High-Resolution Continuously Acquired Peripheral MRA Featuring Self-Calibrated Parallel Imaging

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Introduction:

Moving table magnetic resonance imaging (MRI) techniques potentially improve the scan time efficiency of large field-of-view (FOV) MR imaging applications and provide the physician with seamless images of the extended FOV. Particularly peripheral MR angiography (MRA) requires high spatial resolution to resolve small arteries and at the same time has rigid scan time constraints in order to stay within the arterial window [1]. To fulfill these demands, a combination of a continuous moving table technique with self-calibrated parallel imaging (GRAPPA) [2] is presented. The subject volume of interest was covered with a matrix of phased-array surface coils which traveled through the magnet along with the patient table. In this setup the coil sensitivity profiles were fixed relative to the subject volume of interest. The speed-up in acquisition time was converted into an increase in spatial resolution, aiming towards an optimization of the peripheral MRA protocol.

Methods:

All experiments were performed on a Siemens Avanto 1.5 T (Siemens Medical Solutions, Germany), which provides 32 receiver channels and a matrix of dedicated phased-array surface coils. A reconstruction algorithm for 3D coronal and sagittal datasets [3] was incorporated into a standard Siemens reconstruction program. The new part of the reconstruction did not interfere with the implementation of the GRAPPA algorithm [2]. Since the protocol for parallel imaging acquires a new set of reference lines for each repetition, the coil sensitivity profiles for the actual partial FOV of the continuously acquired dataset were calculated on-the-fly. This enabled the combination of continuous data acquisition during table movement with parallel imaging.
For parallel imaging, all 32 receiving channels were used. For the protocol without parallel imaging, adjacent phased array coils were combined, which in that case reduced the number of receiving channels to 16. All receiving channels were active during the entire acquisition. Peripheral MRA examinations were performed on 5 healthy volunteers with a non-parallel move during scan protocol and with the GRAPPA protocol with increased resolution. Prior to data acquisition, blood pressure cuffs were placed at the mid-femoral level of both legs to avoid venous overlay [4]. They remained inflated to 60mm Hg until the end of the exam. A 3D FLASH sequence was used with TR / TE 2.02ms / 0.89ms, FOV 400mm x 1398mm and a slab of 115mm. The total acquisition time was 77s. The table velocity was 18mm/s. The voxel size of the standard protocol was 1.6 x 1.3 x 1.6mm³. With an acceleration factor of 2, it was possible to reduce the voxel size to isotropic 1.3mm in the GRAPPA protocol. Data acquisition was performed during biphasic automatic injection of 0.2mmol/kg Multihance (Bracco, Milano, Italy). SNR and CNR were determined on coronal source images for both protocols in 8 arterial segments.

Results and Discussion:

The use of parallel imaging reduced the data acquisition time for the examination. The reduced acquisition time was used to increase the image acquisition data matrix, the number of phase encoding steps as well as the number of acquired slices, while maintaining the slab thickness. According to the reduction in voxel size by a factor of 1.5, an SNR reduction of the same order was measured in images acquired with parallel imaging. When compared to images acquired with the non-parallel peripheral MRA imaging protocol, the images showed a crisper appearance with more detailed depiction of intramuscular arterial branches in 5/5 volunteers (Fig. 1). The time for data reconstruction was significantly increased from about 10 to 30 minutes.

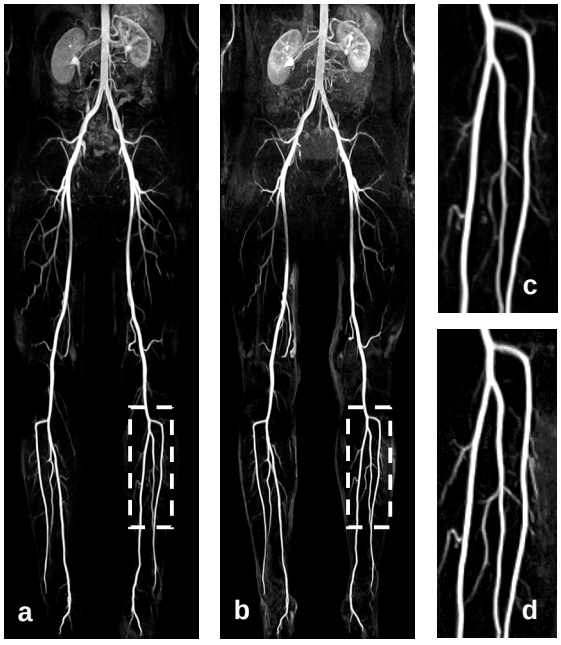

Fig. 1: Coronal MIPs of a continuously acquired 3D peripheral MRA a) without, b) with parallel imaging. c) shows the MIP blow-up of a) and d) the blow-up of b) at the level of the trifurcation. Note the crisper appearance and better depiction of small intramuscular arterial branches in d).

Conclusion:

The combination of a continuous moving table technique with parallel imaging enabled the acquisition of seamless peripheral MRA with a more detailed display of the arterial vessel system. Active switching of receivers that are connected to only the coil elements that are in the isocenter during acquisition potentially would decrease the data rate and the reconstruction time accordingly. The robustness of the technique and image quality achieved in this study justifies further investigation on patients.

References:

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