

Background & Objective

Neuromelanin-sensitive MRI (NM-MRI) is increasingly used to assess **substantia nigra (SN)** integrity in Parkinson's disease (PD) [1-4]. The high spatial resolution required for NM-MRI leads to **low SNR and increased noise** [5]. Standard scanner reconstruction typically relies on **temporal averaging**, which may be suboptimal as it does not account for other types of artifacts/noise present across scans.

Objective: To evaluate whether an advanced preprocessing pipeline improves NM-MRI image quality compared with conventional averaging approaches.

Material & Methods

- **Dataset:** 20 participants including 4 controls, 5 prodromal-PD, 11 PD, 3T MT-GRE NM-MRI from the PPMI dataset [6], 5 repeated NM-MRI scans per participant.
- **Preprocessing Pipeline:** Bias Field Correction (BCor), Motion Correction (MoCo), MP-PCA Temporal Denoising (tDen), 3D Aggregation (Aggr), Spatial Non-Local Means (NLM).
- **Pipeline Evaluation:** ROI of 128 × 128 × 5 voxels covering the SN.
- **Metrics:** Temporal SNR (tSNR), High-Frequency Energy Ratio (HFER; lower = better denoising).
- **Statistics:** Wilcoxon signed-rank tests between pipeline stages.

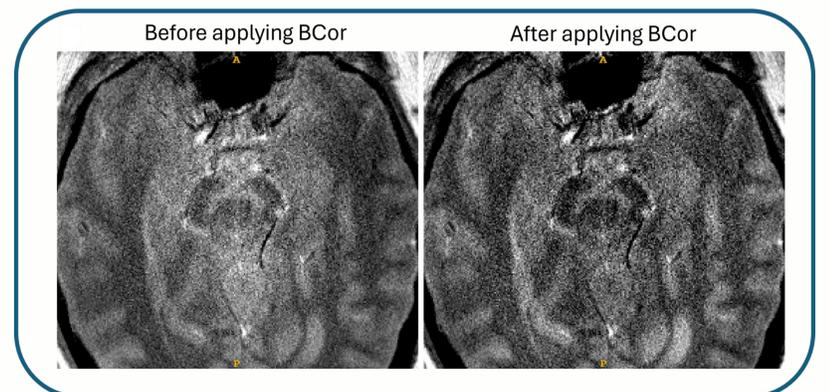


Figure 1. Effect of bias field correction (BCor): Averaged NM-MRI image before and after applying BCor.

Results

Visual Assessment: Bias correction reduced intensity inhomogeneity. Preprocessing pipeline reduced noise compared with simple averaging. Mild smoothing was observed after NLM step (Fig 1 & 2).

Quantitative Findings: tSNR increased after MoCo and tDen, while HFER decreased after NLM (Fig 3). The combined pipeline outperformed temporal averaging.

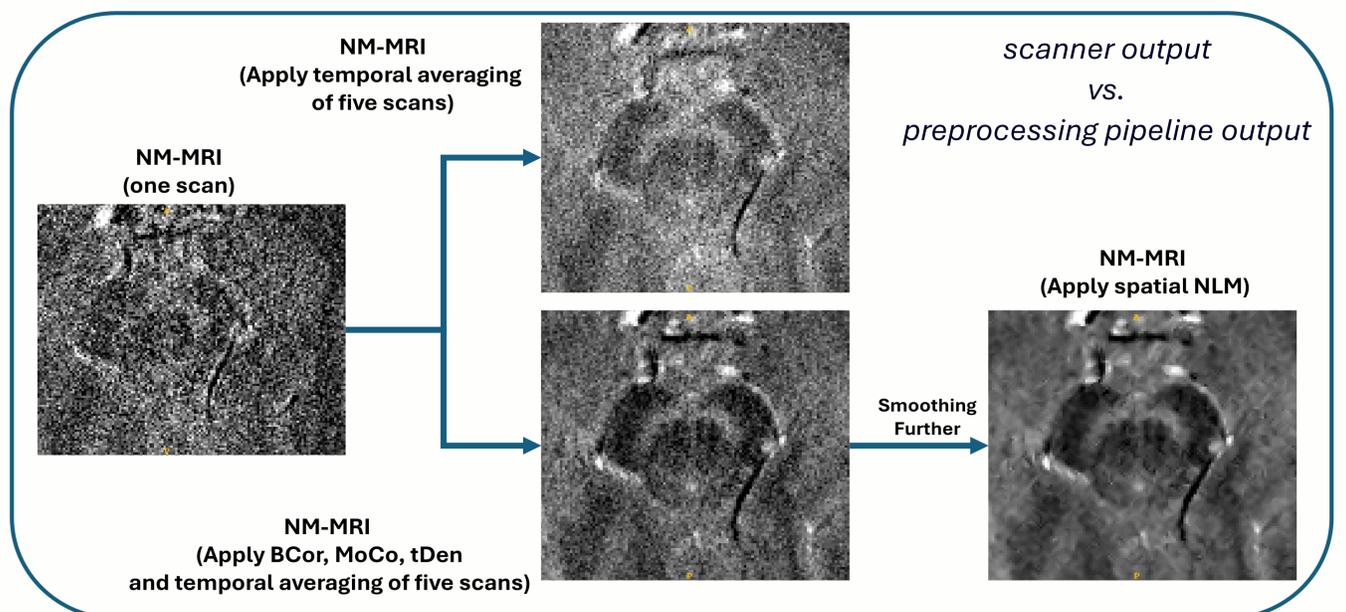


Figure 2. Routine temporal averaging (scanner-like output) versus the suggested preprocessing pipeline for aggregating five NM-MRI scans.

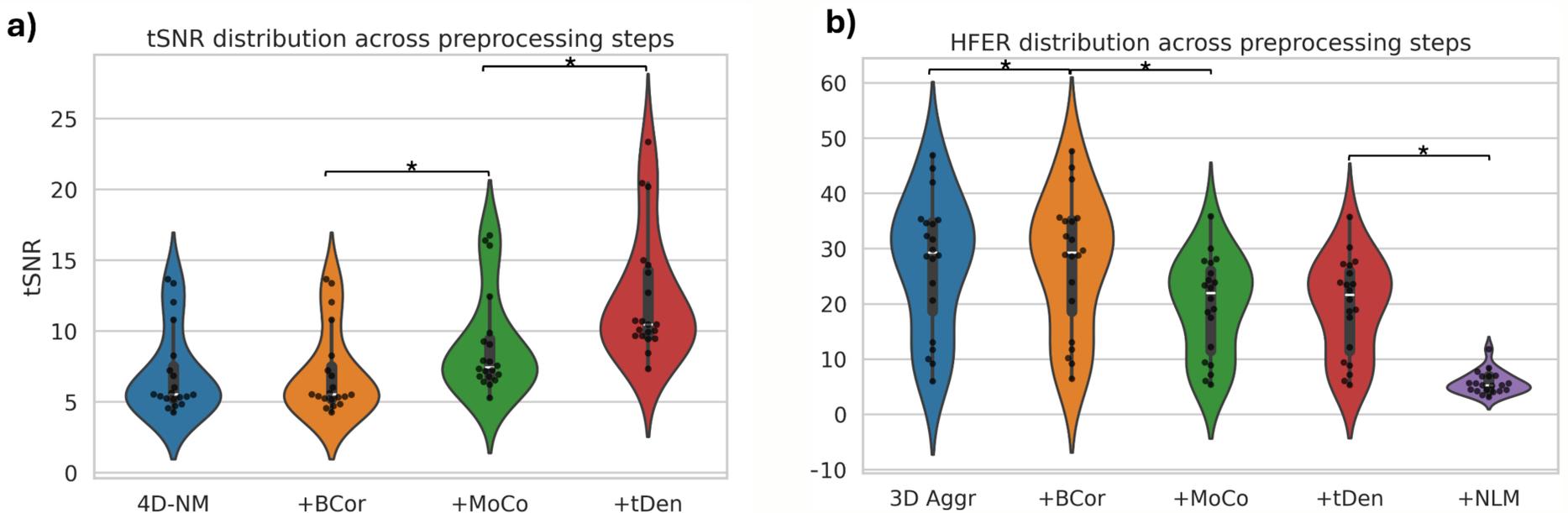


Figure 3. The tSNR (a) and HFER (b) measures across preprocessing steps.

Conclusions

Advanced preprocessing substantially improves NM-MRI image quality over standard averaging.

These improvements may support **more robust downstream analysis and cohort stratification** in PD studies.

References: [1] Wang et al., Parkinsonism Relat Disord, 2019. [2] Sasaki et al., Neuroreport, 2006. [3] Biondetti et al., Brain, 2020. [4] Gaurav et al., Mov Disord, 2021. [5] Trujillo et al., Brain, 2024. [6] <https://www.ppmi-info.org/access-data-specimens/download-data>.