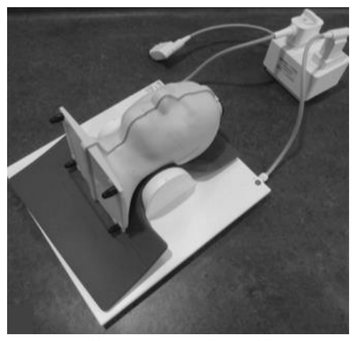
HSLU Hochschule Luzern

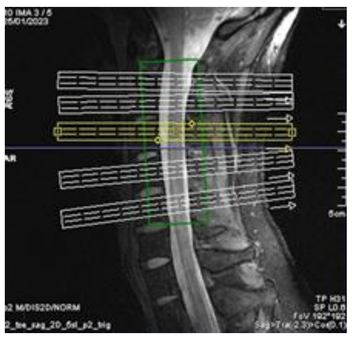
Technik & Architektur
Master of Science in Biomedical Engineering

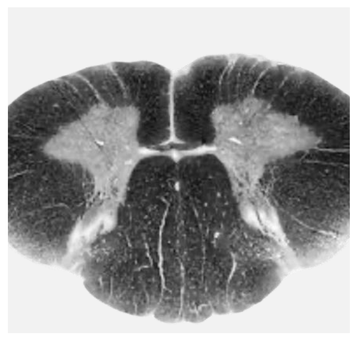
Master Thesis in Biomedical Engineering

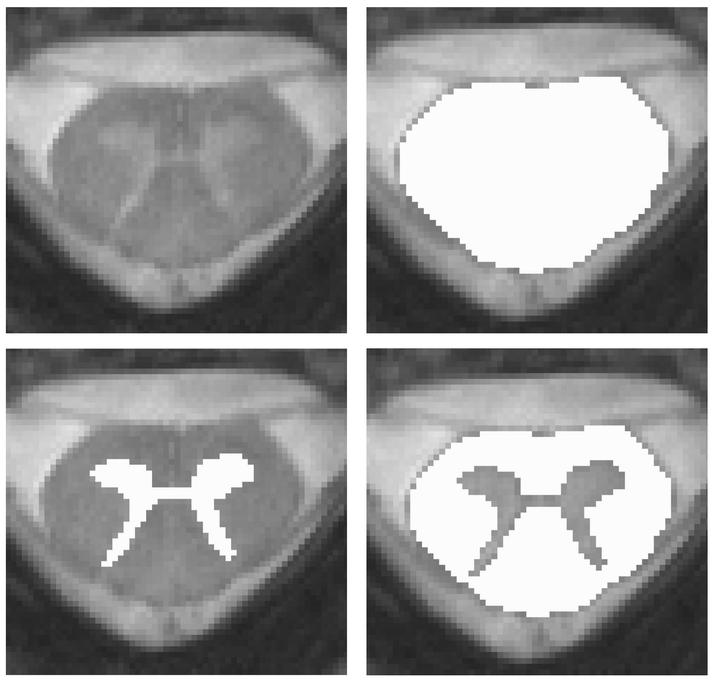
Ultra-High Resolution Macro- and Microstructural Imaging of the Entire Cervical Cord Using 7T MRI

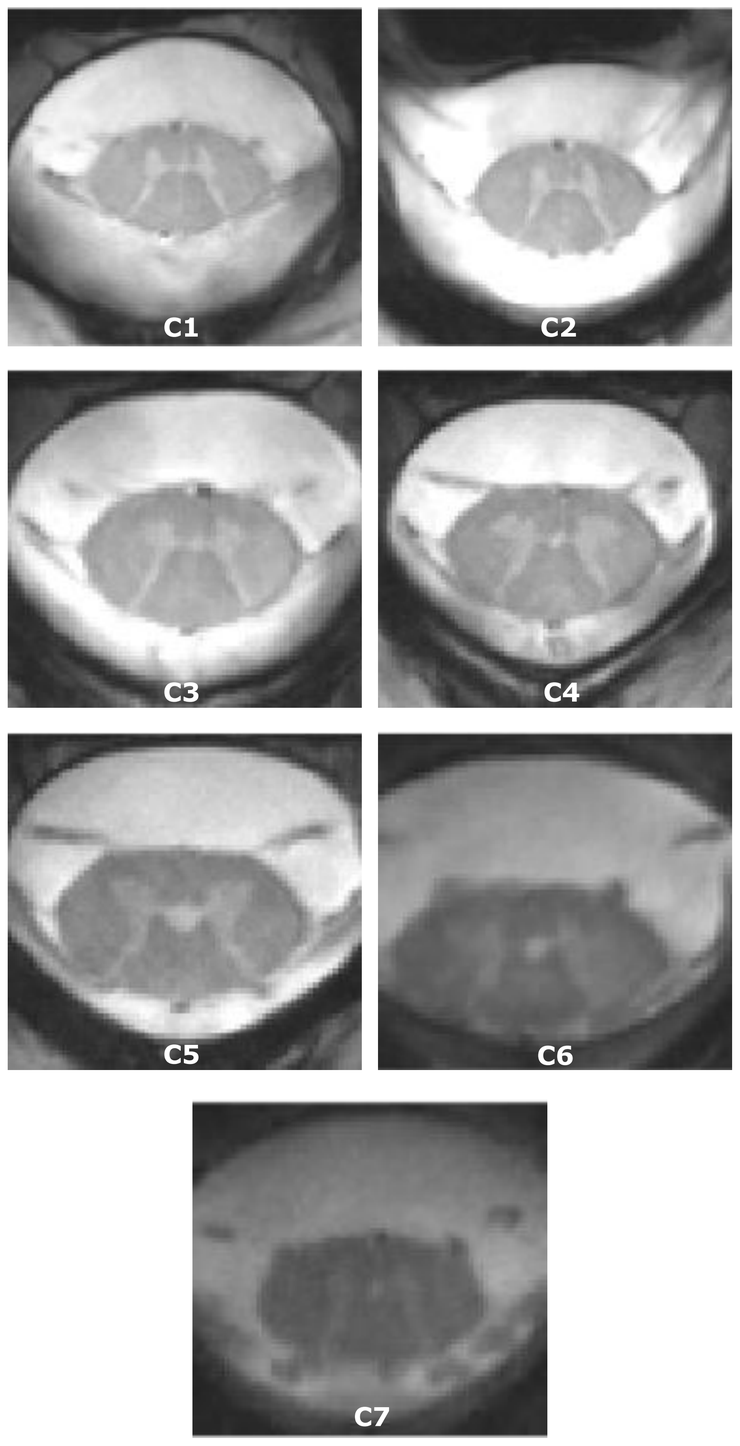

7T MRI


8-channel coil

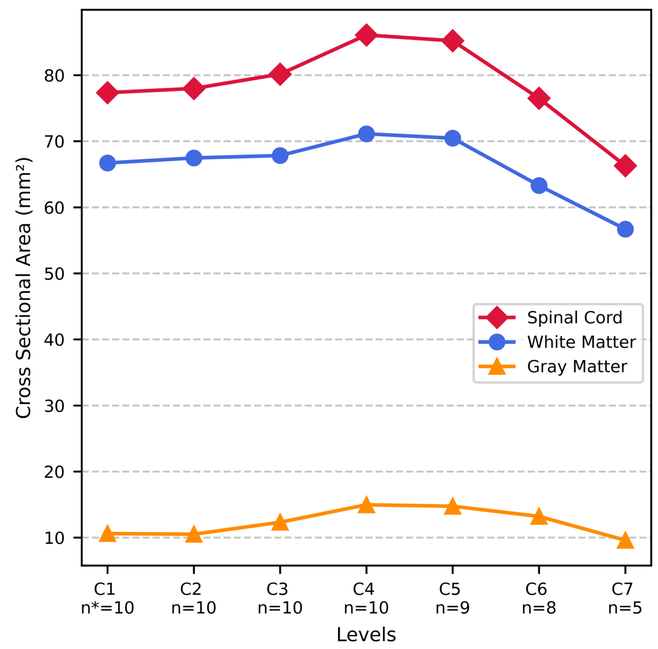

7T multi-slab acquisition


Histology Spinal Cord

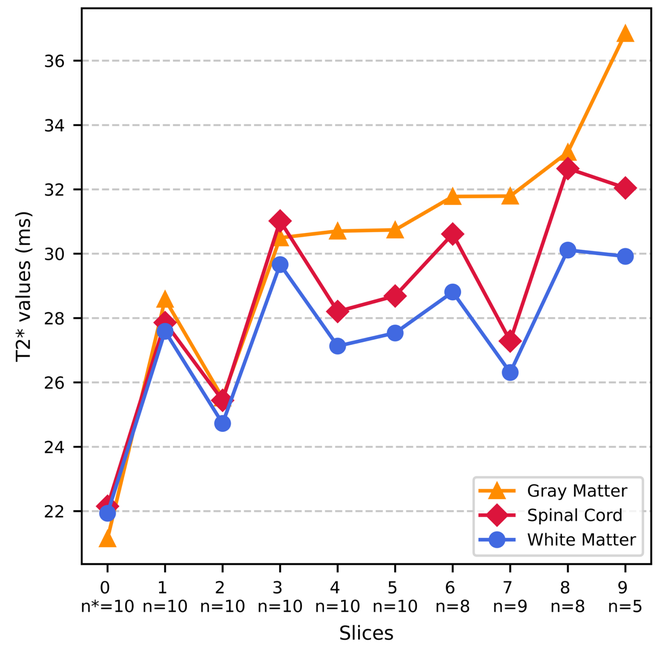

Example of C4 segmentation using SCT



7T T2*-weighted images of cervical spinal cord



Cross-sectional Areas across C1-C7



T2* Values across C1-C7

Problem Description

As interest in advanced diagnostic tools and high-fidelity imaging continues to grow, especially in the context of neurological disorders, researchers and clinicians are seeking more precise and comprehensive methods for evaluating spinal cord anatomy. This trend has led to increased exploration of ultra-high-field MRI technologies, particularly 7T MRI, which enable in vivo imaging with unprecedented spatial resolution and tissue contrast. A key concept emerging from this development is the generation of accurate macro-structural biomarkers, including cross-sectional area (CSA) and T2* relaxometry metrics, for better characterization of spinal cord tissues.

This research therefore focuses on the use of 7T MRI to image the entire cervical spinal cord in healthy individuals. It aims to answer the following research question: How effectively can 7T MRI provide high-resolution CSA and T2* metrics across cervical levels, and to what extent can these metrics serve as normative references for future pathological studies?

Method

This study applied an established 7T MRI protocol to scan ten healthy volunteers using a Siemens 7T MRI and an eight-channel cervical coil. High-resolution T2*-weighted images were acquired across C1–C7 and processed using a pipeline involving denoising, motion correction, averaging and tissue segmentation. CSA and T2* values for gray and white matter were extracted with the Spinal Cord Toolbox and analyzed statistically using two-way ANOVA and Tukey HSD to assess tissue-specific and spinal level differences.

Results

The study focuses on analyzing the outcomes of high-resolution imaging across cervical levels, using both quantitative metrics and visual assessments. The analysis revealed clear anatomical trends in the cervical spinal cord, with CSA and T2* values peaking at C4/C5, aligning with the cervical enlargement. Through statistical analysis, it was confirmed that both CSA and T2* values are significantly influenced by tissue type (gray vs. white matter) and spinal level. Gray matter consistently exhibited higher T2* values than white matter.

The inter-subject variability (CoV < 5%) across participants highlights the consistency of the protocol.

The thesis concludes that 7T MRI enables the generation of high-fidelity, level-specific biomarkers across the cervical spine. Further research should expand to clinical populations and explore longitudinal changes to validate the protocol's diagnostic and monitoring potential.

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