

Free-breathing volumetric abdominal MRI with a modified helical bSSFP-sequence

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Target audience: Scientists who are interested in new acquisition strategies and abdominal imaging

Purpose: Applications using helical data acquisition for abdominal imaging have been presented previously [1, 2]. Adjacent views are sampled with a radial readout in the k_x - k_y -plane and, like in spiral CT, a simultaneous movement in the slice direction (z -direction). Therefore a continuous acquisition of data and a reduction of measurement time are possible. In this work, helical MRI was used to acquire volumetric images of the abdomen during free breathing, using a bSSFP-sequence and a golden angle reordering [3, 4]. The robustness of the helical approach against motion and flow allows continuous data acquisition in a 3D manner.

Methods: The modified helical k -space scheme is shown in Fig. 1. The excited slice and hence the views were shifted continuously along the slice-axis (z -axis) by changing the pulse excitation frequency. Within the k_x - k_y -plane the views were arranged using a golden angle reordering. An additional selectable parameter pitch (p) describes the shift between two views. Thus a higher pitch increases the shift along the z -axis between two views and leads to a reduction of the measurement time. The sequence was implemented on a clinical 3T scanner and in-vivo experiments were performed on healthy volunteers during free breathing. For the experiments a volume of 17.5 cm along the slice direction was acquired. To compare the results, a measurement using a radial (without shifting the views) bSSFP-sequence was performed. Therefore 35 slices with slice thickness of 5 mm were acquired to cover the desired volume ($T_{acq} = 99$ s). For the helical measurement the excited slice thickness was 5 mm and the acquisition time was reduced by shifting the views ($T_{acq} = 49$ s). For the reconstruction, a sliding-window method and an iterative SENSE algorithm [5] was used. Thus the reconstruction of slices at any arbitrary positions are possible.

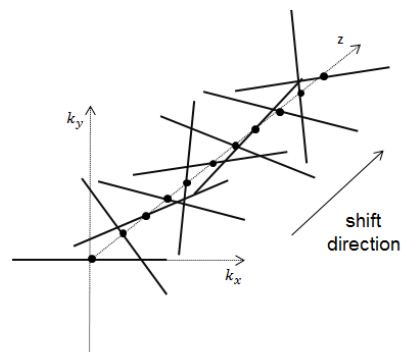


Fig. 1. k -space scheme: the views are sampled with a golden angle reordering within the plane and are simultaneously shifted along the slice direction.

Results: Fig. 2 shows a comparison between radial (without shifting) and helical bSSFP measurement with a shift of 0.02 mm per view (pitch = 2). The reconstruction of the helical data set was done using a sliding window of 377 views, resulting in an effective slice thickness of 7.5 mm. In order to demonstrate the 3D-capability of the helical approach, reformatted sagittal and coronal views of a continuous data set from another experiment are shown in Fig. 3.

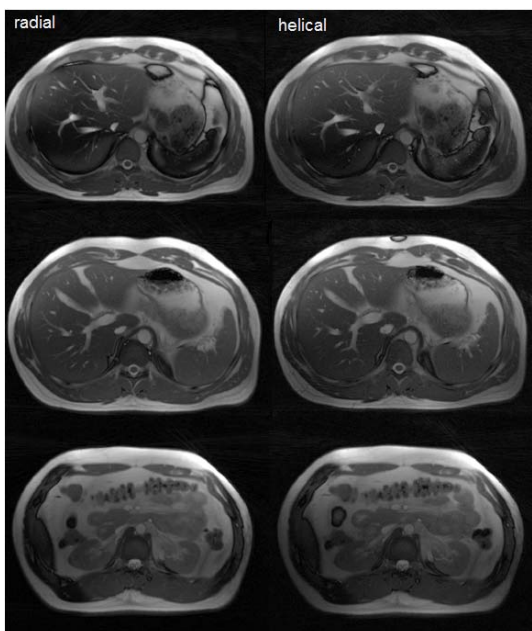


Fig. 2. Comparison of three transverse slices of the abdomen of a healthy volunteer. Left taken with a radial and right with a helical bSSFP-sequence during free breathing. Measurement parameters: FOV = 400 mm, BR = 384, $T_{acq} = 99$ sec for radial and $T_{acq} = 49$ sec for helical.

Discussion and conclusion: The helical bSSFP-technique allows continuous acquisition of MRI-data and therefore a reduction of measurement time without loss of image quality. In contrast to continuous moving table techniques, shifting via RF-pulse allows imaging along any scan plane orientation. The presented images show a good visualization of small structures and the in-plane image quality is almost the same as in the radial image. Using the additional information from the view shifting a 3D image set (consisting of transversal, sagittal and coronal slices) could be computed. Thus, helical MRI, in particular helical bSSFP, is a good candidate for free breathing volumetric abdominal imaging.

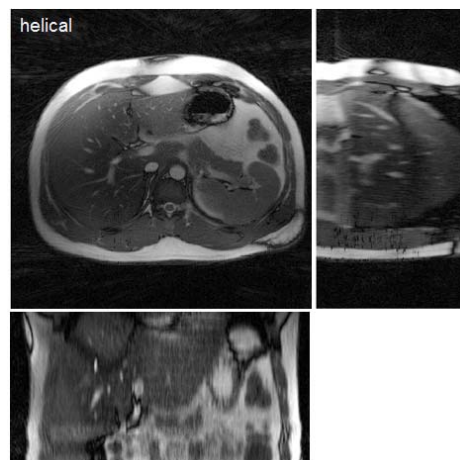


Fig. 3. A transverse and reformatted sagittal and coronal slice of the abdomen of a healthy volunteer during free breathing demonstrate the 3D-coverage of helical bSSFP.

References:

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