Redefining MRI:
From Image to Insight

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MRI 측정표준 (MRI Metrology)

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A Metrology-Informed Perspective on Standardized Brain Imaging: Anatomical, Pituitary, and Synthetic Data Applications

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Brain MRI is increasingly utilized as a quantitative measurement tool rather than a purely visual modality. However, scanner-, protocol-, and site-related variability introduce non-biological discrepancies that hinder multi-center data integration, reproducible biomarker extraction, and clinical translation. In MRI metrology, calibration standards provide an important conceptual framework for improving measurement accuracy, precision, and comparability. Rather than reporting a completed metrological standardization project, this presentation provides a retrospective and prospective perspective on how measurement-science concepts may be mapped onto existing neuroimaging pipelines to strengthen their reproducibility and clinical interpretability.

We discuss potential integration points across three pillars of our established neuroimaging research. First, in ultra-high-field 7T brain tissue and artery segmentation, we examine how calibration-informed approaches could help address field-strength-specific challenges, including B1/B0 intensity inhomogeneities and non-uniform signal characteristics, thereby supporting more consistent structural baselines for delicate vascular and tissue targets. Second, in 3T pituitary gland segmentation, we consider how harmonized ROI definitions, spatial referencing procedures, and standardized volumetric reporting could reduce observer-related variability and improve the reliability of small-structure morphometry. Third, for 3T synthetic data generative models, we discuss how metrology-inspired validation benchmarks could be used to assess whether generated volumes preserve biologically meaningful anatomical and distributional characteristics beyond visual realism alone.

By shifting the evaluation paradigm from isolated model-performance metrics toward measurement-oriented endpoints, this perspective emphasizes intensity stability, ROI-based measurement reproducibility, and downstream morphological consistency. Ultimately, this presentation outlines how viewing independent imaging studies through a measurement-science lens can help bridge technical AI development and quantitative radiology. Future incorporation of calibration-informed principles into existing imaging pipelines may support more reliable, comparable, and clinically interpretable quantitative MRI workflows.

Keywords: *Quantitative MRI, MRI Metrology, Calibration standards, Brain image standardization, Synthetic neuroimaging data*