New developments in dynamic time-resolved Magnetic Resonance (MR)- Angiography (TREAT) and high resolution MR-imaging of cerebral arterio-venous malformations (cAVM) using parallel imaging at 3T.

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Purpose:

Cerebral arterio-venous malformations (cAVM) are vascular tumors typically containing a central nidus where arterio-venous shunting takes place. They include the risk of hemorrhage, stroke and perfusion steel effects. Since recently, modern non-invasive treatment options such as robotic radiosurgery (Cyberknife) are available requiring high-resolution (HR) morphologic imaging as well as time-resolved angiographic techniques with three-dimensional (3D) properties as a basis for the stereotactic planning of the treatment. Standard digital subtraction angiography as the current modality of reference does not provide 3D information. Magnetic Resonance imaging (MRI) is the only modality to offer both morphologic and dynamic information all in one. Parallel imaging techniques (PAT) have proven to increase spatial resolution while reducing acquisition time (1,2). The combination of PAT and 3T allows further improvement in temporal and spatial resolution including 3D-imaging and dynamic MRA with isotropic voxel size and options for 3D-post processing. The present study is designed to evaluate the feasibility and the potential of HR-time-resolved echo-shared angiographic techniques (TREAT) in MRA to depict the nidus of cAVMs and to determine the value of 3D-post-processing with multi-planar reformations (MPR) and image fusion in the planning of the non-invasive stereotactic treatment.

Patients and Methods:

Seventeen patients (aged 31.4±13 years) presenting with known cAVM underwent MRI of the brain on a 3T 32-channel whole body MR-scanner (Magnetom Tim Trio, Siemens Medical Solutions, Erlangen, Germany) using a dedicated 12-channel head-coil. HR-MRI included T2-weighted (w) 3D-Turbo spin echo (SPACE; variable flip angles, TR 2000, TE 441, BW 850, ETL 123ms) and a T1w post-contrast 3D-gradient echo (GRE) sequences (FLASH), both with isotropic voxel size of 1 mm^3. Dynamic assessment of the bolus passage within the cAVM was achieved after intravenous injection of 15ml Gadobutrol (Gadovist®, Schering, Germany) using a time-resolved FLASH sequence with view-sharing (3) (3 segments) and parallel imaging techniques (time-resolved echo-shared angiographic techniques: TREAT) and with an isotropic voxel size of 2x2x2 mm at a high temporal resolution of one 3D-data set/700ms. Parallel acquisition techniques at an acceleration factor of 3 in left-right phase-encoding direction and GRAPPA reconstruction algorithms were applied for all measurements. 3D post processing (MPR and image fusion) was performed using a 3D-workstation (Leonardo, Siemens medical solutions) to create one single data set comprising both HR-morphologic and vascular information of an early arterial phase from TREAT imaging depicting the nidus.

Results:

TREAT was feasible in all cases. In 2/17 cases the total tumor size of the cAVM exceeded the field of view, but the nidus was fully comprised within the field of measurement. In all patients, the relevant vascular components of the cAVM representing the nidus were identified with a data set of the arterial phase of dynamic TREAT-MRA. One patient presented multiple nidus of one cAVM in different locations. The overall vascular tumor extension of the cAVM visualized on morphologic post-contrast T1w sequences was different from the size and configuration of the nidus determined by the arterial phase of dynamic MRA in the majority of the cases. 3D image fusion of the TREAT data set in the arterial phase was successful in all cases. Image fusion of MR-data sets with computed tomography was used as a basis for stereotactic treatment planning in all but 2 cases, where no residual tumor was identified on dynamic TREAT after embolization.

Conclusion:

Dynamic MRA and high resolution 3D-morphologic imaging with isotropic voxel size is feasible using PAT at 3T and can easily be integrated in routine imaging of cAVM. Dynamic MRA with TREAT allows for a precise assessment of the central tumor nidus in cAVM. 3D-post processing of the isotropic data sets permitting image fusion and multiplanar reconstructions distinctly supports the precise planning of a non-invasive and sparing stereotactic treatment of cAVM.

References :

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Figure 1: Sagittal and axial planes of a T2w 3D-TSE (A;B) and an early arterial phase of dynamic MRA (TREAT) (C;D) depicting the nidus of an AVM in the left fronto-temporal region.

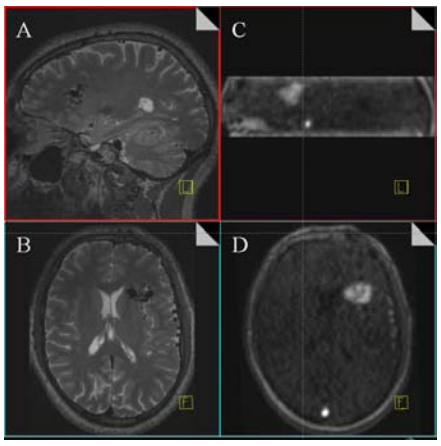

Figure 2: 3D-postprocessing with multiplanar reformations (MPR) and image fusion (Leonardo, Siemens):The vascular nidus of the AVM is best demarcated in an early arterial phase of the time resolved MRA and color-coded after the fusion to one single data set comprising the isotropic 3D-data of T2w-TSE and the isotropic data of the dynamic TREAT-MRA at an early arterial phase.