3D-imaging of the knee with an optimized 3D-TSE sequence and a 15 channel knee-coil at 3T

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Purpose: Highly resolved isotropic 3D-TSE-imaging of the knee has proven clinically feasible, however fluid signal and signal homogeneity have been still somewhat limited (1). The purpose of this study was to evaluate a highly–resolved isotropic PDfs-weighted 3D-TSE-sequence (SPACE) with advanced acquisition strategies for optimized contrast and image quality for knee-MRI at 3T with a 15-channel knee coil.

Material and Methods: 15 healthy volunteers and 50 patients were examined with a 15-channel-knee coil at 3T (Magnetom VERIO, Siemens) using a sagittal PDfs-weighted 3D-TSE-sequence (TR1200msec/ TE31msec/ Voxel-size 0.6x 0.5x 0.5mm/ acquisition time 10:48min). The variable flip angles of the echo train have been optimized for improved contrast, radial k-space sampling and elliptical scanning were introduced for sharper delineation of surfaces and more time efficient acquisition. For comparison a 2D-TSE-sequence in 3 planes (TR4050msec /TE30msec / Voxel-size 0.3x0.3x3.0mm/total acquisition time 12:20min) was acquired. Signal- and Contrast-to-Noise-Ratios (SNR; CNR) were calculated with the subtraction method (2). Using 1mm-reformats in 3 planes, 2 radiologists independently assessed depiction of cartilage, menisci and ligaments and detection and diagnostic confidence of internal knee disorders in volunteers and patients respectively (5-point-scale). Statistical analysis was performed with paired t-tests, interreader correlation was assessed with weighted-kappa-coefficients.

Results: SNR of fluid (3D-TSE vs.2D-TSE: 201 ± 43 vs. 130 ± 28) and cartilage (97 ± 12 vs. 62 ± 9) of the isotropic 3D-TSE-sequence were significantly higher ($p<0.001$) than of the 2D-TSE-sequence, whereas SNR of structures with typically low signal intensity (i.e. subchondral bone, menisci) was significantly lower in the 3D-TSE-sequence($p<0.001$). CNR of fluid/cartilage (188 vs. 44 /115 vs. 26) and of cartilage/bone (93 ± 12 vs. 47 vs. 8) were significantly higher for the 3D-TSE-sequence ($p<0.001$).

Anatomical detail depiction was significantly better for the femoral trochlea (3D-TSE vs. 2D-TSE: 4.9 ± 0.3 vs. 3.7 ± 1.0) and small structures like meniscal roots (4.95 ± 0.2 vs. 4.4 ± 0.6) ($p<0.01$) in the 3D-TSE-sequence. Detection and diagnostic confidence of internal knee disorders were not significantly different, however delineation of subtle cartilage lesions in regions usually suffering from partial volume, e.g. the dorsolateral femur condyle (Figure 1) or the femoral trochlea were clearly visible in the 3D-TSE-sequence, whereas partially missed in the 2D-TSE-sequence. Interreader-correlation was slightly better for the 3D-TSE-sequence ($\kappa=0.87$ vs 0.82). Despite imaging time >10min, confining motion artifacts were observed in only a few patients (n = 6).

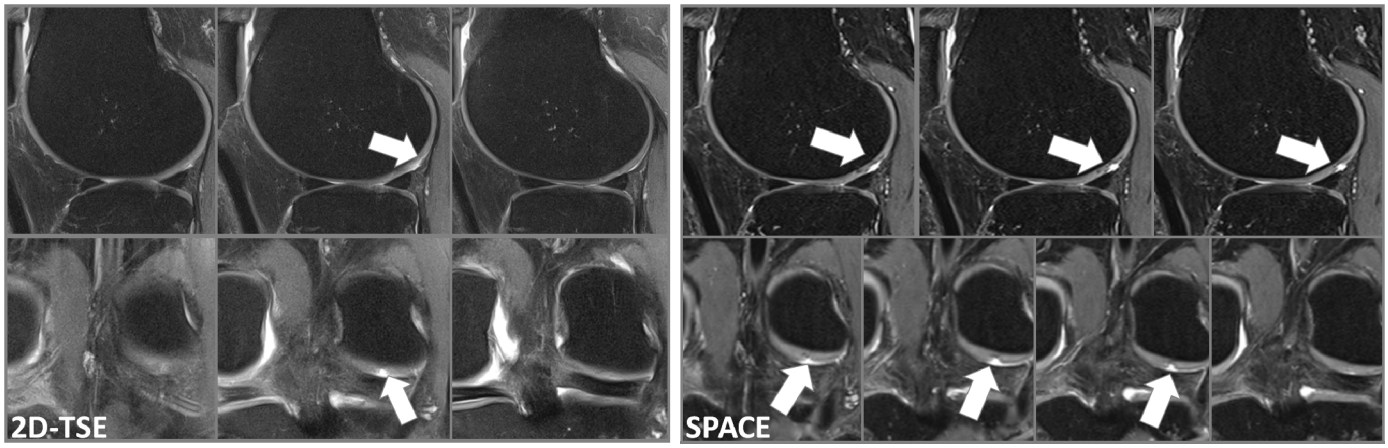

Figure 1: Small cartilage lesion of the dorsolateral femur condyle. In the sagittal 2D-TSE-sequence the lesion is almost undetectable. In the coronal sections, the lesion can only be seen on one slice and was initially missed by both readers. In the 3D-TSE-sequence (SPACE) the lesion can be seen on several slices both in sagittal and coronal 1mm thick reconstructions and was detected by both readers. Also note the excellent fluid/cartilage contrast and the relatively homogenous image quality of the 3D-TSE-sequence.

Conclusion: 3T and a 15-channel-coil allow for isotropic Knee-MRI with an optimized 3D-TSE-sequence, providing excellent image quality and clinical performance at least equivalent if not better to current 2D-protocols. The isotropic resolution allows for free 3D-reconstructions and is helpful for depicting small lesions usually suffering from partial volume effects. This technique holds high potential for future knee-MRI protocols.

References:

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