; 3=absent), and for abnormalities or anatomic variants. Number of vascular segments (palmar arches, metacarpal, common digital, arteria radialis indicis, princeps pollicis and proper digital arteries) and segment conspicuity was assessed (0=non-diagnostic; 1=poor, impairing diagnosis; 2=suboptimal without diagnostic impairment; 3=good arterial signal). Temperature challenge images were reviewed for vessel changes.

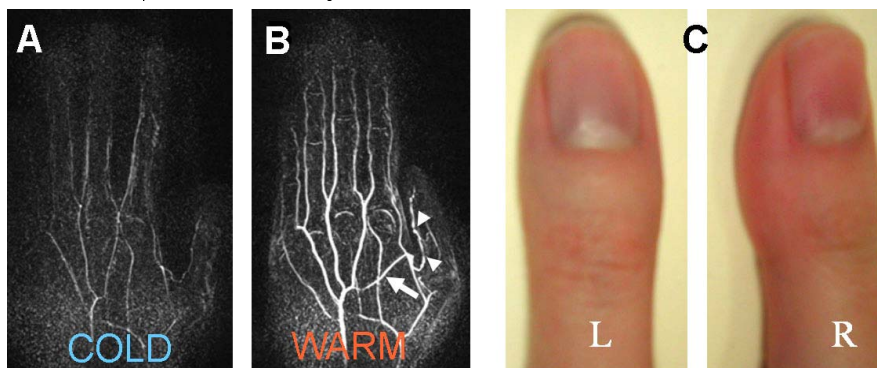


**Fig 1.** Persistent median artery (arrow) on non-contrast enhanced MRA.

**Fig 2.** Scleroderma. Tortuosity and proper digital artery beading (arrowheads).

**Fig 3.** Proper digital vessels and terminal nutrient vessels (inset) are well seen.

**Fig 4.** Female volunteer with history of cold sensitivity in the left thumb. A) Cold challenge resulted in small vessel caliber and poor visualization of left hand digital arteries. B) Increased vessel diameter and completion of superficial arch on warming (arrow). Note princeps pollicis beading with focal stenoses (arrowheads). C) Pale, blue left thumb on examination compared with the normal right thumb.



## Results:

Image quality was generally excellent (n=6) or satisfactory (n=4), with poor image quality in 1 patient in atrial fibrillation. Motion artifact affected image interpretation of the digits in 3 subjects. One vessel segment was partially excluded from the imaging field of view. No venous "contamination" was evident in any subject. Anatomic variations included a persistent median artery (Fig 1). Both scleroderma patients had abnormal imaging, with vessel tortuosity and irregularity noted in one patient (Fig 2) and fewer vessel segments visualized overall. 175 vascular segments were visualized in 11 hands (21 palmar arch, 64 common digital/metacarpal, 20 arteria radialis indicis/princeps pollicis, and 70 proper digital artery segments). High in-plane resolution enabled visualization of terminal nutrient arteries in 3 subjects (Fig 3). 57/70 proper digital arteries were visualized out to their terminal third. There was high vessel segmental conspicuity: palmar arch (2.8±0.6), common digital/metacarpal (2.8±0.6), arteria radialis indicis/princeps pollicis (2.6±0.6) and proper digital (2.6±0.7) arteries. Transition from cold to warm challenge resulted in increased number of visualized segments from 4 to 17 in one subject and 14 to 19 in the other (Fig 4).

## Conclusion:

3D ECG-gated non-gadolinium enhanced VFA-MRA of the hands enables clear separation of veins from arteries, with excellent small vessel conspicuity. The technique can be repeated multiple times at a single session without intravenous contrast, with potential clinical application in the assessment of vascular reactivity with warming and cooling, such as with Raynaud's phenomenon in a connective tissue disease population. With a custom designed hand coil utilizing elements of appropriate size and optimized sensitivity profiles, further gains in spatial resolution and imaging speed are possible.

## References

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