Spinal cord development

Whilst the cranial end of the neural tube forms the brain and cerebellum, the caudal end develops to form the spinal cord.

The spinal cord, and with it the Central Nervous System (CNS), begins its development in the 3rd week of the embryonic period. At approximal 21 days after fertilization, the ectodermal germ layer is pear-shaped and broader in the cephalic (head) than in the caudal region.

During vertebrate development, the posterior end of the embryo progressively elongates in a head-to-tail direction to form the body plan. Recent lineage-tracing experiments revealed that bi-potent progenitors, called neuromesodermal progenitors (NMPs), produce caudal neural and mesodermal tissues during axial elongation. However, their precise location and contribution to spinal cord development remain elusive.

Shaker et al. used NMP-specific markers (Sox2 and BraT) and a genetic lineage tracing system to localize NMP progeny in vivo.

Sox2 and BraT double-positive cells were initially located at the tail tip, but were later found in the caudal neural tube, which is a unique feature of mouse development. In the neural tube, they produced neural progenitors (NPCs) and contributed to the spinal cord gradually along the AP axis during axial elongation. Interestingly, NMP-derived NPCs preferentially contributed to the ventral side first and later to the dorsal side at the lumbar spinal cord level, which may be associated with atypical junctional neurulation in mice.

The current observations detail the contribution of NMP progeny to spinal cord elongation and provide insights into how different species uniquely execute caudal morphogenesis [1)].

Pediatric Spinal Cord Development

Pediatric spinal cord morphometry has been relatively understudied because of non-optimal image quality due to the difficulty of spine imaging, rarity of post-mortem analysis, motion artifacts, and pediatric MR imaging research focus on understanding spinal injury or pathology. The pediatric brain has been comparatively well-studied with white matter (WM), gray matter (GM), and cerebrospinal fluid (CSF) differences observed with age and gender. Therefore, a greater understanding of pediatric cervical and thoracic spinal cord morphometry would be beneficial for developing clinically relevant cord growth models. We focused on retrospectively characterizing cervical and thoracic spinal cord growth and morphometry changes in a healthy pediatric population. High resolution multi-echo gradient echo (mFFE) images were acquired from pediatric spinal cord scans from 63 patients (mean: 9.24 years, range: 0.83-17.67 years). The mFFE scans were then registered to the template space for uniform viewing and analysis by using a customized semi-automatic processing pipeline involving Spinal Cord Toolbox (SCT). Jacobian control determinants were calculated, and subsequent WM, GM, dorsal column, lateral funiculi, and ventral funiculi scalar averaging was conducted. Random effects models were used to model age-related Jacobian scalar differences. Observing the growth of cord

matter by patient age and vertebral level suggests that the upper cervical spinal cord, specifically C2-C3, and mid-thoracic spinal cord, T3-T8, grow faster than other cervical levels and thoracic levels, respectively. This knowledge will facilitate clinical decision making when considering spine interventions and conducting radiological analysis in children with cervical and thoracic spine abnormalities [2].

1)
Shaker MR, Lee JH, Kim KH, Ban S, Kim VJ, Kim JY, Lee JY, Sun W. Spatiotemporal contribution of neuromesodermal progenitor-derived neural cells in the elongation of developing mouse spinal cord. Life Sci. 2021 May 15:119393. doi: 10.1016/j.lfs.2021.119393. Epub ahead of print. PMID: 34004249.
2)
Kumar A, Vandekar S, Schilling K, Bhatia A, Landman BA, Smith S. Mapping Pediatric Spinal Cord Development with Age. Proc SPIE Int Soc Opt Eng. 2022 Feb-Mar;12032:1203213. doi: 10.1117/12.2612210. Epub 2022 Apr 4. PMID: 36506260; PMCID: PMC9733418.