MRI Quality Control and System Performance Using ACR Phantom Tests and Automated Software

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PURPOSE

For monitoring the performance and stability of Magnetic Resonance Imaging (MRI) systems, it is essential to implement regular quality control (QC) protocols. We evaluated the MRI system performance of the Philips Ingenuity TF PET/MR, using the American college of radiology (ACR) QC protocol [1] and automated QC software implemented in MATLAB.

METHODS

A total of 80 MRI scans were performed during years 2013 to 2018 using the ACR QC protocol and the ACR QC phantom. The protocol consisted of a localizer series, a T1-weighted spin-echo (SE) and a T2-weighted dual-echo SE series (Figure 1). All scans were performed with the Philips Ingenuity TF PET/MR, which includes an MRI system based on Achieva 3T X-series, with a maximum gradient strength of 40 mT/M and a slew rate of 200 T/m/s.

In the initial analysis, 21 scans were analyzed by a human observer and automatic software implemented in MATLAB2015b [2], which performs the analysis according to ACR guidelines [1]. Five tests were included: geometric accuracy, slice thickness accuracy, slice position accuracy, image intensity uniformity and percent signal ghosting. The reference limits are 148±2 and 190±2 mm for geometric accuracy, 5.0±0.7 mm for slice thickness accuracy, below 5 mm for slice position accuracy, above 82 % for image intensity uniformity and below 0.025 for percent signal ghosting. We report the mean and standard deviation of the manual (M) and automatic (A) measurements.

RESULTS

For geometric accuracy, (M=147±1), (A=148±1) and (M=190±0.5), (A=191±0.2) were measured for the localizer and T1 series, with good agreement between automatic and manual measurements. Figure 2 and Figure 3 show comparison between manual and automatic measurements in slice thickness accuracy, slice position accuracy, image intensity uniformity and percent signal ghosting tests.

For slice thickness accuracy, (M=5.5±0.5), (A=4.7±0.8) and (M=5.9±0.5), (A=4.5±1.4) were measured for the T1 and T2 series. The human observer ranked the slice thickness accuracy above the reference limit 5 times for the T1 series and 12 times for the T2 series, while the automatic software ranked the corresponding series 6 times and 5 times over the limit.

For slice position accuracy, (M=5.6±3.3), (A=4.2±2.7) and (M=5.3±2.8), (A=4.0±2.5) were measured for the T1 and T2 series. The human observer ranked the position accuracy above the reference limit 11 times for the T1 series and 9 times for the T2 series, while the automatic software ranked the corresponding series 4 times over the limit on both the T1 and T2 series.

For image intensity uniformity, (M=85±1), (A=96±1) and (M=89±2), (A=97±2) were measured for the T1 and T2 series. For percent signal ghosting, (A=0.0010±0.0009) and (M=0.0015±0.0007) were measured. The time to analyze and report was two minutes with the automatic software.

DISCUSSION AND CONCLUSION

Majority of the tests reached the acceptance criteria when using manual or automatic evaluation. Slice thickness and slice position accuracy were the most common to fail as ranked by the human observer and automatic software. The human observer tended to measure slice thickness and slice position higher while intensity uniformity was measured lower. We intend to compare this variability between the manual and automatic measurements by further analysis in the future. In conclusion, using automated software was beneficial for image analysis workflow and should result in decreased variability over repeated measurements. The QC software used in this paper with a test dataset can be downloaded from the following link: http://bit.ly/2AIvaSZ.

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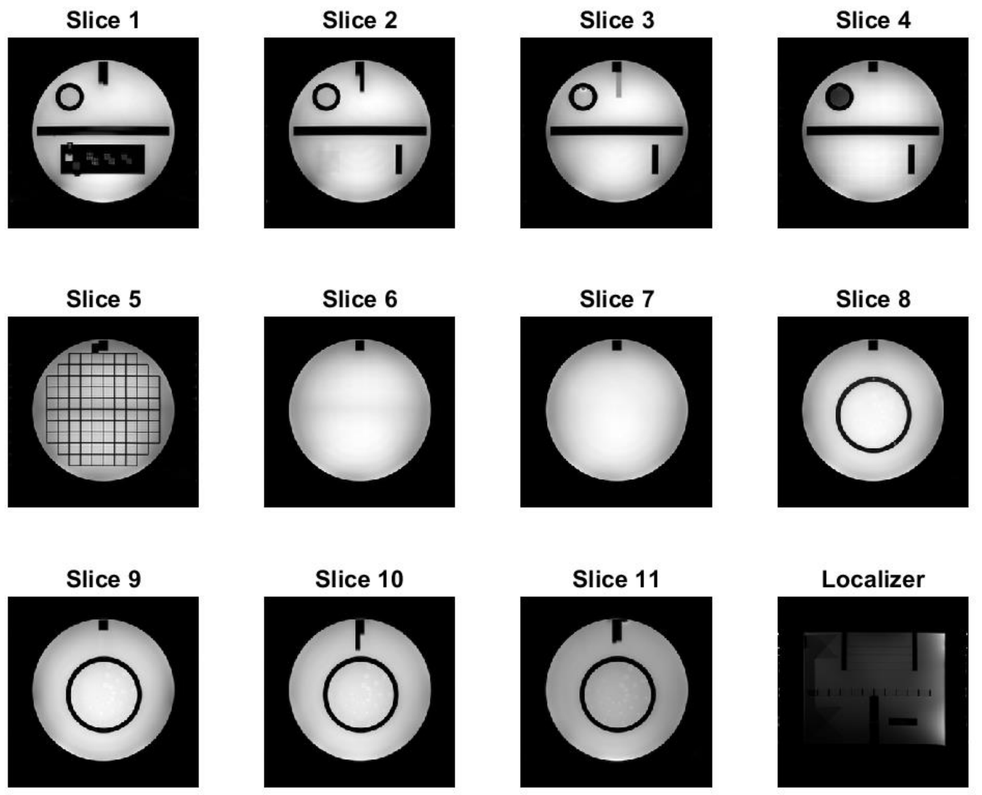

Figure 1. Image of the T1-weighted ACR phantom series and a localizer image from the ACR quality control protocol.

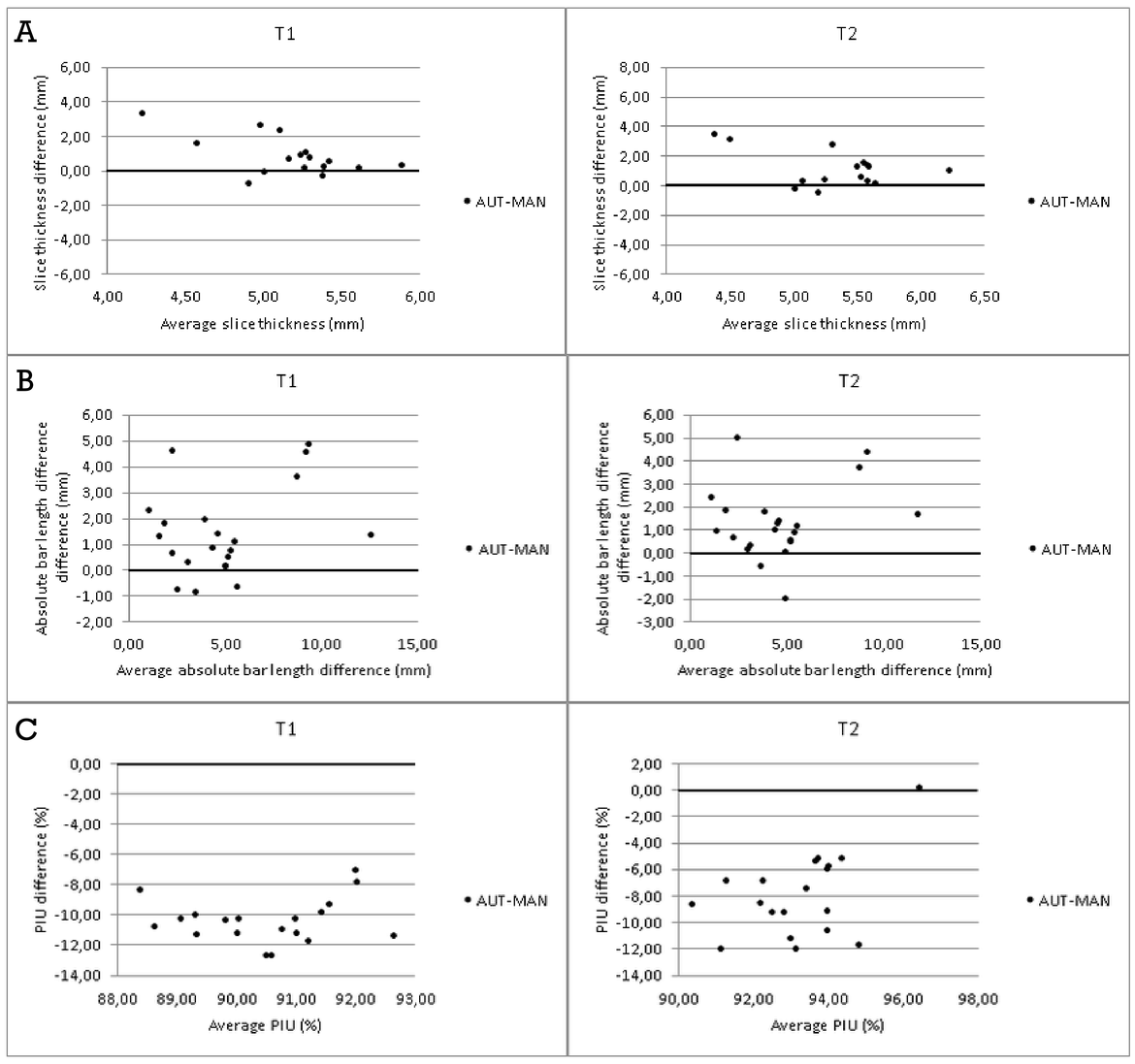

Figure 2. Difference between manual and automatic measurements in slice thickness accuracy (A), slice position accuracy (B) and image intensity uniformity (C) tests.

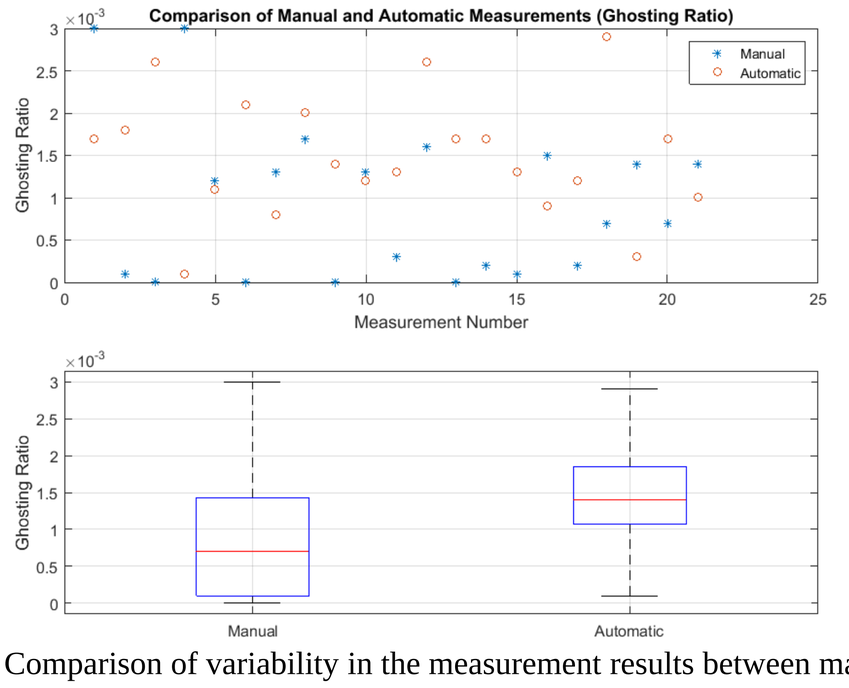

Figure 3. Comparison of variability in the measurement results between manual and automatic measurements, percent signal ghosting ratio test.