The traveling heads: Initial comparisons of multicenter data on 7 Tesla MRI systems

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Target Audience: Researchers working on ultra-high-field (UHF) MRI with interest in quantitative and multicenter data.

Introduction: 7 Tesla MR is available at many sites and has demonstrated benefit for a broad range of (bio) medical imaging applications [1]. While as the SNR increases with field strength there is unfortunately also a higher artifact-to noise-ratio[2]. Image quality and even system calibration procedures might be influenced by such artifacts and other variations between systems. This is of particular interest for multicenter trials, where data are acquired with multiple highly sensitive MRI scanners. With this work we collected initial data from same subjects at different sites to determine comparability and as a preparatory step for future multicenter trials.

Methods: Image data from two different healthy subjects were collected at two sites equipped with a 7T MRI whole-body system (Magnetom 7T, Siemens Healthcare, Germany). One of the systems utilizes an actively shielded magnet (*site 1*), while the other utilizes passive shielding (*site 2*). The system of *site 1* was equipped with a SC72 gradient coil (max. gradient strength 70 mT) and the scanner of *site 2* used an AS095DS gradient coil (max. gradient strength 38 mT). To facilitate data analysis, the measurement setup was kept as similar as possible between the sites. A commercial RF head coil (Nova Medical, Inc., Wilmington, MA, USA) with 1 TX and 32 RX channels was used at both sites, and subject positioning was standardized as much as possible through use of cushions.

The imaging protocol consisted of a spin echo based B1 mapping sequence (TR:1200ms, TE:14ms, 5xFA:45°-135°, SL:11, 8x8x5mm) for transmitter calibration. A vendor-provided AutoAlignment function was used to acquire the following imaging sequences: MP2RAGE[3] (TR:6000, TE:3ms, FA:4°+5°,TI:800+2700ms, 3D, SL:192, 0.8mm iso, PAT:3, TA:9:38), TSE (TR:10570ms, TE:13+118ms, 3D, SL:32, 0.3x0.3x2mm, PAT:2, TA:8:18), modified TOF[4] (TR:21ms, TE:4.3ms, FA:20°, 3D, SL:112, 0.2x0.2x0.4mm, PAT:4, TA:6:41) and SWI (TR:29ms, TE:15ms, FA:15°, 3D, SL:112, 0.3x0.3x1mm, PAT:3, TA:9:05). All measurements were acquired within 50 minutes with all online filters and subsequent data corrections accessible through the user interface deactivated. Data were analyzed qualitatively by visual inspection and quantitatively after co-registration between scanners. ROIs were defined in multiple brain structures and image contrasts compared between the two sites. For anatomic sequences (MP2RAGE and TSE), the contrast of gray and white matter, striatum, and thalamic nuclei were compared against CSF. For the angiographic sequences (TOF and SWI), the vessel contrast against background (white matter) was used for quantification.

Sequences	Deviation
MP2RAGE	4%
TSE	4%
TOF	5%
SWI	11%

Table 1: Mean image contrast deviations between the two sites.

Results: The transmitter reference amplitude for both subjects was 10% higher at *site 1* than *site 2*. RF safety supervision log files revealed that the higher transmitter amplitude was related to higher reflection of forward power (1% vs. 0.4%). Qualitative analysis of image data showed high agreement between the two 7T sites (Fig.1). Similar structures and vessels were delineated. Quantitative image contrasts also showed very high agreement for most imaging sequences with a mean difference of 6% over all sequences and subjects. The highest differences of about 11% were found for SWI, where the contrast was defined between low signal regions like veins and white matter.

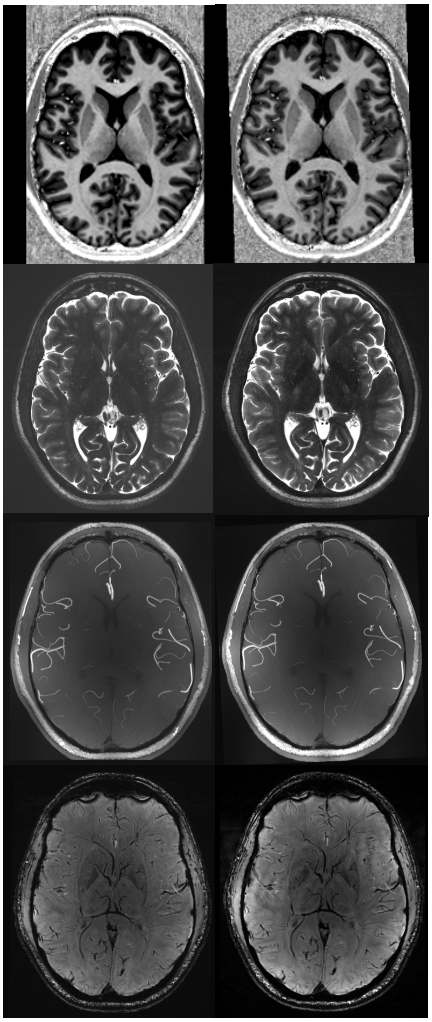

Fig. 1: *Exemplary data from one subject measured at two 7 Tesla sites. Left column shows data from* site 1 *(actively shielded, SC72 gradient coil). Right column shows data from* site 2 *(passively shielded, AS95 gradient coil).*
Image contrasts are:
1st row: MP2RAGE uniform image
2nd row: TSE T2-weighted
3rd row: TOF, MIP 10mm thin slice
4th row: GRE. SWI

Discussion and Conclusion: The 7 Tesla scanners compared are from same vendor but had hardware differences that might affect image quality, most notably the magnet and the gradient coil. However, most of the technical subsystems that are involved in signal generation and reception including the RF coil were similar. The data showed strong correspondence both qualitatively and more importantly quantitatively, boding well for future multicenter trials that rely on equivalency of results between sites. Further work will include more sites and subjects to improve statistical power and verify these preliminary results.

References: 1. Kraff et al., JMRI (2014) epub: DOI: 10.1002/jmri.24573; 2.Bernstein et al., JMRI 24:735–746 (2006); 3. Marques et al., abstract no. 1393, ISMRM 2008 (Toronto); 4. Johst et al., Invest Radiol. 47(8):445-50 (2012).

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