# 3D T2w-MRI using a Magnetization-Prepared Golden Angle Radial Sequence with Motion-Corrected ESPIRiT Reconstruction

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**Target Audience:** For clinicians and physicists interested in motion corrected T2-w body MRI.

**Purpose:** T2-weighted MRI is the central component for body cancer MRI protocols. Three-dimensional (3D) high-resolution acquisitions are desirable for lesion detection and surgical planning, however, in clinical routine T2-w MRI is often restricted to 2D multi-slice acquisitions, because 3D acquisition times are relatively long and achieving robustly good image quality is often hindered by motion corruption. The purpose of our work was to develop a 3D T2-w motion robust imaging sequence using a magnetization-prepared radial imaging technique with self-navigating motion correction.

**Methods:** After IRB approval and informed consent was obtained, one healthy volunteer prostate was scanned at 1.5T (Avanto, Siemens Healthcare, Erlangen, Germany) and one liver at 3T (Skyra). A T2-prepared[1] ($TE_{prep}$ = 50 ms) sequence with a 3D radial readout ("stack-of-stars") with golden angle (GA) view ordering was used. The readout sequence was balanced Steady State Free Precession (bSSFP) for prostate or spoiled gradient echo (GRE) for liver imaging. Acquisition for prostate (liver) was transversal with 224x224 (288x288) matrix size, 520 (720) radial views, 2 views / $TR_{prep}$, 40 segments, 20 partitions, resolution 1.34x1.34 (1.04x1.04) $mm^2$, slice thickness 3.5 (6) mm, $TR_{prep}$/TR/TE of 1000/5/3 ms, flip angle 85 (20)$^o$, bandwidth 320 Hz/px, and a total acquisition time (TA) of 4 min 20 s (6 min) for the full data set. To assess the feasibility for bulk motion correction, during the prostate acquisition, the volunteer was asked to move every 60 s. For retrospective motion corrected data analysis, a self-navigating signal was extracted from the central $k_z$ line every $TR_{prep}$ and views with motion corruption were excluded. Image reconstruction was performed offline with L1-ESPIRiT[2] implemented in C/C++, where coil sensitivity maps were estimated from a gridded center 18×18×10 cube region. Randomized shifting wavelets were used as the regularization term.

**Results:** In the prostate, deliberate bulk motion resulted in signal spikes in the self-navigating signal (**Fig. 1**) and in the liver scan respiratory motion could be detected (**Fig. 3**). Acquisition with deliberate bulk motion (prostate, **Fig. 2b**) or respiratory motion (liver, **Fig. 4b**) resulted in blurry, non-diagnostic images. After removing the motion corrupted GA views, image quality was improved (**Fig. 2d, 4c**). With motion corrected, under-sampled data (prostate: R=3, **Fig 2d**; liver R=2, **Fig. 4d**), acceptable image quality could be achieved in short acquisition times (prostate: TA=45 s, liver: TA=3 min).

**Discussion:** Bulk and respiratory motion could be reliably detected using the self-navigating radial sequence. The golden angle view ordering allowed for flexible retrospective image reconstruction, allowing removal of motion-corrupted views. ESPIRiT reconstruction yielded good image quality even in under-sampled data sets.

**Conclusion:** Using T2-prepared 3D GA radial imaging with self-navigated motion correction and ESPIRiT image reconstruction, 3D T2-w MRI can be performed robustly in the body, even if severe motion occurred during the acquisition.

**References:** [1] Brittain et al, MRM 33:689-696(1995). [2] M Uecker et al, MRM 71:990-1001(2014).

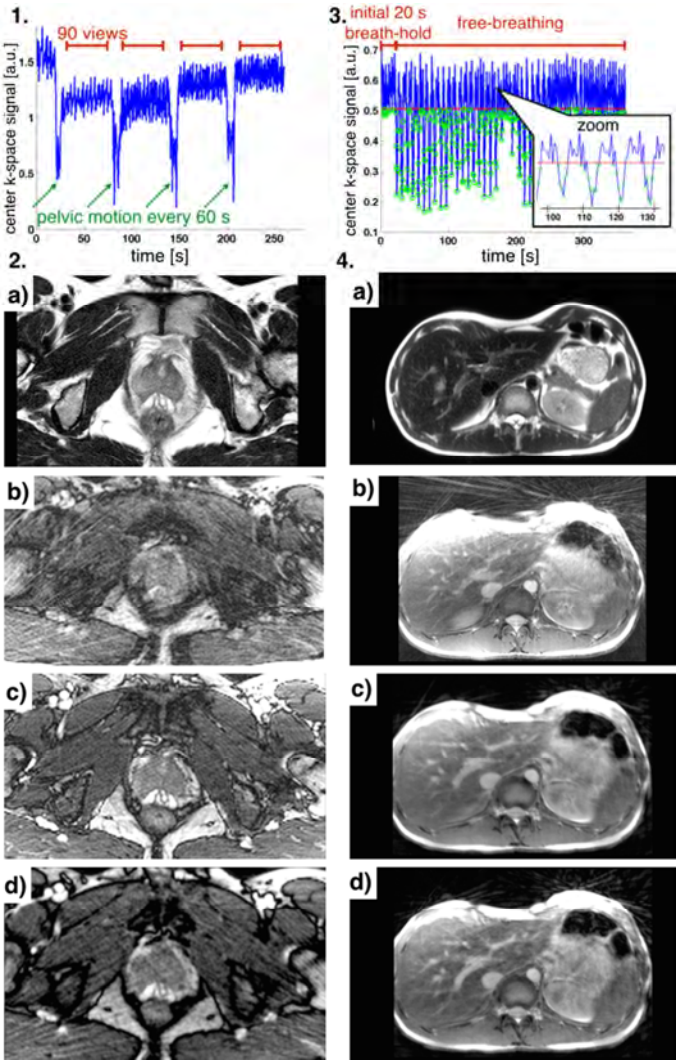


**Figure 1:** Self-navigating signal showed spikes, when volunteer was asked to move. **Figure 2:** 2D T2-TSE (TE=95 ms) prostate acquisition without deliberate motion for reference (a). The 3D radial T2-prep acquisition with deliberate bulk motion showed severe artifacts (b), while the same sequence without deliberate motion yielded good image quality (c). The same data as shown in (b), was retrospectively corrected for motion using the self-navigating signal and ESPIRiT reconstruction of the under-sampled (90 views, R=3.9) motion-corrected data set was able to recover good image quality (d). **Figure 3:** In the liver scan, the self-navigating signal detected the respiratory cycle; green markers indicate the discarded data for motion correction. **Figure 4:** 2D T2-HASTE (TE=74 ms) liver acquisition for reference (a). Free-breathing 3D radial T2-prep sequence, TA = 6 min (b) showed streaking artifacts. Streaking was removed after motion correction (c). Using only half the acquisition time (TA = 3 min), motion corrected and ESPIRiT reconstructed images yielded good image quality (d).