

3D-TSE-imaging of the ankle - a new perspective?

M. Notohamiprodjo¹, A. Horng², B. Kuschel², P. Bär³, M. F. Reiser⁴, and C. Glaser⁴

¹Institute for Clinical Radiology, University Hospitals Munich, Munich, Bavaria, Germany, ²University Hospitals Munich, Institute for Clinical Radiology, ³Siemens Sector Healthcare, ⁴Institute for Clinical Radiology, University Hospitals Munich

Purpose: Standard protocols of the ankle joint often comprise additional angulated sequences to visualize the complex anatomy. Highly resolved isotropic 3D-Turbo-Spin-Echo (TSE) - sequences in combination with multichannel-coils and high field strengths show promise for future application in routine musculoskeletal imaging (1, 2) allowing for free three-dimensional reconstruction of the isotropic dataset. It may help dispense additional ligament angulations and the reduced partial volume effects may be beneficial for the detection of small cartilage lesions. In this study we present the first clinical results with a 3D-TSE-sequence for rapid 3D-imaging of the ankle joint at a field strength of 3T.

Material and Methods: 15 volunteers and 25 patients were examined in a 3T-scanner (Magnetom VERIO, Siemens Sector Healthcare) with a dedicated 8-channel-ankle-coil and a highly resolved isotropic sagittal PDfs-weighted 3D-TSE-sequence (TR1100msec/TE37msec/Voxel-size:0.6³mm/acquisition-time 6:43min). The variable flip angles were optimized for tissue contrast. Radial k-space sampling and elliptical scanning were introduced for sharper delineation of surfaces and more time efficient acquisition. Signal- and Contrast-to-Noise-Ratios (SNR;CNR) were calculated with the subtraction method (3). Using free 3D-reformats two radiologists independently assessed depiction of cartilage, ligament and tendon (insertions and midportion) anatomy and depiction of lesions of these structures (5-point-Likert-scale). They were compared to a 2D-TSE-sequence (TR2830ms/TE27ms/Voxel-size:0.3x0.3x3mm/total acquisition-time 12:40min) acquired in the 3 major anatomical planes. Statistical analysis was performed with paired t-tests, interreader-correlation with weighted-kappa-coefficients.

Results: SNR and CNR of fluid and cartilage were not significantly different, whereas SNR of low signal structures (ligaments/tendons/subchondral bone) were significantly lower for the 3D-TSE-sequence ($p < 0.01$), leading to a significantly higher CNR of e.g. ligament/fat (3D-TSE vs. 2D-TSE: $39 \pm 16 \pm$ vs. 12 ± 5) or ligament/fluid (208 ± 40 vs. 152 ± 30) ($p < 0.01$).

Overall depiction of the ankle ligaments was superior in the 3D-TSE-sequence with significant advantages for the insertions of the calcaneofibular ligament (3D-TSE vs. 2D-TSE: 4.4 ± 0.8 vs. 3.4 ± 1.1) and the course and distal insertion of the tibionavicular (4.8 ± 0.6 vs. 4.0 ± 0.7) and anterior tibiotalar ligament (4.7 ± 0.7 vs. 3.8 ± 1.0). Depiction of cartilage was significantly better ($5.0 \pm 0.0/4.3 \pm 0.5$), particularly in regions usually suffering from partial volume, i.e. the anterolateral talus bone. There were no significant differences in the number of detected cartilage ($n = 18$ vs. $n = 16$) or ligament ($n = 17$ vs. $n = 17$) lesions (Figure 1 and 2). No abnormality seen in the 2D protocol was missed in the 3D-TSE. However, a small additional number of discrete cartilage lesions could be found. Diagnostic confidence showed a non significant tendency for better results in the 3D-sequence. Interreader-correlation was excellent ($\text{kappa} = 0.82 - 0.84$) for both sequences.

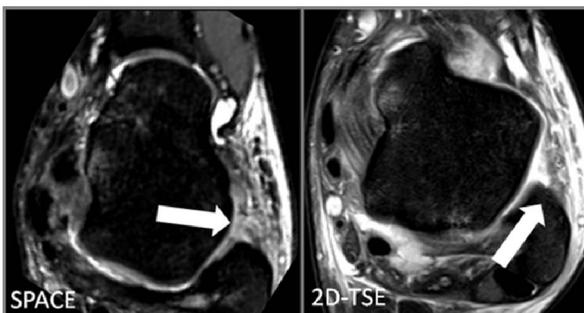


Figure 1: Partial tear of the anterior fibulotalar ligament. In SPACE the remnants of the proximal insertion can be readily identified (arrow).

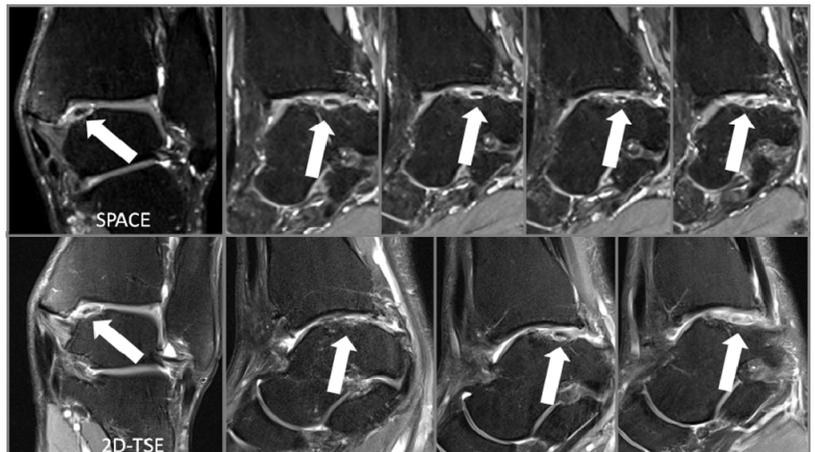


Figure 2: Osteochondritis dissecans of the medial talus bone. In the SPACE sequence reduced partial volume effects lead to improved depiction of the osteochondral fragment (arrow).

Conclusion: 3T and the optimized acquisition-techniques of the evaluated PDw-3D-TSE-sequence allow rapid acquisition of a highly-resolved isotropic dataset. In the ankle acquisition time can be shortened by up to 50% as compared to the 2D protocol. Free 3D-ligament angulations facilitate cartilage and ligament depiction at least comparable to current 2D-protocols if not better. Small cartilage lesions can be visualized with reduced partial volume effects. The technique holds high potential for future Ankle-MRI-protocols.

References:

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