4 W-PM

s-Image Representation of Diffusion Tensor Contrast and Fiber Geometry: Leukometric Analysis in the Brainstem and Cerebellum

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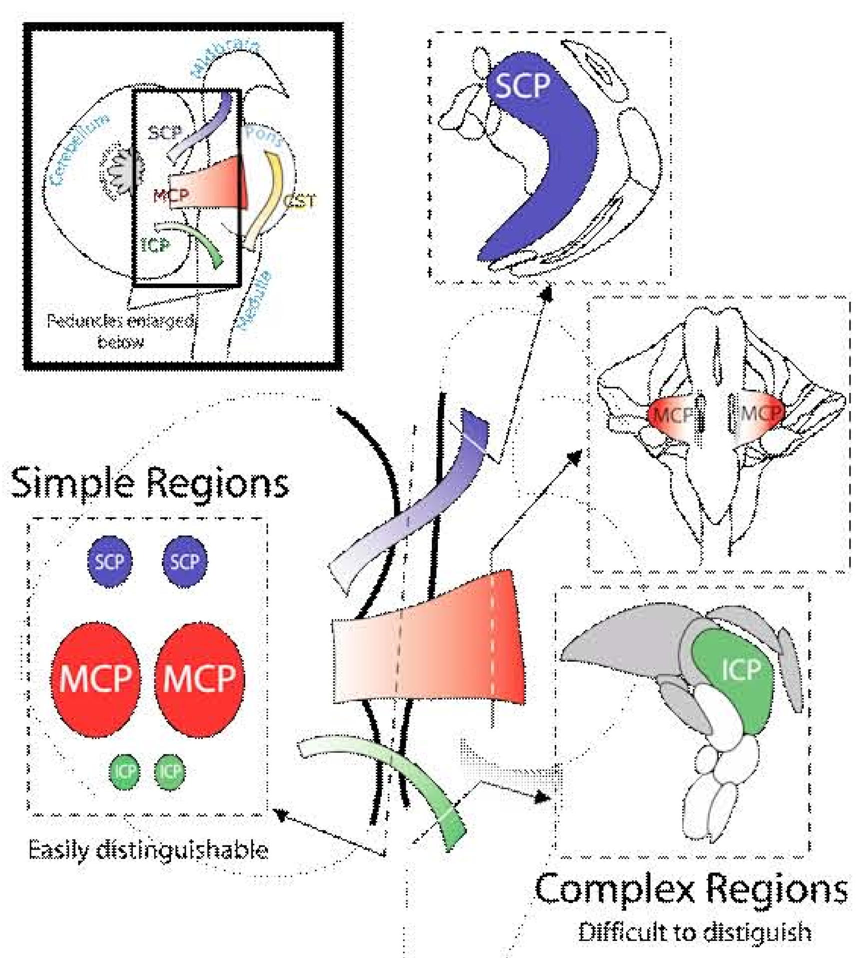
Objective

- Diffusion tensor imaging (DTI) provides a wealth of information about local tissue microstructure and fiber connectivity.
- Scalar quantities, such as fractional anisotropy (FA) and mean diffusivity (MD), describe local properties of water diffusion, while vector orientation indicates tissue organization.
- General purpose techniques for combining local and connectivity information have not been commonly used, in part due to the complexity and variability of fiber tracking results.

- **We present a framework (s-images) for simultaneously considering local and connectivity data in cross-sectional and longitudinal cohorts.**
- **We demonstrate descriptive statistics in a study of cerebellar disease.**

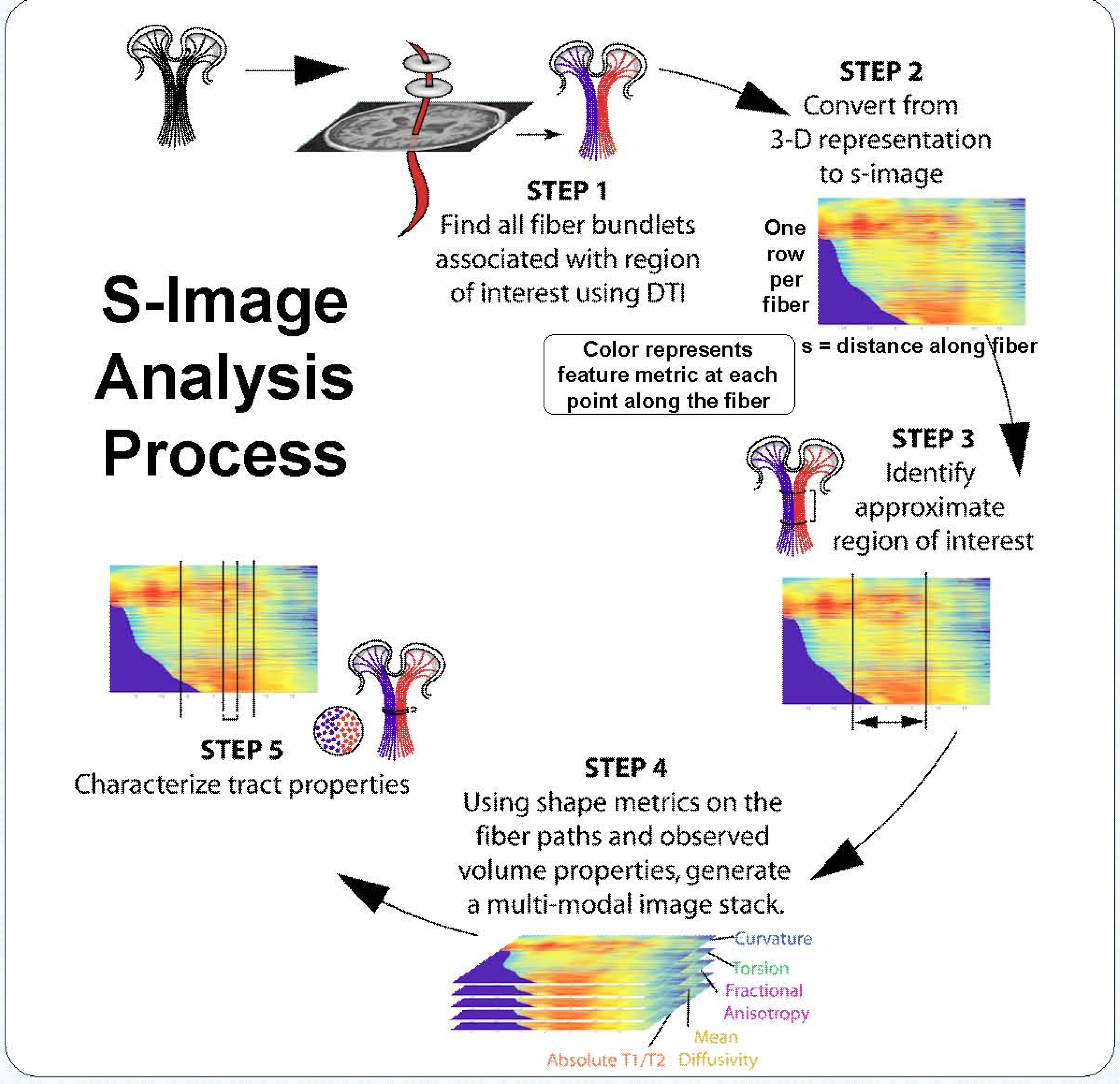
Brainstem/Cerebellum Anatomy



CST – corticospinal tract, ICP – inferior cerebellar peduncle, MCP – middle cerebellar peduncle, SCP – superior cerebellar peduncle

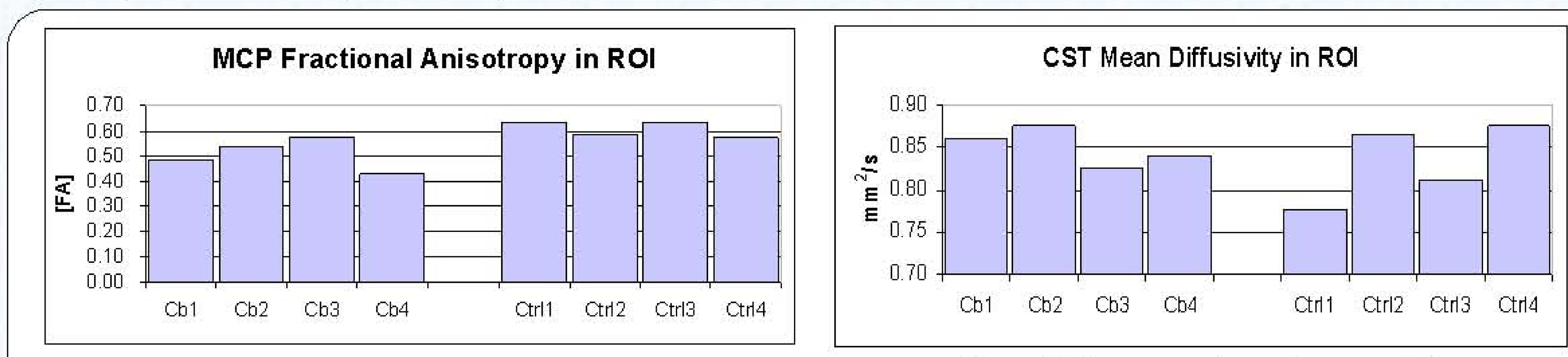
Methods

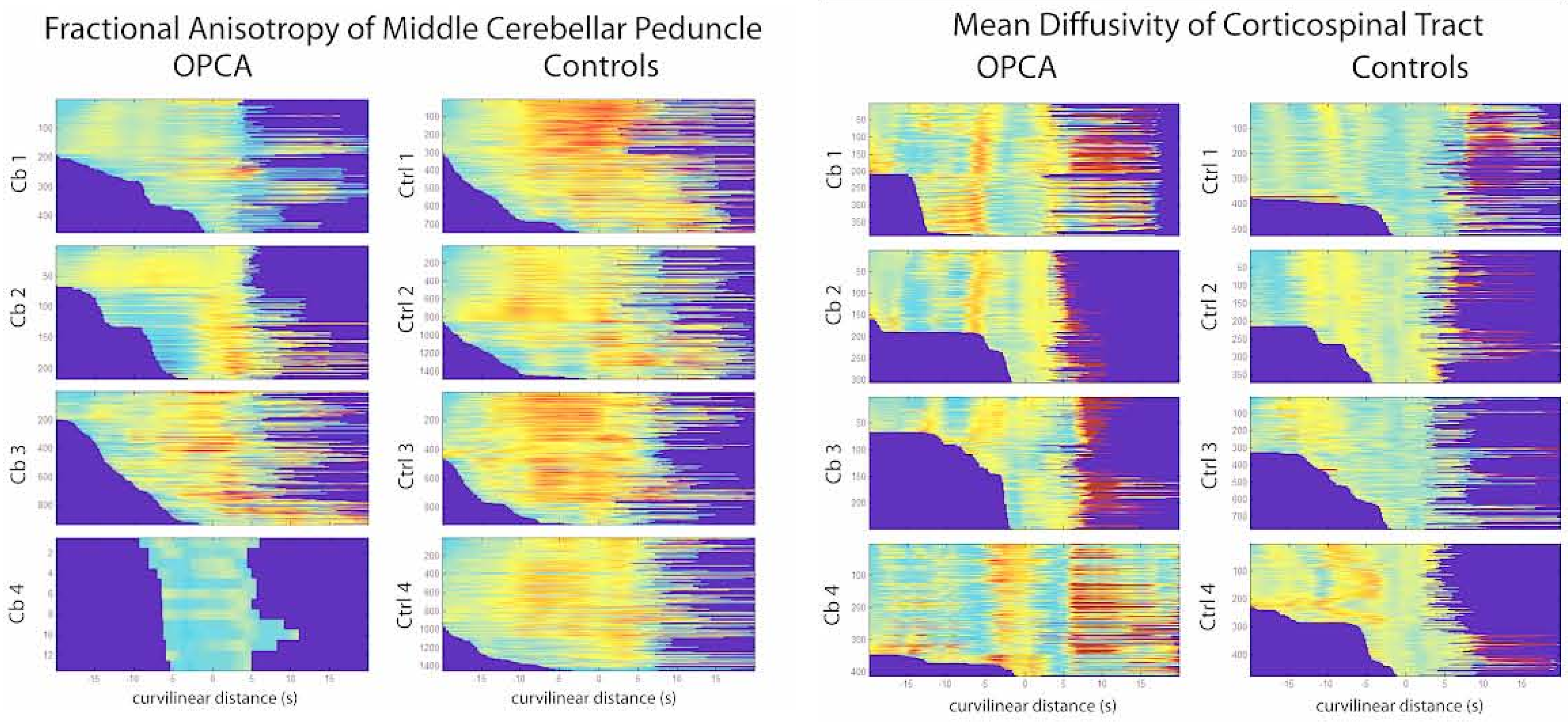
- A multi-slice, spin echo, single-shot EPI sequence was used to achieve whole brain coverage (0.82x0.82x2.2 mm resolution). Diffusion tensors were estimated from three repeated acquisitions of 32 diffusion encoded volumes and a scanner average of five minimally weighted volumes on a 3T MR scanner (Intera, Philips Medical Systems, The Netherlands). Fiber tracking was initiated at all voxels with FACT as implemented in DTIStudio (Susumu Mori, Baltimore, Maryland).
- An expert rater manually delineated cross-sectional regions of interest (ROIs) at specific anatomical landmarks, which were used to select fibers that corresponded to the tracts. These ROIs established an origin for a 1D coordinate system ("s") corresponding to the curvilinear distance along the path of fiber. Fibers in each tract were aligned in an image such that a row corresponded to a fiber and a column corresponded to a distance along a fiber from the origin. Fibers were ordered by the starting location. Images were generated based on volume properties (e.g., FA or ADC) or fiber geometry (e.g., curvature or torsion).



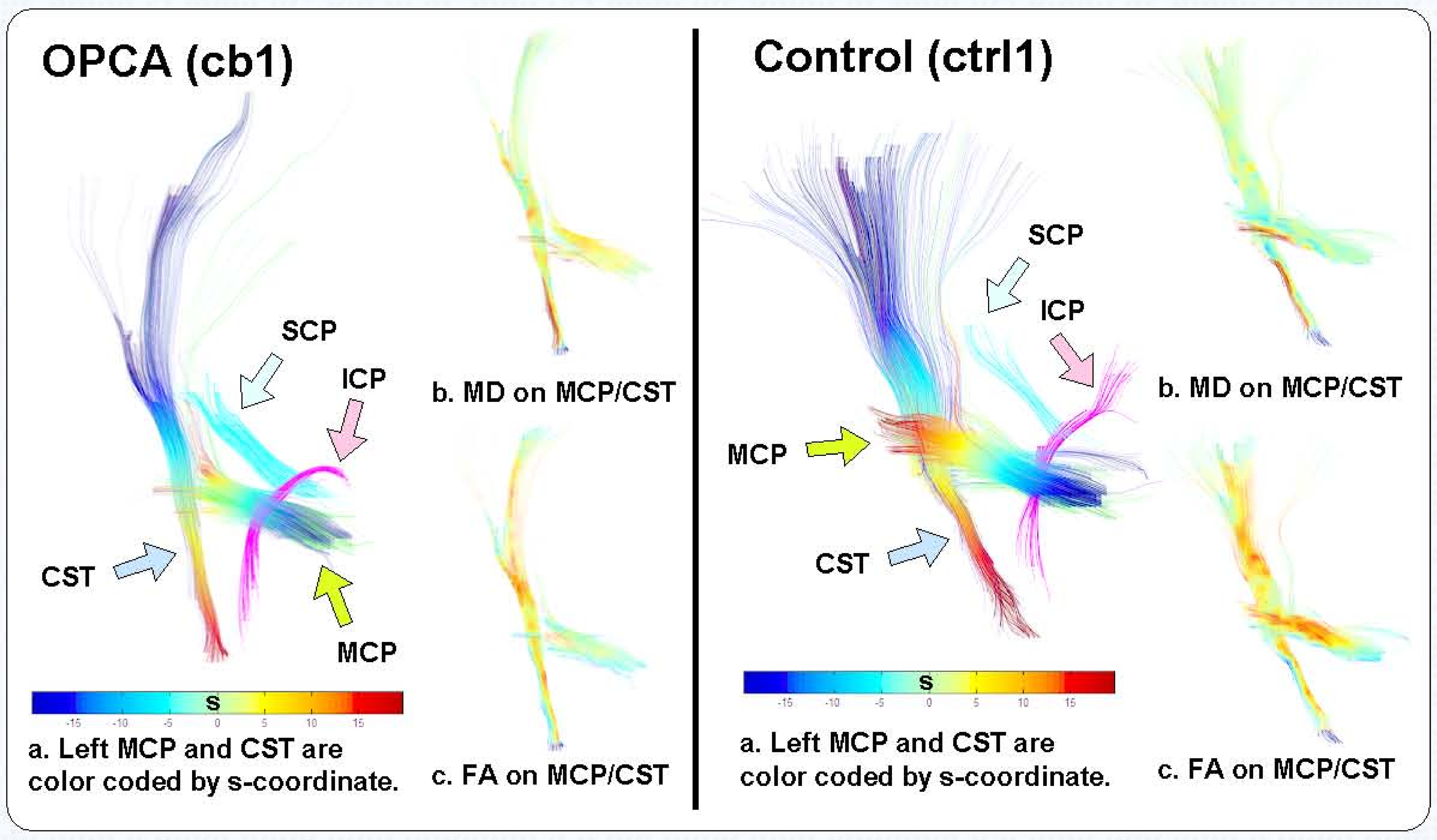
Results

We studied 4 patients with olivopontocerebellar atrophy (OPCA) and 4 matched controls, focusing on the middle cerebellar peduncle (MCP) and corticospinal tract (CST) which had previously demonstrated abnormalities.





Region of interest analysis (upper) indicated increased MD in the CST and decreased FA in the MCP of OPCA subjects relative to control. However, there was substantial overlap between the groups. In the s-image framework (lower), distinct visual patterns are evident between the OPCA and controls. Simple statistics on these images can fully separate the groups.



Discussion

- **We achieve substantial data reduction by collapsing fiber structure into a 1D system, while preserving connectivity information and spatial correlations.**
- **s-Images may be well suited to localizing low contrast brainstem and cerebellar nuclei that are adjacent to white matter tracts. Alternatively, s-image spatial patterns would provide a means of assessing global pathological changes or focal effects (e.g., lesions or tumors).**
- **With s-images, one may intuitively generate measures that are independent of brain volume, so analyses can be robust against inter-individual differences in age, gender, body size, etc.**
- **s-Images provide a visually intuitive framework for managing high dimensional information from diffusion tensor imaging.**

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