Isotropic MRI of the Ankle at 3.0T using 3D-FSE-Cube with Extended Echo Train Acquisition (XETA)

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INTRODUCTION: MRI with two-dimensional fast spin-echo (2D-FSE) requires multiple acquisition planes because of slice gaps and partial-volume artifacts. Volumetric 3D-FSE acquisitions with isotropic resolution [1] overcome these limitations, allowing reformations in arbitrary planes. We compared 3D-FSE-Cube, an isotropic fast spin-echo acquisition using a variable refocusing flip angle eXtended Echo Train Acquisition (XETA [2-3]) and 2D-accelerated auto-calibrated parallel imaging (ARC [4-5]) with conventional 2D-FSE in the ankle at 3.0T.

METHODS: Fifteen ankles of healthy volunteers were imaged in the sagittal plane using a GE Signa 3.0T MRI scanner (GE Healthcare, Milwaukee, WI) and an 8-channel head coil. 3D-FSE-Cube reduced imaging time by combining very long echo trains (ETL=78) with partial Fourier and auto-calibrated parallel imaging. Using 1D-acceleration (3.4× net acceleration—parallel imaging and partial-Fourier), we acquired 132 sagittal 0.6 mm sections in 6:40. Using 2D-acceleration (6.1× net acceleration factor), we acquired 132 sagittal 0.6 mm sections in 5 minutes. 2D-FSE images were acquired with 2 mm slices and a 0.5 mm gap, 3 acquisitions, echo train length 8, and a scan time of 5:27. All scans had the following parameters: TR/TE 3000/35ms, 256x256 matrix, 15 cm field-of-view, and bandwidth ±31 kHz.

2D-FSE was acquired in the axial plane for comparison with reformats of the 3D data, and both 2D-FSE and 3D-FSE-Cube were acquired with and without fat suppression. For each method, the signal-to-noise ratio (SNR) was measured in cartilage, muscle, and joint fluid. A paired t-test was used to compare SNR.

RESULTS: Cartilage SNR (Figure 1) was significantly higher using 3D-FSE-Cube with 1D-acceleration (25±3) than with 2D-acceleration (20±5) and 2D-FSE (19±5; $p < .01$). Muscle SNR (29±9) with 3D-FSE-Cube with 1D-acceleration was also significantly higher than with 2D-acceleration(17±6) and 2D-FSE (14±3; $p < .01$). Fluid SNR was higher using 3D-FSE-Cube (76±7) with 1D-acceleration than with 2D-accelreration (63±9) and 2D-FSE (67±13; $p < .05$).

3D-FSE-Cube allowed reformation of the images in arbitrary planes (Figure 2). Reformations of the 3D-FSE-Cube images were similar to the directly acquired 2D-FSE data, except the 3D-FSE-Cube had much thinner slices. Fat suppression was uniform on all sequences, and no significant blurring was seen on the 3D-FSE-Cube images.

DISCUSSION: Isotropic data from 3D-FSE-Cube with eXtended Echo Train Acquisition (XETA) allows for reformations in arbitrary planes, making multiple 2D acquisitions unnecessary. Slice thickness is 3 times less than 2D-FSE, decreasing partial-volume artifacts. 3D-FSE-Cube is a promising high-resolution MR imaging technique that may improve depiction of complex ankle anatomy.

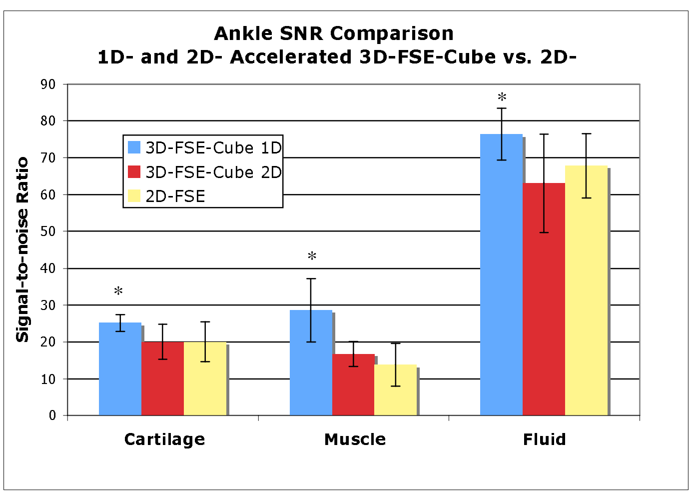

Figure 1: Signal-to-noise ratio (SNR) comparison between 1D- and 2D-accelerated 3D-FSE-Cube and 1D- and 2D- acceleration and 2D-FSE for cartilage, muscle, and fluid. The SNR for 1D-accelerated 3D-FSE-Cube was significantly higher than 2D-accelerated 3D-FSE-Cube and 2D-FSE (* = $p < .05$).

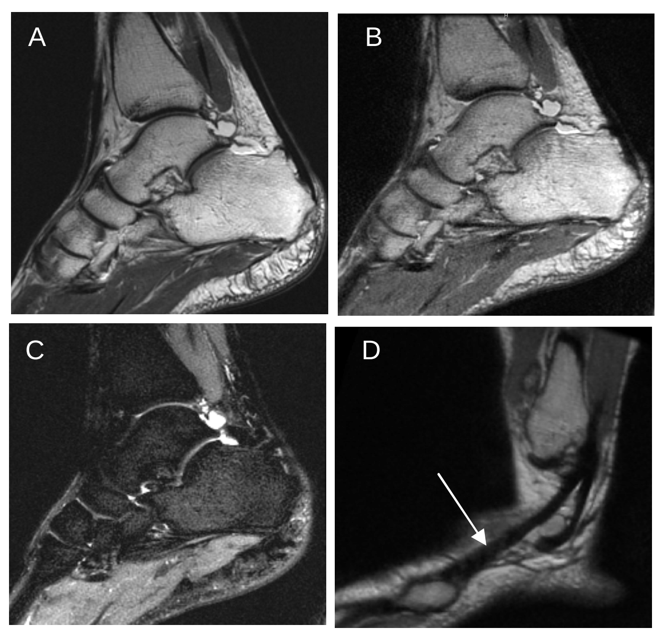

Figure 2: A) Sagittal 2D-FSE image, slice thickness 2 mm. B) Sagittal 3D-FSE-Cube image with one-dimensional acceleration, slice thickness 0.6 mm. C) Sagittal 3D-FSE-Cube with one-dimensional acceleration and fat saturation, slice thickness 0.6 mm. D) Oblique reformation showing the peroneus brevis tendon (arrow).

ACKNOWLEDGMENTS: NIH (EB002524-04), SCBT-MR

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