A novel partial averaging approach for reducing motion ghosting in Dixon TSE

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Target Audience

Technicians and Scientists interested in motion artifact reduction techniques for Dixon TSE.

Purpose

Dixon TSE provides complete fat suppression even in difficult B0 inhomogenous areas. However, Dixon TSE is known to be sensitive to motion artifacts. Breathing motion of subcutaneous fat can introduce ghosts overlapping with the region of interest. In this feasibility study we investigate a novel partial averaging approach for Dixon TSE acquisition.

Methods

In a segmented k-space acquisition of multi-shot TSE sequences, motion during a single shot in a multi-shot sequence leads to repetitive ghosts in the image. Partial averaging where the k-space center is acquired more times and hence denser than peripheral k-space is shown in Fig 1. This variable density sampling leads to low and high frequency components of the motion ghosts appearing at different repetitive locations in the image. The motion ghost signal piling up at distinctive locations in the image can be distributed by various randomization steps: 1. random reordering of profiles within k-space segments and varying the random order over acquisitions, 2. randomizing the subsampling over acquisitions as indicated in Fig. 1. Simulations (IDL) and phantom experiments were performed to demonstrate artifact levels from motion ghosting for the individual steps and compare them to the standard two average scan. All experiments were performed on Philips 1.5T and 3.0T (Best, The Netherlands) clinical scanners. A volunteer study was performed on ten subjects testing this technique for the dual acquisition Dixon TSE acquisition in various applications: lumbar spine, pelvis, breast, knee and shoulder.

Results

Phantom scans are shown in Fig. 2 a) for two averages (NSA) and Fig 2b) with the partial averaging approach for 1.5 averages. To simulate motion, the lowest tube in the phantom (see arrow) was removed after one shot during a pause of the scan. Note the motion ghost amplitude is reduced from 26.23 to 19.98 for the drawn ROI. 2 c) and d) show respective results on a volunteer in the lumbar spine. Motion artifacts are distributed using the partial averaging approach. Results from the volunteer study are shown in Fig. 3 and 4 for the breast and pelvis application. Cardiac motion is reduced with the partial averaging approach (Fig. 3 b, d) compared to the standard one average scan (Fig. 3 a, c). Scan time in both scans are identical using higher SENSE factors in the partial averaging approach. For pelvis scans (Fig. 4) breathing motion artifact is reduced with increased partial averaging factors and provides good quality with 1.5 averages. In applications with pulsatility and breathing related artifacts the motion artifact level was always improved with the partial averaging approach. In case of incidental motion such as in shoulder scans, the randomized partial averaging approach did not always improve the quality of scans compared to the single average approach. This very likely is due to the fact that motion is not reproducible over scans and only took place in the partial averaging scan.

Discussion / Conclusion

The presented partial averaging approach provides the possibility to effectively reduce the artifact level in Dixon TSE possibly improving the diagnostic quality of scans. We have demonstrated that variable density random sampling helps to effectively improve motion ghosting, even when compared to the longer two average scans.

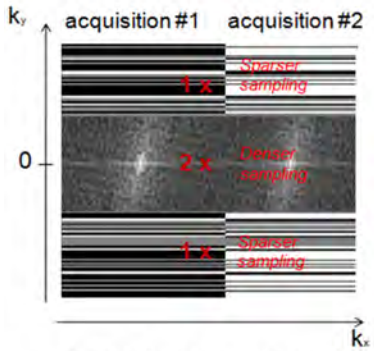

Figure 1: *Partial averaging method*

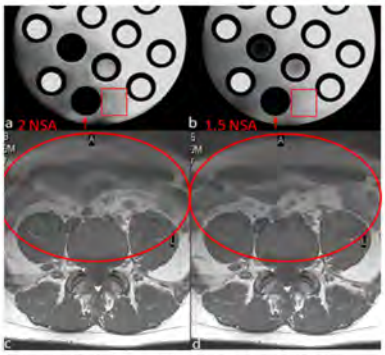

Figure 2: *Decreased ghost level of 1.5 NSA (b, d) compared to 2 NSA (a, c)*

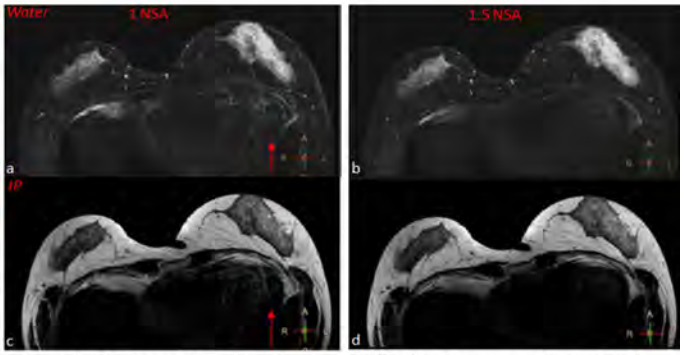

Figure 3: *Decreased ghost level with 1.5 NSA (b, d) compared to 1 NSA (a, c) in the breast application (T2w TSE)*

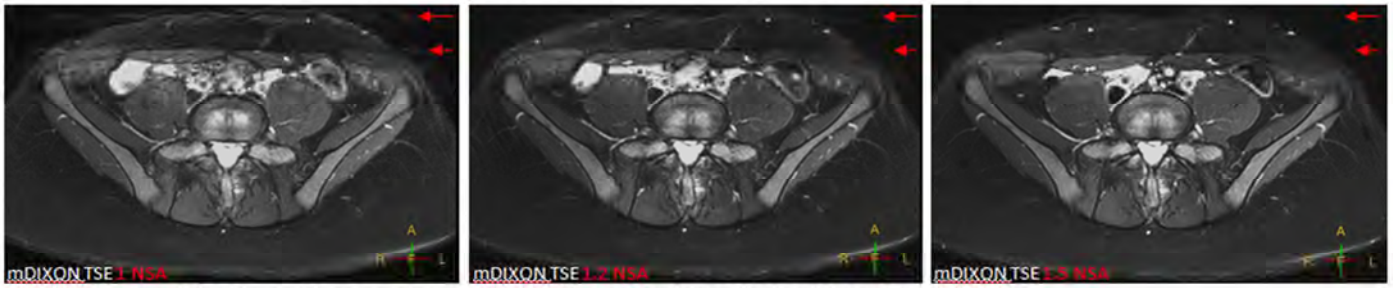

Figure 4: *Decreased ghost level with increase in partial NSA factors in the pelvis application (Water, T2w TSE)*