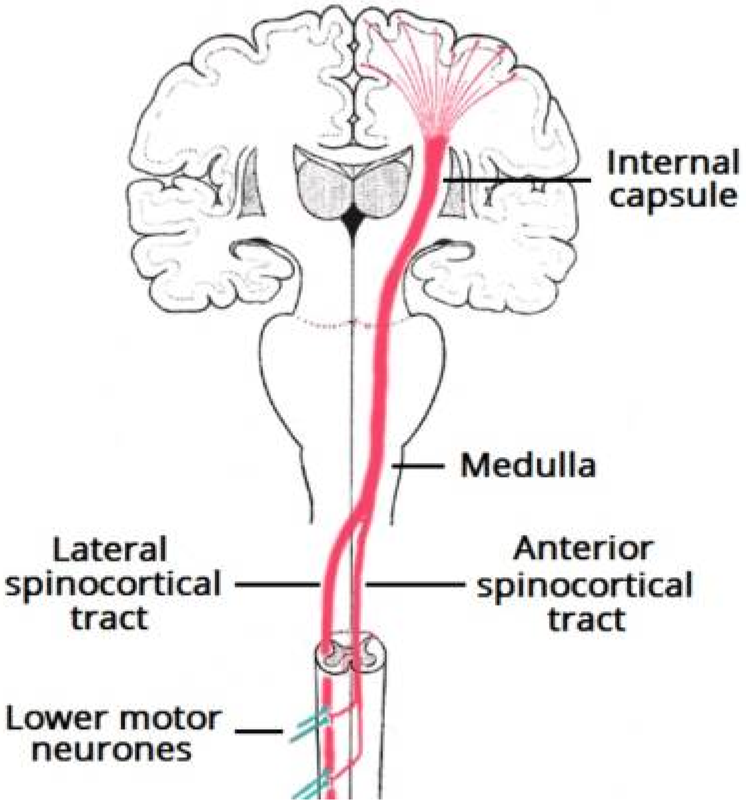
Corticospinal tract



The corticospinal tract (CST) represents the major pathway responsible for voluntary movement.

The corticospinal tract conducts impulses from the brain to the spinal cord. It contains mostly axons originated from the motor cortex. The corticospinal tract is made up of two separate tracts in the spinal cord: the lateral corticospinal tract and the anterior corticospinal tract. The corticospinal tract also contains betz cells, which are not found in any other region of the body. An understanding of these tracts leads to an understanding of why one side of the body is controlled by the opposite side of the brain.

Function

The corticospinal tract is concerned specifically with discrete voluntary skilled movements, such as precise movement of the fingers and toes. The brain sends impulses to the spinal cord relaying the message. This is imperative in understanding that the left hemisphere of the brain controls the right side of the body, while the right hemisphere of the brain controls the left side of the body. The tracts cross in the medulla oblongata in a process also known as decussation.

Localization

Neurite orientation dispersion (NODDI) seems to be useful in reflecting the high-grade glioma infiltration to corticospinal tract (CST), and can evaluate the CST destruction with a performance similar to DTI by providing additional information about neurite density for HGG-induced CST injury [1].

Motor mapping is used to localize the CST and to determine the safe distance from the CST.

Continuous dynamic mapping was found to be a feasible and ergonomic technique for localizing the exact site of the CST and distance to the motor fibers. The acoustic feedback and the ability to stimulate the tissue continuously and exactly at the site of tissue removal improves the accuracy of mapping, especially at low (< 5 mA) stimulation intensities [2].

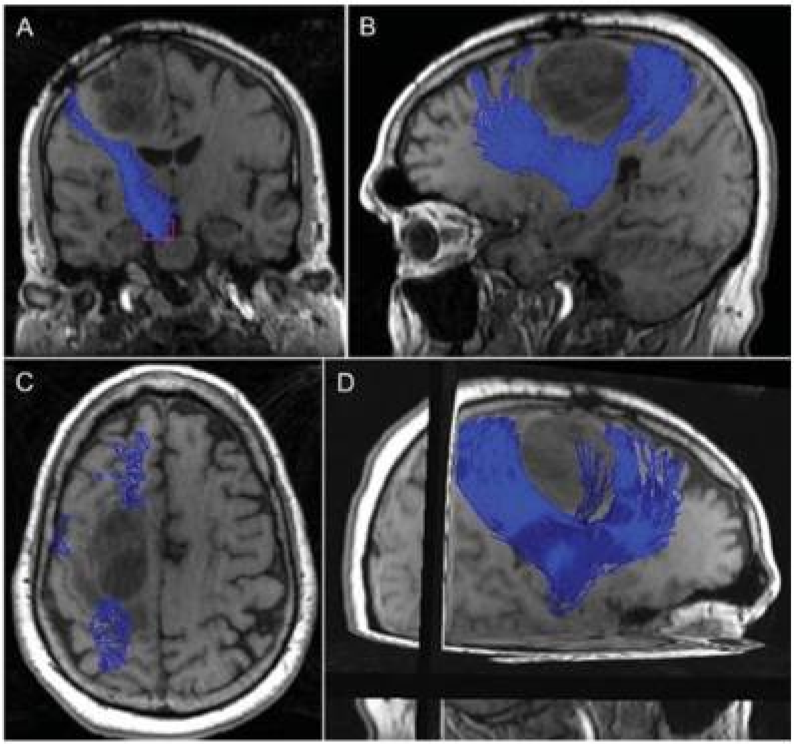
Functional corticospinal tract fibers originating from the dorsal premotor cortex can be defined and removed safely under local anesthesia with the aid of integration of functional neuronavigation and subcortical Electrostimulation [3].

Non-invasive measures of corticospinal tract (CST) integrity may help to guide clinical interventions, particularly in children and young people (CAYP) with motor dysfunction. Stefanou et al compared diffusion tensor imaging (DTI) metrics extracted from the CST generated by tensor and non-tensor based tractography algorithms.

For a group of 25 CAYP undergoing clinical evaluation, the CST was reconstructed using (1) deterministic tensor-based tractography algorithm, (2) probabilistic tensor-based, and (3) constrained spherical deconvolution (CSD)-derived tractography algorithms.

Choice of tractography algorithm significantly altered the results of tracking. Larger tracts were consistently defined with CSD, with differences in FA but not MD values for tracts to the pre- or post-central gyrus. Differences between deterministic and probabilistic tensor-based algorithms were minimal. Non-tensor reconstructed tracts appeared to be more anatomically representative. Examining metrics along the tract, difference in FA values appeared to be greatest in voxels with predominantly single-fibre orientations. Less pronounced differences were seen outwith of these regions.

With an increasing interest in the applications of tractography analysis at all stages of movement disorder surgery, it is important that clinicians remain alert to the consequences of choice of tractography algorithm on subsequently generated tracts, including differences in volumes, anatomical reconstruction, and DTI metrics, the latter of which will have global as well as more regional effects. Tract-wide analysis of DTI based metrics is of limited utility, and a more segmental approach to analysis may be appropriate, particularly if disruption to a focal region of a white matter pathway is anticipated [4].



Expected positive map for corticospinal tract. T1-weighted magnetic resonance imaging in the coronalA, sagittalB, axialC,)and 3-dimensionalDviews. The disconnection is made superior and medial to the corticospinal tract, best seen in the coronal plane.

Case reports

Congenital or early acquired brain structural lesions often cause contralateral hemiparesis as well as cognitive deficits, developmental delays, and seizures. Among them, seizure is the most debilitating condition, as it greatly impairs the quality of life in both the affected individuals and their caregivers and prevents them from active social participation.

A 34-year-old man with hemiparesis and early-onset seizures since childhood owing to a congenital brain lesion. He developed intractable seizures in the last two years, and was subsequently admitted for resective epileptic surgery. During the operation, we employed an innovative intraoperative neurophysiological monitoring technique. Unlike routine application for transcranial stimulation (TCS), we recorded compound muscle action potentials (CMAPs) over the bilateral limb muscles simultaneously instead of over the contralateral muscles only, to determine the patterns of the corticospinal projections. TCS over the bilateral hemispheres was applied before craniotomy and direct cortical stimulation over the lesioned hemisphere was applied after craniotomy. By integrating both approaches, we could first identify the pattern of corticospinal projections before craniotomy and then accurately define the non-eloquent area, which in turn guided the resection to successfully accomplish the surgical goal.

The technique is simple because no patient participation is required. Moreover, we believe that it has the potential to replace conventional preoperative functional magnetic resonance imaging and transcranial magnetic stimulation in resective epilepsy surgery, particularly for young patients. Not only can it improve the safety of surgical procedures, it can help predict the functional outcome as well [5)].

Pathology

Stroke-induced damage to the CST as well as to other motor tracts leads to motor deficits which may show favorable functional recovery particularly in the pediatric population.

Narrative reviews

In a narrative review Levi et al. from The Miami Project to Cure Paralysis (Miami, FL) & Belford Center for Spinal Cord Injury, OSU Neurological Institute (Columbus, OH) published in the Journal of Neurosurgery Spine to critically reassess historical concepts of corticospinal tract (CST) somatotopy in the spinal cord and evaluate its implications for traumatic cervical spinal cord injuries, particularly central cord syndrome (CCS).

1. There is no discrete somatotopic ("layered") organization of CST fibers in the human spinal cord. 2. CST integrity is essential for hand function. 3. CCS hand weakness arises from diffuse CST damage—not selective injury of a "hand" fiber layer [6].

Critical Review

 Strengths: * Comprehensive synthesis of anatomical, tract-tracing, MRI, primate ablation, evolutionary, and human neuropathological evidence. * Challenges long-held dogma—valuable for neurosurgeons managing CCS by shifting focus to diffuse injury mitigation.

⚠ **Limitations:** * As a narrative review, lacks quantitative meta-analysis or systematic methodology. * Emphasizes foundational studies, many preclinical, with limited direct clinical correlation. * Conclusions, while strongly reasoned, remain inferential without prospective imaging–functional studies in CCS patients.

 Overall Quality: This is a well-argued, methodologically diverse narrative. Yet for maximal impact, it needs future clinical validation—especially prospective diffusion-MRI correlation with hand motor outcomes.

Verdict & Takeaway

Score: 7.0 / 10 – solid scholarship, but limited clinical-grade evidence **For practicing neurosurgeons:** Refocus your assessment of CCS: presume diffuse CST injury rather than a selective "layer" lesion. Tailor interventions accordingly—especially in surgical decompression and emerging neuroprotective strategies targeting widespread CST damage. **Bottom line:** This article dismantles outdated CST somatotopy assumptions, redirecting focus toward diffuse CST preservation to optimize hand recovery in CCS.

Reference

'Publication date:': Apr 1, 2022 'Corresponding author:' Allan D Levi
— alevi@med.miami.edu

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