Phantom-Based Automated Quality Control of Proton Density Fat Fraction Imaging Using Embedded Pocket Phantoms In Clinical MRI

Vijay R Sharma[1], Jeremy Heilman[2], Samuel A Hurley[3], Karl K Vigen[3], Scott B Reeder[3], Ali Pirasteh[3] and Diego Hernando[3]

[1]Department of Medical Physics, University of Wisconsin-Madison, WI-USA

[2]Resoundant Rochester, MN-USA

[3]Radiology, University of Wisconsin-Madison, WI-USA

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

ABSTRACT

Purpose: Proton density fat fraction (PDFF) is widely used as a quantitative MRI biomarker in clinical care. Accurate PDFF measurement requires robust quality control, commonly performed using phantom-based assessment. This work evaluates an automated algorithm for quantitative analysis of a commercial pocket phantom within patient MRI exams to facilitate embedded phantom-based quality control.

Methods: Pocket phantoms (Phantom Packs, Calimetrix, Madison, WI) with nominal PDFF values of 0, 10, 20, 30, and 75 percent were positioned within the imaging field of view beneath patients during routine MRI examinations **(IDEAL-protocol)**, with data from three studies included. A Python-based automated analysis pipeline was used to detect phantom vials on water-only DICOM images, and map circular regions of interest to the corresponding PDFF DICOM images. Mean, median, standard deviation, minimum, and maximum PDFF values were automatically computed for the slice identified by the algorithm as optimal for phantom analysis. Automated PDFF measurements were compared to known nominal and manually calculated phantom values to assess quantitative consistency and identify out-of-range measurements.

Results: The algorithm successfully detected phantom vials and generated PDFF measurements, with values closely matching known nominal PDFF values. As a representative case, the mean(standard deviation) PDFF values measured in each of the vials were 3.6(±0.7), 9.2(±0.5), 22.1(±0.6), 31.4(±0.6) and 74.4(±1.0) reflecting consistency with nominal values. Further, the automated framework selected this slice for quantitative analysis, yielding PDFF measurements consistent with manual measurements, with near-unity agreement (slope ≈ 0.99, R ≈ 1.0).

Conclusion: Automated analysis of PDFF pocket phantoms in patient MRI exams enables effective embedded quality control. Using known phantom values as a reference, this approach reduces reliance on manual review and enhances the efficient of quality assurance processes. It has the potential to improve data consistency in clinical trials and support routine clinical MRI quality assurance.

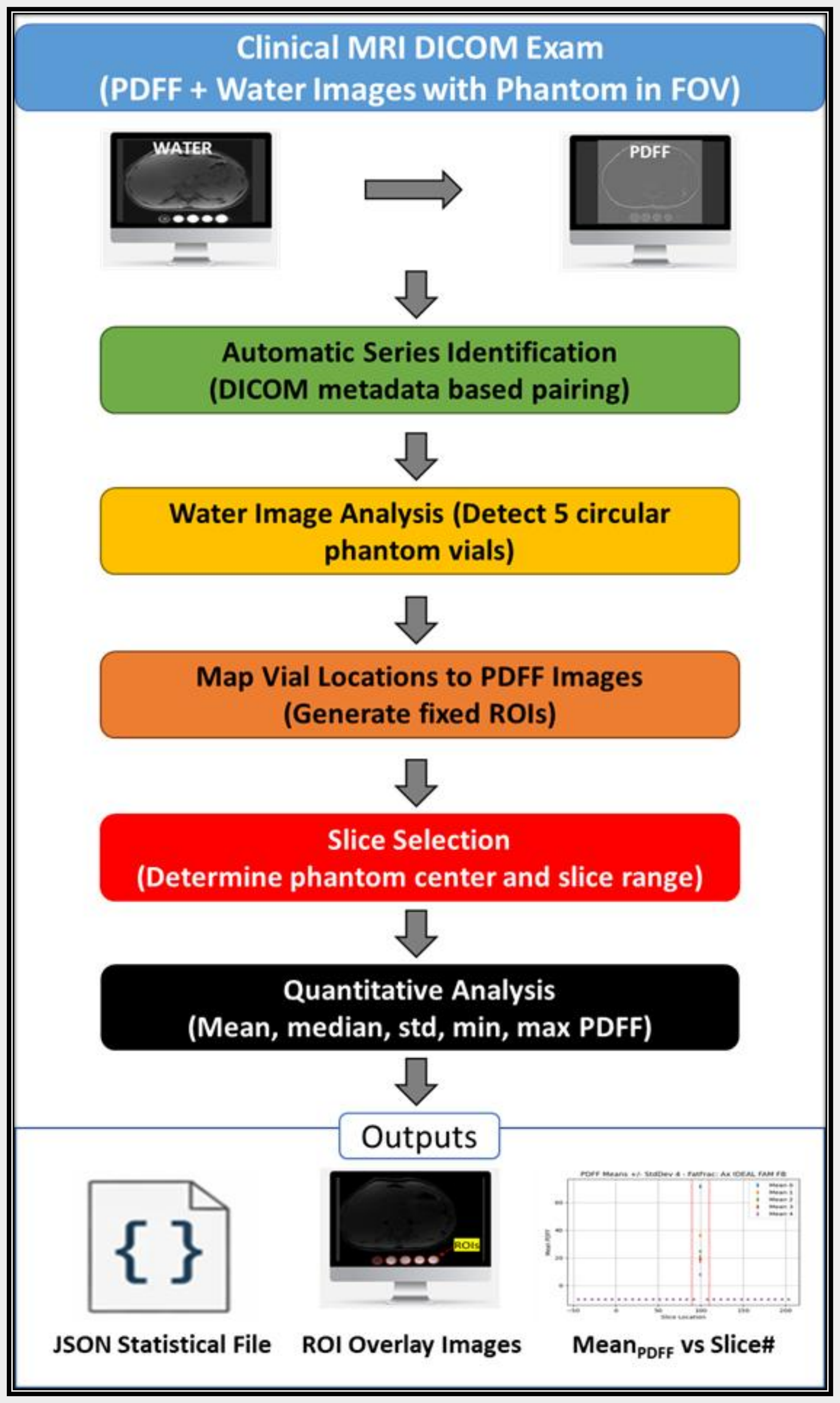
CONTACT

Prof. D Hernando
Department of Radiology,
University of Wisconsin-Madison, WI
[email] dhernando@wisc.edu

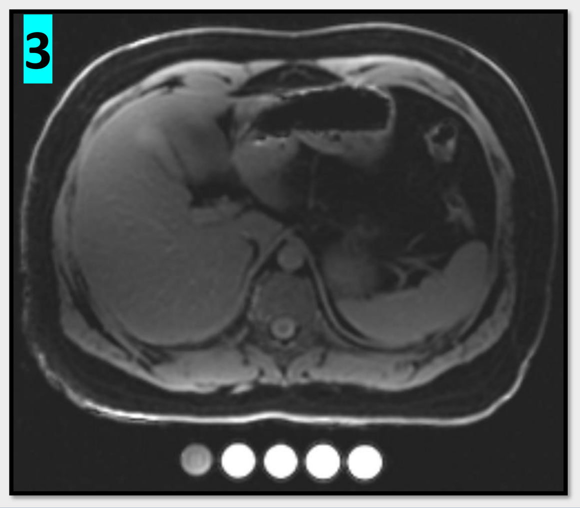
CLINICAL IMPACT

This work introduces a novel automated phantom-based quality control (QC) framework for PDFF MRI that operates directly on routine clinical DICOM data. A key conceptual advance is the use of commercial PDFF pocket phantoms placed underneath the patient and embedded within routine clinical MRI examinations, allowing phantom-based quality control to be performed concurrently with patient imaging rather than through separate, dedicated phantom acquisitions. Unlike conventional phantoms that typically relies on manual inspection or site-specific quality assurance checks performed intermittently, the proposed approach automatically detects PDFF pocket phantom within patient exams, identifies individual vials, and quantitatively compares measured PDFF values against known ground truth values. This enables objective and reproducible assessment of PDFF measurement consistency without additional acquisition time or operator intervention. Furthermore, by performing slice-based analysis and generating statistical metrics and visual outputs, the framework help enables algorithm-driven quality assurance. Our approach represents a shift from passive phantom use toward active, automated quality assurance that can be applied across multiple systems, sites, and time points to support longitudinal monitoring of PDFF performance.

WORK_FLOW



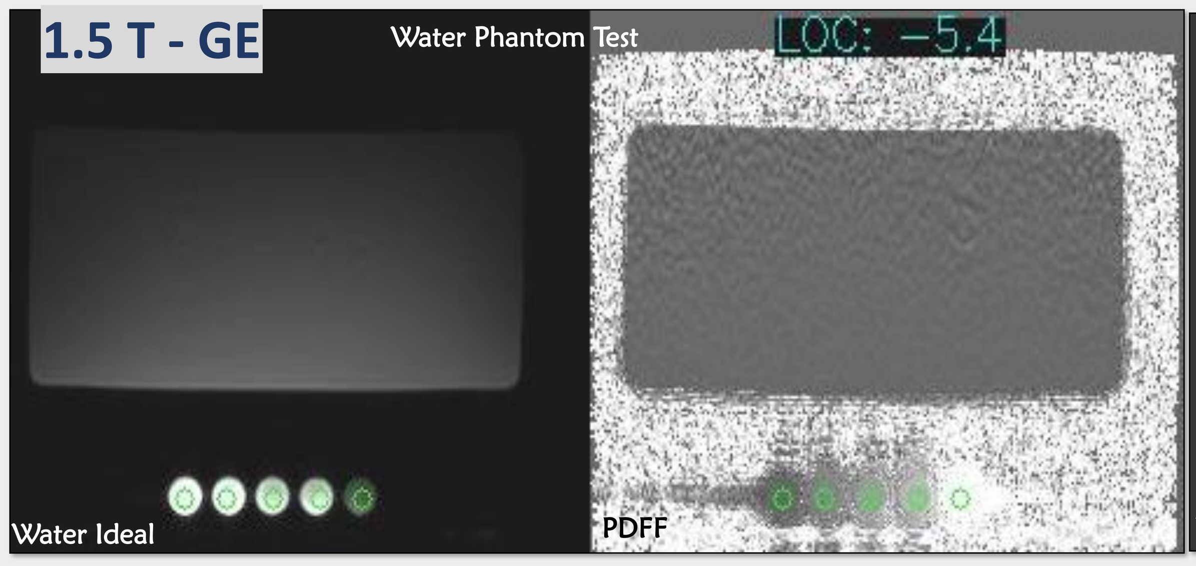
IMAGING PROCESS

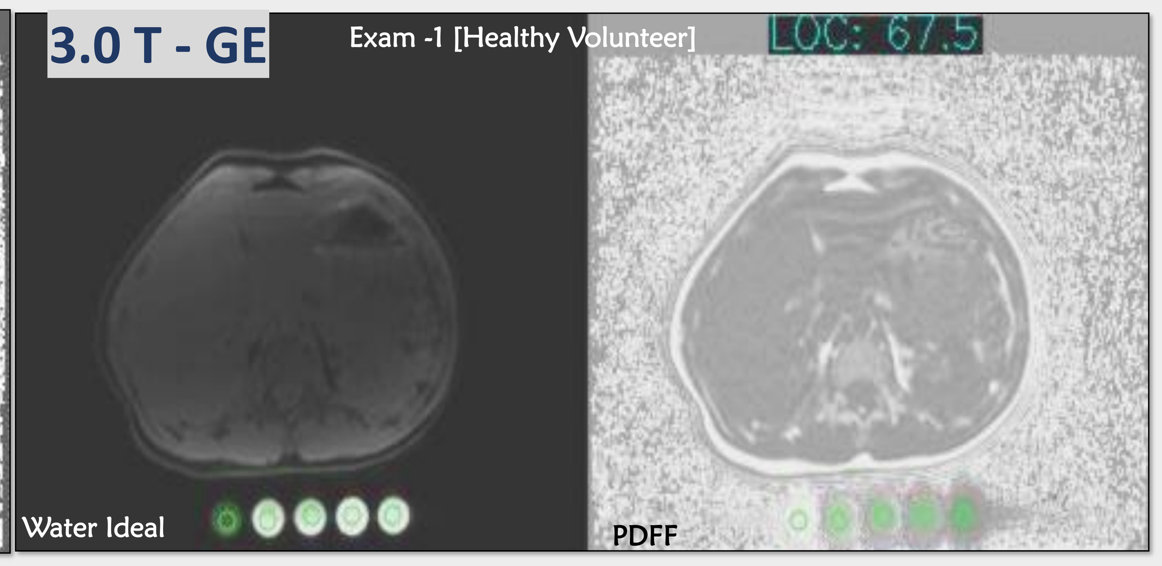


Methods

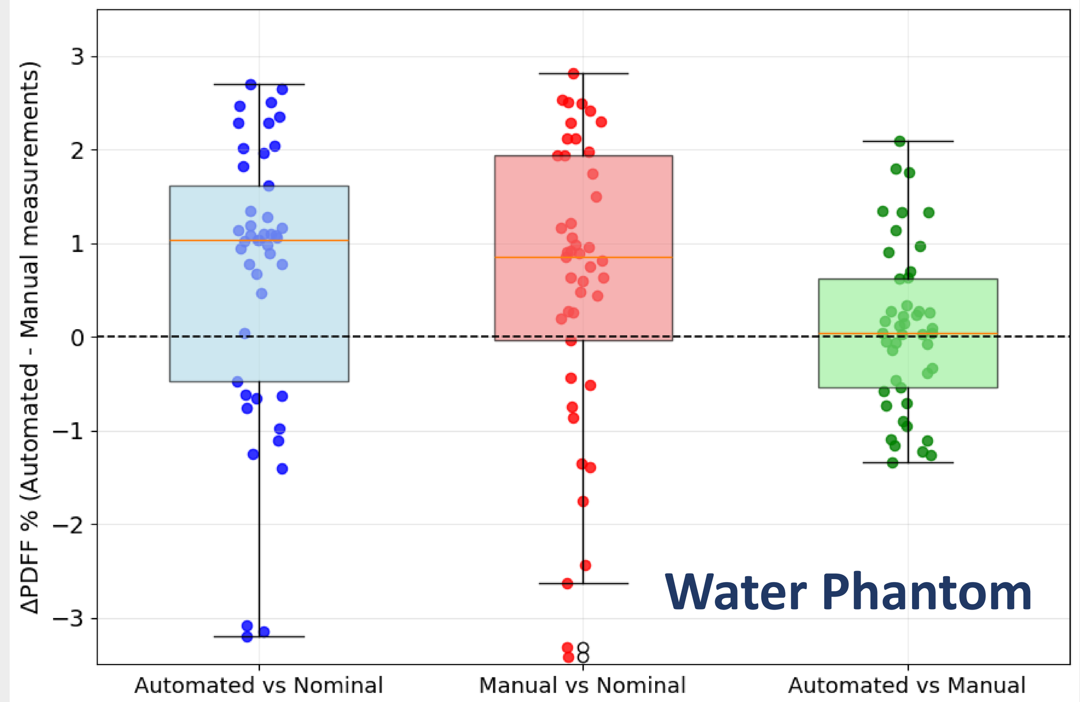
Exam (Healthy Volunteers)	1	2	3
Field Strength	3T	3T	1.5T
Type	3D	3D	3D
Matrix (px)	224x128	224x128	224x128
# Slices	32	32	28
FOV (cm)	40x32	40x32	40x32
Slice Thickness (mm)	8	8	8
# Echoes	6	6	6
Flip Angle (degree)	3	3	5
TR (ms)	6.2	7.4	13.8
Parallel Imaging	ARC	ARC	ARC
PI Factor	2x2	2x2	2x2

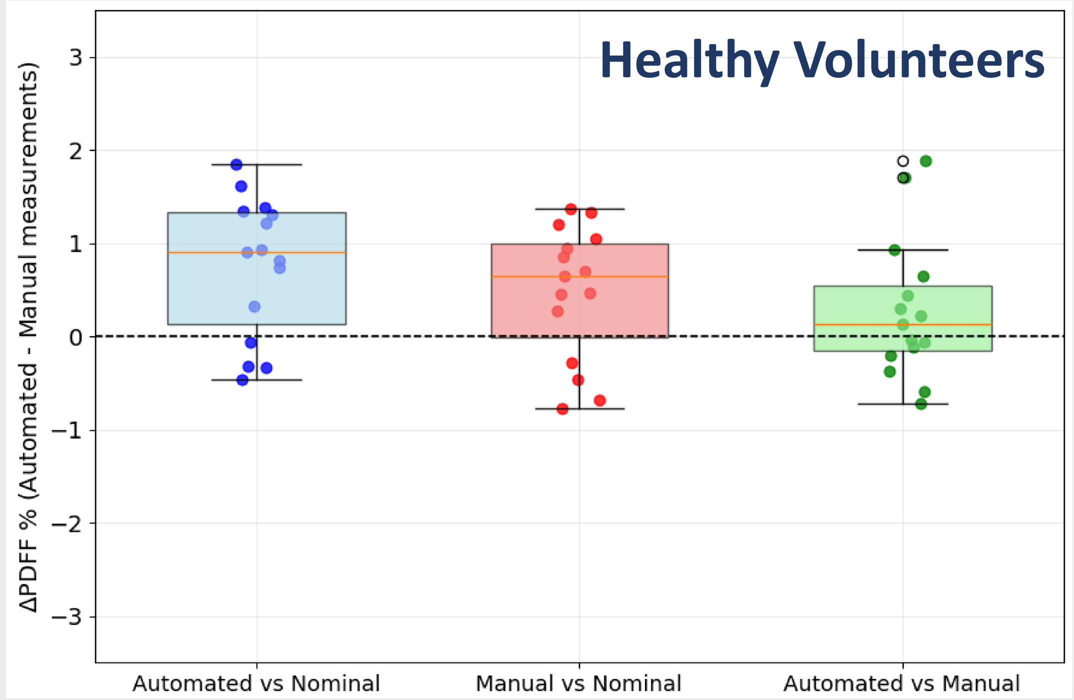
AUTOMATED MEASUREMENTS





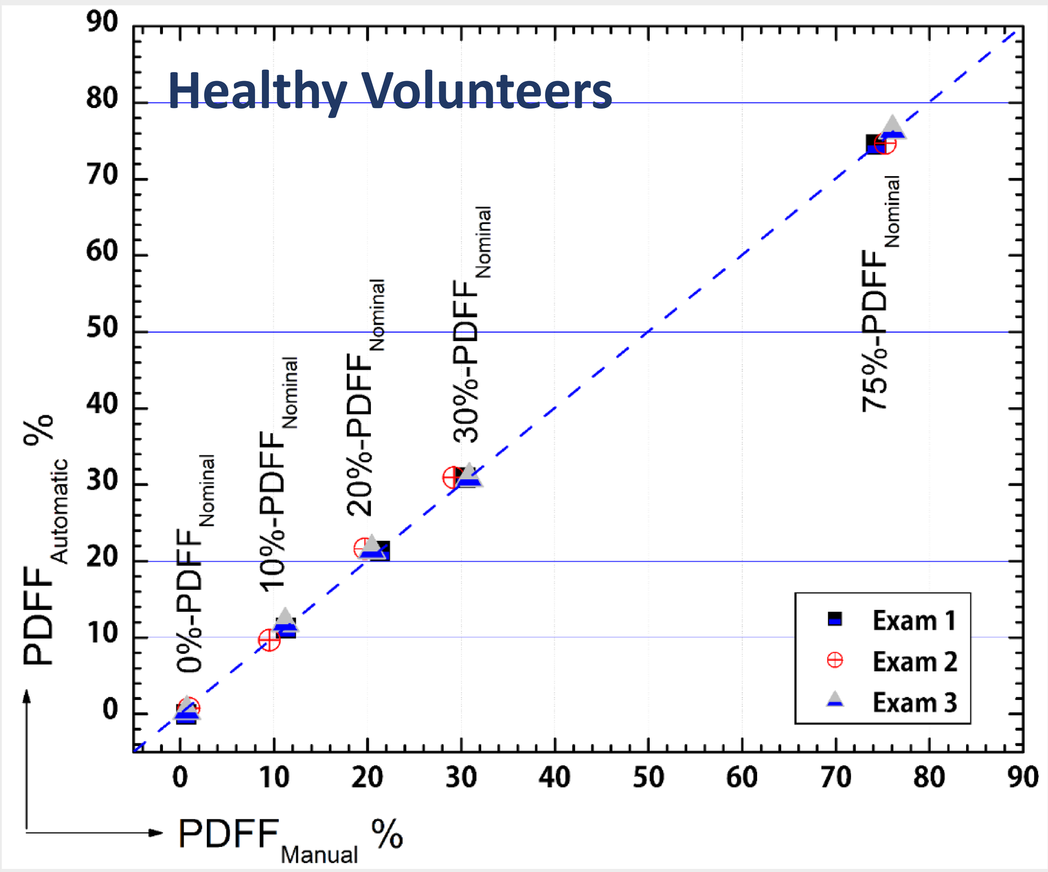
RESULTS





CONCLUSION

1. PDFF Phantom Packs provide a practical path for embedding quantitative MRI quality assurance directly into routine clinical imaging.
2. Initial evaluation focuses on clinical compatibility, including workflow impact, scan time, image quality, and technologist usability.
3. Phantom-based PDFF measurements allow to systematic assessment of bias, variability, and outliers across scanners, field strengths, and reconstruction methods.
4. Establishing acceptance windows for phantom PDFF error (Δ_{PDFF}) may help identify problematic clinical exams and trigger expert review before patient measurements are interpreted.
5. This work supports the long-term goal of automated, exam-specific QA for MRI-PDFF, improving confidence in quantitative fat measurements across clinical applications.



THANK YOU !~!