Harmonization of brain PET images in multi-center PET studies using Hoffman phantom scan

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Background: Image harmonization has been proposed to minimize heterogeneity in brain PET scans acquired in multi-center studies. However, standard validated methods and software tools are lacking. Here, we assessed the performance of a framework for the harmonization of brain PET scans in a multi-center European clinical trial.

Method: Hoffman 3D brain phantoms were acquired in 28 PET systems and reconstructed using site-specific settings. Full Width at Half Maximum (FWHM) of the Effective Image Resolution (EIR) and harmonization kernels were estimated for each scan. The target EIR was selected as the coarsest EIR in the imaging network. Using "Hoffman 3D brain Analysis tool," indicators of image quality were calculated before and after the harmonization: The Coefficient of Variance (COV%), Gray Matter Recovery Coefficient (GMRC), Contrast, Cold-Spot RC, and left-to-right GMRC ratio. A COV% ≤ 15% and Contrast ≥ 2.2 were set as acceptance criteria. The procedure was repeated to achieve a 6-mm target EIR in a subset of scans. The method's robustness against typical dose-calibrator-based errors was assessed.

Results: The EIR across systems ranged from 3.3 to 8.1 mm, and an EIR of 8 mm was selected as the target resolution. After harmonization, all scans met acceptable image quality criteria, while only 13 (39.4%) did before. The harmonization procedure resulted in lower inter-system variability indicators: Mean ± SD COV% (from 16.97 ± 6.03 to 7.86 ± 1.47%), GMRC Inter-Quartile Range (0.040–0.012), and Contrast SD (0.14–0.05). Similar results were obtained with a 6-mm FWHM target EIR. Errors of ± 10% in the DRO activity resulted in differences below 1 mm in the estimated EIR.

Conclusion: Harmonizing the EIR of brain PET scans significantly reduced image quality variability while minimally affecting quantitative accuracy. This method can be used prospectively for harmonizing scans to target sharper resolutions and is robust against dose-calibrator errors. Comparable image quality is attainable in brain PET multi-center studies while maintaining quantitative accuracy.

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