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ANATOMICAL ANALYSIS OF MICE SPINAL CORD : TOWARDS NUMERICAL MODELLING

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ABSTRACT

Cerebrospinal fluid contacting neurons (CFS-cNs), surrounding the central canal (CC) of the spinal cord, have a ciliated dendritic ending inside the central canal in contact with the cerebrospinal fluid (CSF). The CSF-CNs detect components in the CSF to modulate the locomotion, control the posture, detect spine curvature and participate in the locomotion. However, it is unknown whether they detect mechanical stress coming from CSF flow and if it influences their activity. Developing an experimental study is challenging due to the cilia's small size (~5µm), thus creating a numerical model of the system based on a mice model is the considered alternative. The aim is to analyse the anatomy of the spinal cord, to quantify inter and intra variability and to retrieve normalized data to build the geometry of the numerical model.

Spinal cords of 18 mice (3 weeks old – 4 males and 5 females, and 8 weeks old – 5 males and 4 females) were retrieved and fixed 24 hours in 4% paraformaldehyde using an immunohistochemistry protocol. A morphometric analysis using different development tools (FIJI, Matlab and python) allow the determination of characteristic lengths and the isolation of the contours of the gray matter, white matter, CC and CSF-cNs to assess differences according to sex, age and vertebral level. A simplified 2D model of cilia and CSF flow within the central canal as well as an experimental CSF flow measurements protocol are also developed.

Results show that the lengths of the gray and white matters differ according to the vertebral level, which is related to the shape and curvature of the spinal cord. The thoracic segments have a higher ratio between ventral and dorsal horn lengths compared to the cervical and lumbar segments. Sex-related differences are significant for all segments, though slightly less so for the lumbar segment. This result raises the question about potential differences in mechanical properties and/or microarchitecture depending on sex. The size of the spinal cord increases with age. However, the gray matter surrounding the central canal appears to decrease with growth. These results suggest a morphometric evolution of the spinal cord with growth. Using all data, 3D model of the spinal cord and CC and 2D model of the CC with the CSF-cNs are generated and the experimental protocols will be performed.

With its morphological analysis, this work brings precise data to develop the numerical model taking in consideration morphological variability of the spinal cord.