# Motion detection and dual retrospective correction for MR spectroscopy in the human spinal cord

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**Introduction:** Subject motion is one of the major problems for MR spectroscopy (MRS) since it often leads to increased line width, frequency shifts, reduced peak areas, insufficient water suppression (1), and to a displacement of the acquisition voxel. Especially, if the region of interest is small (like the spinal cord or tumors) even small movements will shift the measurement voxel out of the region of interest resulting in inaccurate results. However, especially in the clinical routine patient movement cannot be eliminated and the detection of patient motion by observing exclusively the spectra is sometimes impossible (1). Therefore, **in this investigation**, 1D navigator acquisitions interleaved with the MRS measurement are used for real-time subject-motion detection in the spinal cord. In addition, the combination of interleaved navigator acquisitions with non-water-suppressed MRS is used for a dual retrospective motion correction of spinal cord spectra.

**Methods:** Non-water-suppressed MRS via the metabolite cycling technique at 3 T (Achieva, Philips Healthcare, Best, inner-volume saturated PRESS, TE/TR 30/2500 ms, voxel size 1.2 ml, 4*128 FIDs) was used at the cervical level C3-4 (figure 1) in the human spinal cord (2). The technique allows for frequency alignment, phase and eddy current correction before averaging and thus to an improvement of the spectral quality as previously reported in ref. (2). Interleaved navigators (figure 2) were placed above the MRS-voxel (figure 1). The software allows real-time data processing so that the navigator position evaluation can be displayed online (figure 3). After approval from the local ethics committee, one volunteer was scanned with (scan 2 & 3) and without (scan 1) navigator motion detection. The volunteer was asked to lie still during all measurements except of scan 3. There the volunteer was asked to slowly raise her chin about 2 cm in the middle of the scan and to return to the initial position after ~30 s (~15 FIDs, ~3% of MRS scan-time). Before and after each MRS scan axial T2 weighted images were acquired. If these images were shifted more than 1 mm the MRS measurement was repeated. Furthermore, for an additional spectrum reconstruction (scan 3 b) all FIDs with a misplacement of more than 1 mm based on navigator data were excluded and the remaining FIDs were averaged after phase and frequency correction.

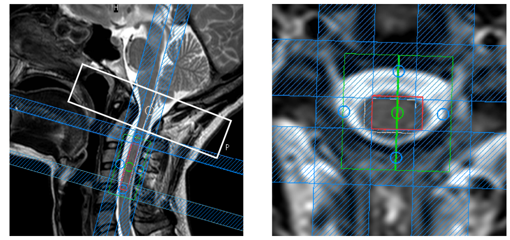

*__Figure 1:__ Sagittal and axial T2 weighted turbo spin-echo images of the cervical spinal cord showing the MRS voxel (red), the navigator (white), the inner-volume saturation bands (blue) and the shim box (green).*

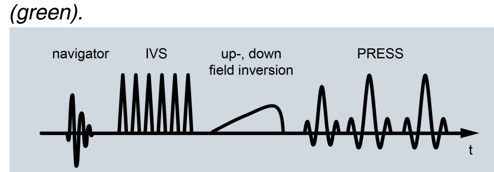


*__Figure 2:__ Pulse sequence: Navigators are applied before inner-volume saturation (IVS), up-/downfield inversion for the metabolite cycling, and PRESS localization. They consist of a two dimensional selective excitation pulse exciting a pencil beam (r=30mm, l=120mm).*

**Results:** The spectra of scan 1 & 2 (figure 3) show that interleaving the MRS sequence by navigators does not negatively affect the MRS quality. In addition, compared to scans without motion (1 & 2) scan 3 a of figure 3 shows a different spectral fingerprint (e.g. increased lipid signal). Despite, the subject motion is not detectable by observing the localization images acquired before and after the MRS scan, the chin rise is clearly visible in the navigator window. In addition, by deleting the motion affected FIDs and by correcting the remaining FIDs for frequency and phase shifts based on the unsuppressed water signal, distortion free spectra can be reconstructed (figure 3, scan 3 b).

**Discussion:** Intra-scan patient movement can lead to a misplacement of the voxel and to a significant distortion of spectra resulting in wrong quantification results. Thus, motion detection is essential. Interleaved navigators allow precise real-time motion detection for MRS without the need of additional scan-time and additional hardware. It allows early intervention (e.g. asking the subject to lay still) and to reject motion corrupted FIDs. In addition, the combination of navigators and non-water-suppressed MRS via the MC technique, seems to be ideal if the region of interest is small like in tumors or in the spinal cord, since navigators are able to detect a misplacement of the voxel whereas the use of the MC technique with ECG triggering allows for the correction (frequency and phase correction of each FID before averaging) of $B_0$ field drifts induced by respiratory motion and heart beating.

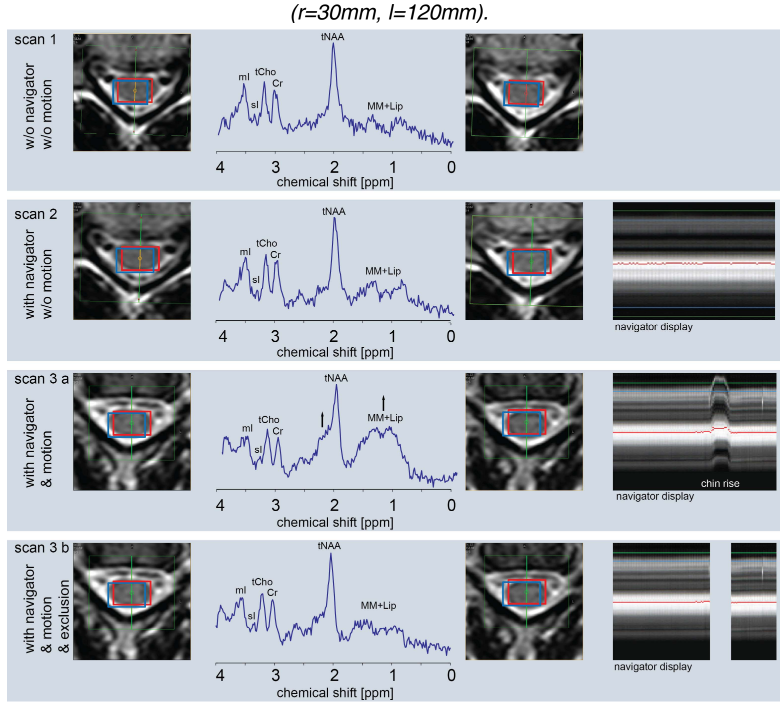


*__Figure 3:__ Localization images recorded before (left to the spectra) and after (right to the spectra), spinal cord spectra, and zoomed in navigator display of the 3 scans. See text for more details.*

**References:**

1. Kreis R. NMR Biomed 2004;17(6):361-381.
2. Hock A. et al., Magn Reson Med 2012.
3. Welch E. B. et al., Magnetic Resonance in Medicine 2001;47(1):32-41.