Assessment of Corticospinal Tracts in Patients with Chronic Ischemic Stroke

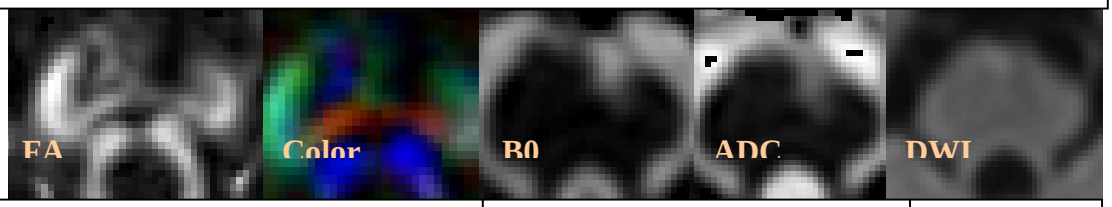
P. Dubey[1], A. Luft[2], D. Hanley[3], L. W. Forrestor[4], S. Wakana[1], F. Villagra[5], P. vanZijl[1], S. Mori[6]

[1]Radiology, FM Kirby Research Center, Kennedy Krieger Institute, Baltimore, MD, United States, [2]Hertie Institut für klinische Hirnforschung, Tübingen, Germany, Germany, [3]Department of Neurology, The Johns Hopkins Medical Institutions, Baltimore, Maryland, United States, [4]Department of Physical Therapy & Rehabilitation Science, University of Maryland, Baltimore, MD, United States, [5]Department of Physical Therapy and Rehabilitation Science, University of Maryland, Baltimore, MD, United States, [6]Radiology, The Johns Hopkins Medical Institutions, Baltimore, MD, United States

Background: The degree of recovery and response to rehabilitation are highly variable in chronic stroke survivors. Imaging modalities that can accurately describe the status of motor pathway would be of great importance for better diagnosis and prescription of appropriate rehabilitation. Recently, DTI studies have shown that diffusion anisotropy is an effective parameter to monitor Wallerian degeneration.(1,2) In this study, we developed a grading system to evaluate the status of the corticospinal tract in the brainstem of patients who had primary stroke in the cerebral hemispheres. . We also compared diffusion parameters measured in brainstem between patients with internal capsule lesions and cortical lesions; internal capsule and cortical lesions lead to differential brain activation, hence functional properties of central motor systems [2]. Our long-term goal is to study the efficacy of multiparamteric assessment of integrity of motor pathways to characterize functional heterogeneity and response to rehabilitative measures in patients with a chronic stroke. **Method:** 11 patients with chronic ischemic stroke in the cerebral hemispheres [n=7], internal capsule [n=4] and 4 patients with primary brain stem stroke were studied. DTI [Single shot-EPI; TR/TE of 7622/80 ms; max b value=700 s/mm2; 30 different gradient directions; 2.5 mm resolution; 50 axial slices; 5min 24s scan time per sequence; 3 repetitions] was performed at 1.5 Tesla scanner combined with SENSE technique - sense factor (R) of 2.5. The fractional anisotropy (FA) and mean Apparent Diffusion coefficient (mADC) map were used. B0 images were used to assess T2 abnormalities. We developed and applied a grading system (Table 1) to qualitatively classify the status of brain stem corticospinal tracts (CST) using color coded maps and MR parameters (FA, ADC, and T2) and also compared with quantitative measurements done by manual delineation of the CST. **Results:** The 15 patients were classified to 4/0/0/1/1/5/4 for grade 0 – 6, respectively. Patients demonstrated varying no atrophy to severe atrophy of the brain stem CST on the affected side. Grade 6abnormality was seen only in patients with primary pontine stroke and not in patients with Wallerian degeneration. Gross abnormalities of B0, mADC maps were seen only in patients with primary brain stem. FA map was most sensitive towards detecting CST Wallerian degeneration, while mADC map, diffusion weighted images, or conventional t2 weighted images appeared normal. Quantitative analyses showed significant reduction in the CST FA in affected side compared to contralateral side [0.33±.03 vs. 0.43±0.014, p=0.03], in patients with cerebral hemisphere strokes. The CST FA was also significantly correlated with CST atrophy, [p=0.02]. There was no significant difference in CST T2 measurement between affected and contralateral side in patients [p=0.2]. There was significant but marginal elevation in diffusivity (mADC) in the affected side of the CST, in patients who were classified as normal on qualitative assessment, [2.01±0.093vs. 1.88±0.09, p=0.02]. The primary stroke area (measured in pixels on the slice with largest affected region) was significantly larger in patients with the CST atrophy, p=0.02. Patients with Internal Capsule stroke demonstrated higher FA, and less atrophy compared to those with MCA stroke, but the difference did not achieve any statistical significance. **Conclusion:** The qualitative classification and ROI-based MR parameter quantification of the brain stem CST revealed inhomogeneous status of the CST in chronic stroke patients, which could not be fully appreciated by conventional MRI. The variability in the Wallerian degeneration may explain the clinical heterogeneity. In the future we aim to correlate functional status with multiparametric characterization of Wallerian degeneration.

Low FA Rt. CST	Rt. CST Atrophy	No visible changes

Patient 1: Rt. MCA territory stroke, Rt. CST atrophy, and visible reduction in rt. CST FA. No changes in other diffusion maps, Grade5.



Missing Tract	Signal Hyperintensity in B0 and Trace	No Change

Patient 2: Primary Lt. Sided pontine stroke: Grade 6

References:

1. Pierpaoli, et al, Neuroimage, 2001, 13, 1174,
2. Thomalla G. et al. Neuroimage. 2004 22, 1767-74
3. Luft AR, et al. Lesion location alters brain activation in chronically impaired stroke survivors. *Neuroimage.* 2004;21(3):924-935.

Description	Grade
Normal	0
FA Abnormal with no Atrophy	1
FA and T2/ADC abnormal with no atrophy	2
Mild to Moderate Atrophy alone	3
Mild to Moderate Atrophy with FA abnormal	4
Severe Atrophy	5
Tract Missing	6