Longitudinal GRASP MRI Reconstruction

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Introduction

- In current clinical practice, many patients need to undergo regular **follow-up MRI exams** (referred to as longitudinal MRI exams) to monitor disease progression or to evaluate treatment response. Usually, images in each MRI exam session are reconstructed in isolation without considering prior imaging information.
- Similar to dynamic MRI reconstruction aims to exploit **image correlations** or sparsity along the time dimension for improved reconstruction quality, longitudinal exams also provide valuable information over an extended temporal scale that can be leveraged for improving image reconstruction.
- We propose **longitudinal MRI reconstruction** strategies that exploit such correlations for improved acceleration rates and reconstruction performance. The proposed methods are built upon the Golden-angle RAdial Sparse Parallel (GRASP) MRI framework and have been demonstrated for two applications, including free-breathing 4D liver MRI and 3D Dynamic contrast-enhanced (DCE) brain imaging.

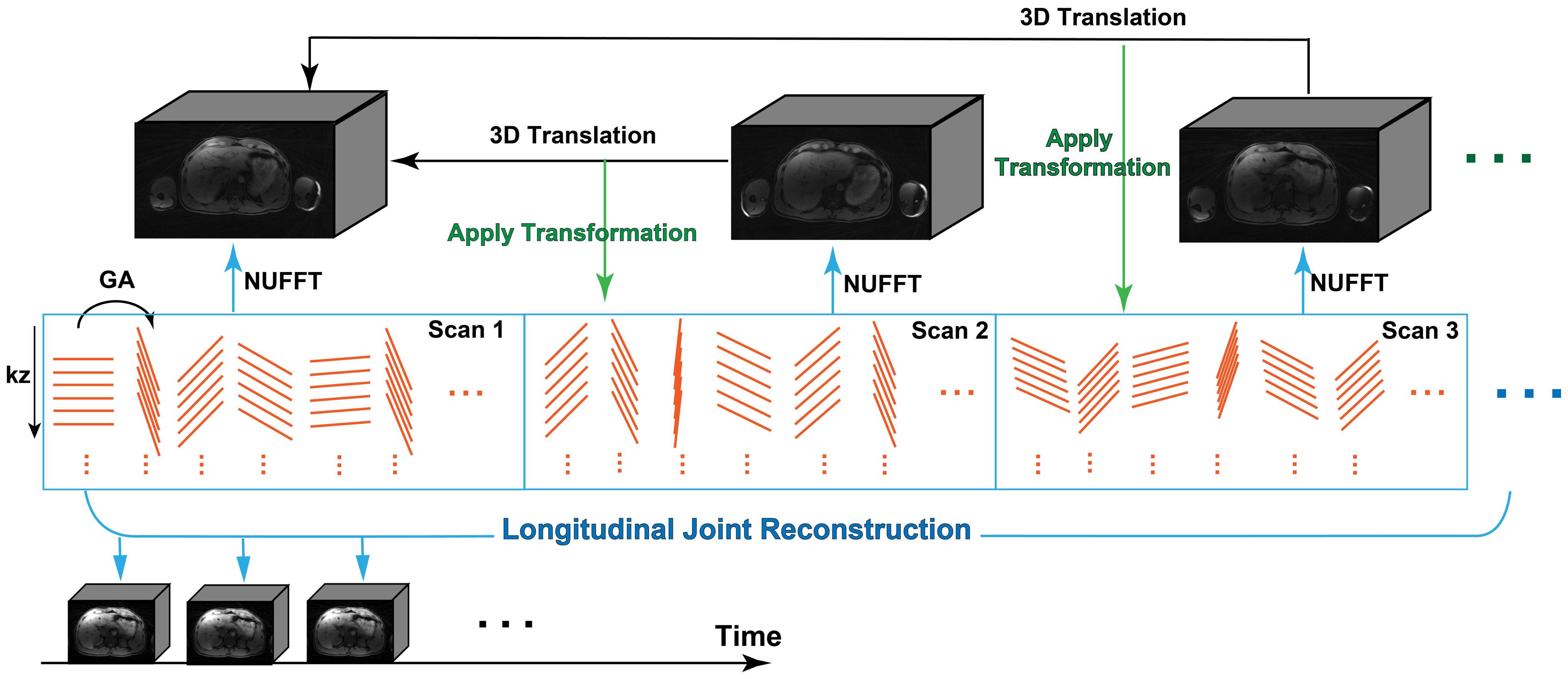

Figure 1: Longitudinal reconstruction framework with example of free-breathing GRASP liver imaging.

Methods

- **Longitudinal Joint Reconstruction:** Before the longitudinal reconstruction, the NUFFT reconstructed 3D images of follow-up scans are registered to the NUFFT reconstructed 3D image of the initial scan through translational transformation (Figure 1). The translation is then applied to the raw k-space data. GRASP reconstruction with a combination of **low-rank subspace constraint** and **a temporal total variation** regularization is then performed on concatenated data **combining all sessions**.

GRASP DCE Brain Imaging

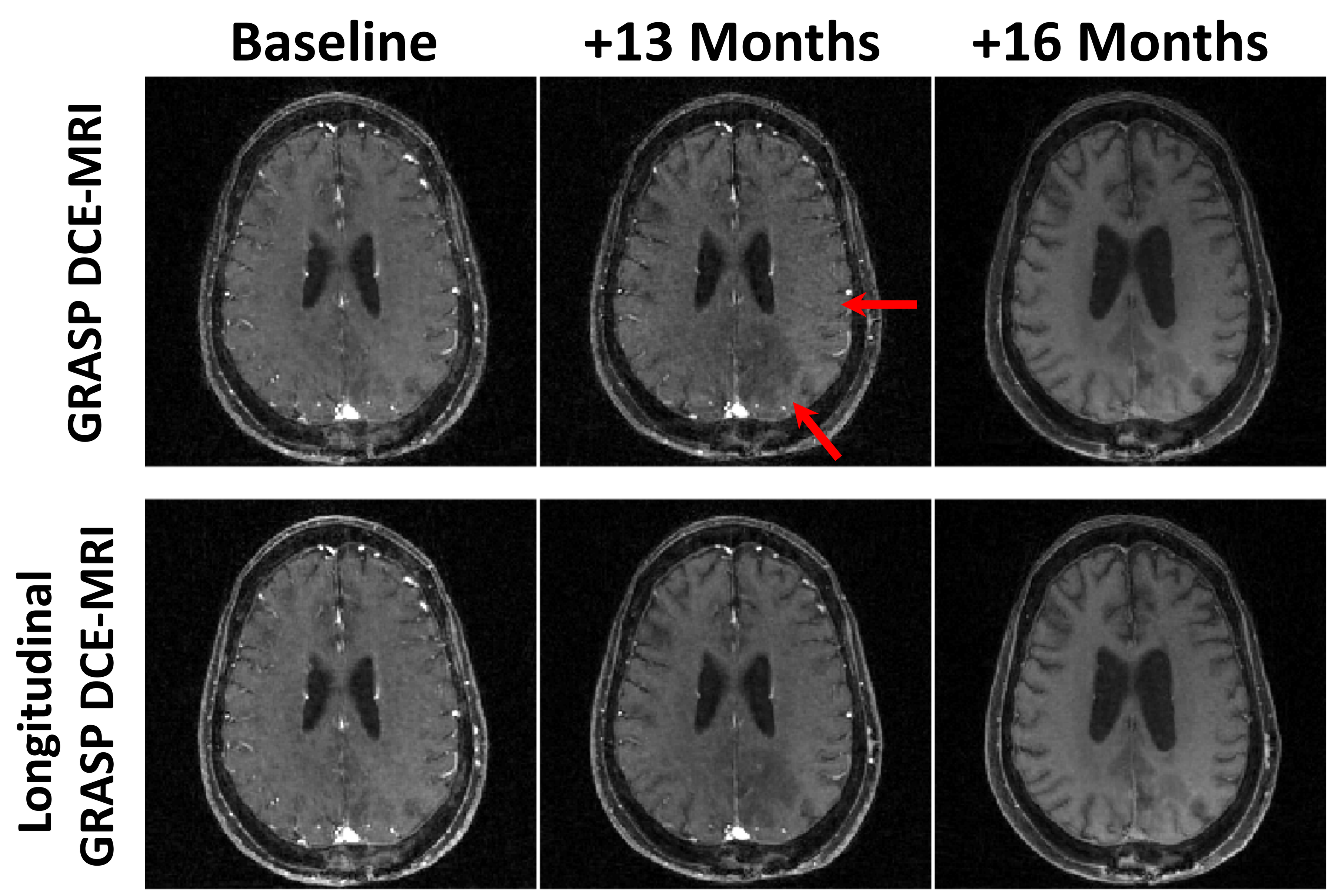

Figure 2: Longitudinal reconstruction of GRASP DCE-MRI Brain Imaging.

- **GRASP DCE Brain Imaging**: Three sessions of GRASP DCE-MRI brain imaging were performed for a patient with lesion. Each scan contains stack-of-star acquisition of 500 golden angle (GA) rotated radial spokes with 0° navigators acquired every 2 GA spokes. Each scan uses a different set of GA radial spokes. Dynamic 4D images are reconstructed with 5 spokes per frame per slice.

Free-Breathing GRASP Liver Imaging

- **Free-Breathing GRASP for 3D Liver Imaging:** Three sessions of free-breathing GRASP [1] liver imaging were performed on the same subject in different time points. Each scan contained 200 golden angle (GA) rotated radial spokes with a 0° navigator spoke (not shown) every 2 GA spokes to track respiratory motion and body movement across scans. Each scan used a different set of GA spokes to ensure temporal incoherence.

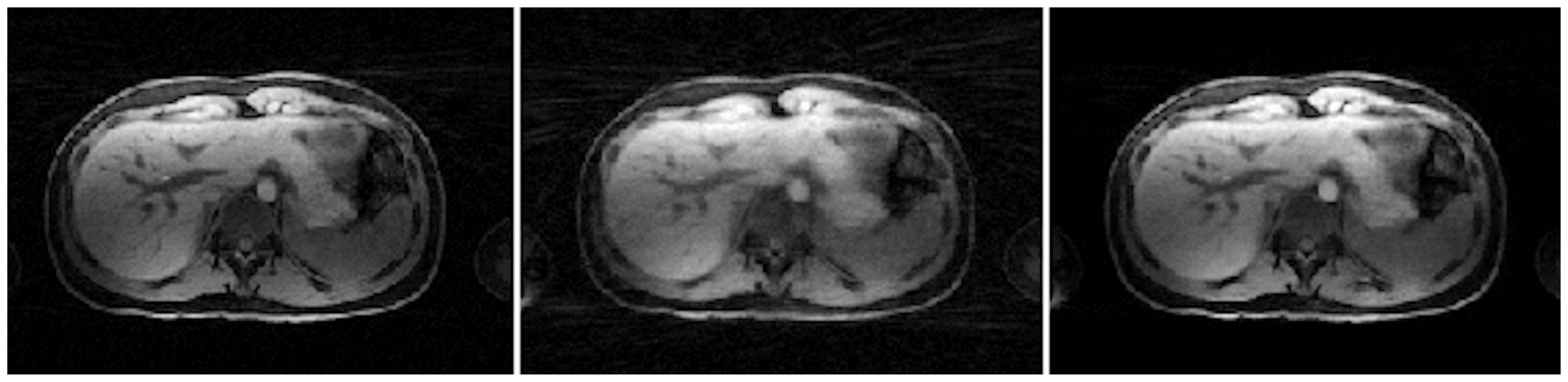

Figure 3: 4D dynamic liver MRI reconstruction. Left: Nyquist reference; middle: individual reconstruction of one image with limited data; right: longitudinal reconstruction of multiple images with limited data each.

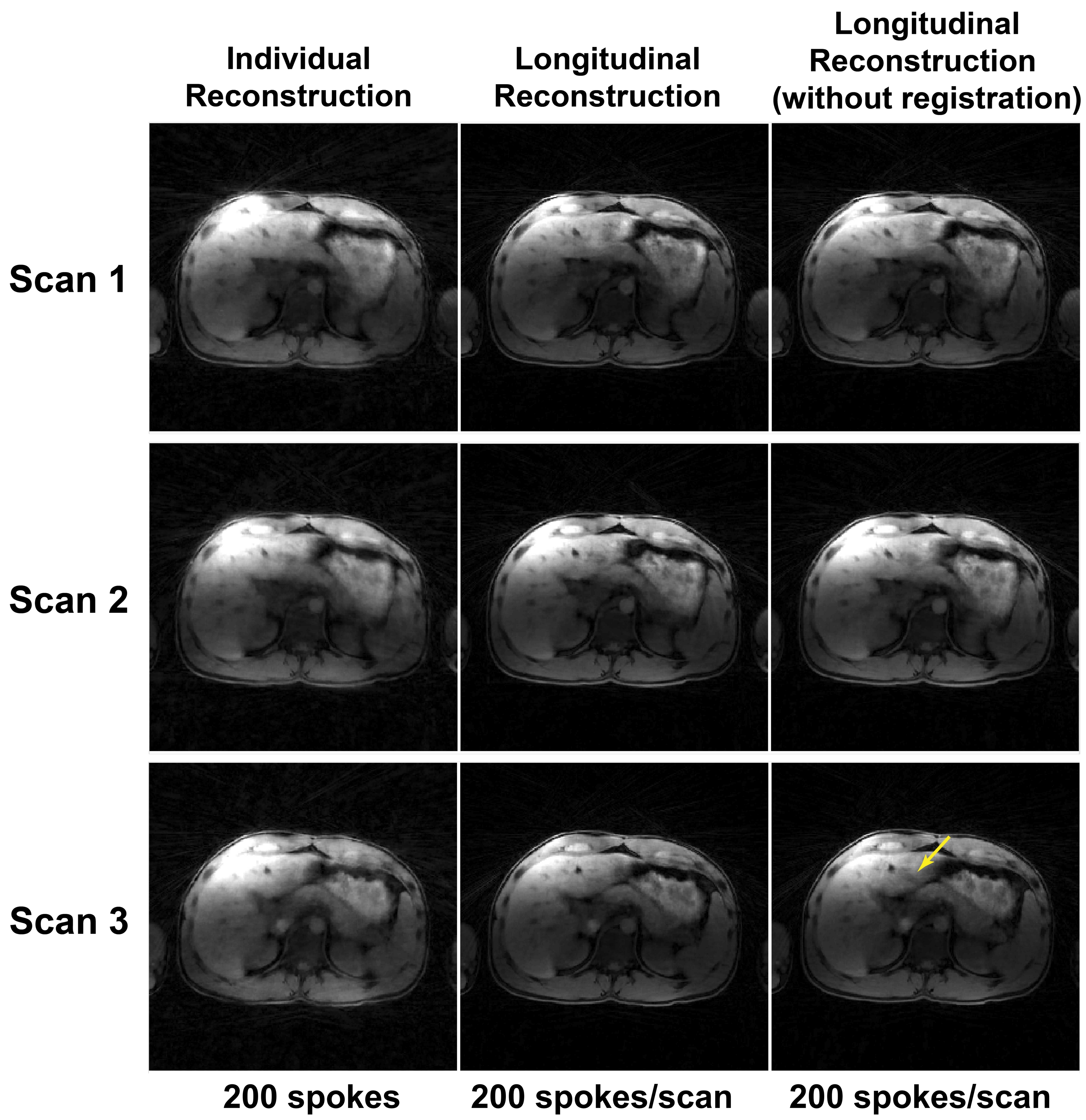

Figure 4: Longitudinal reconstruction of free-breathing 4D liver imaging with registration alignment.

Discussion & Conclusion

- **Information from prior scans** on the same subject could be leveraged to improve image reconstruction and push for highly accelerated data acquisition.
- Even each scanning session is highly accelerated, the longitudinal reconstruction provides improved image quality of each scan while **preserving the distinctive anatomical and pathological features** from each imaging session.
- Further, 3D **translation transformation** through registration preprocessing reduces artifacts and blurring that are caused by the slight mis-alignment of the imaging volume during each scanning session.
- The longitudinal MRI reconstruction could allow for progressive acceleration of data acquisition beyond that can be achieved using only data from a single-visit scan.

REFERENCES

[1] Feng, Li, et al. *Magnetic resonance in medicine* 72.3 (2014): 707-717.