Predictive Value of Structural Integrity of Affected Corticospinal Tracts in Motor Function Outcome of Affected Upper Extremities in Patients with Subcortical Ischemic Stroke: A diffusion spectrum imaging tractography study

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Introduction

The purposes of this study were to investigate: (1) changes in the structural integrity of bilateral corticospinal tracts (CSTs) for patients with subcortical stroke from 20th-30th day (D30) to the 180th day (D180) after stroke; (2) the concurrent relationships between the structural integrity of the affected CST and the motor function of the affected upper extremity at D30 (D90, and D180) for these patients; and (3) the predictive relationships of the structural integrity of the affected CST at D30 with the motor function of the affected upper extremity at D90 and D180.

Materials and Methods

Subjects We studied seven consecutive patients admitted to our hospital for the diagnosis of subcortical ischemic stroke (4 males and 3 females; age range: 51-69 years; mean: 58.8 ± 6.6 years). The severity of the neurological deficit was assessed using the National Institutes of Health Stroke Scale (NIHSS), with higher scores reflecting greater deficit (maximum 42). The motor function of the affected upper extremity was assessed using the Fugl-Meyer Assessment of the upper extremity (FMA-UE), with higher scores reflecting greater function (maximum 66). *Diffusion Spectrum Imaging* MR scans were performed on a 3T MRI system (Trio, Siemens, Erlangen, Germany), using an 8-channel head coil. DSI was conducted with a pulsed-gradient spin-echo diffusion EPI sequence by applying 203 diffusion gradient vectors, each corresponding to one of the isotropic 3D grid points in the q-space, the maximum diffusion sensitivity b_{max} = 6000 s/mm^2, TR/TE = 9100/142 ms, in-plane resolution = 2.9 mm and thickness = 2.9 mm. Forty-five trans-axial slices were acquired encompassing the whole brain. *CST Tractography* Fiber tracking was performed using DSI Studio software developed in house. For fiber tracking of the CST, two regions of interest (ROIs) were placed on axial sections: motor area (precentral gyrus) and cerebral peduncles. Once a fiber tract was demonstrated in its entire length the mean generalized fractional anisotropy (GFA) values for the entire tract were calculated using the custom software written in Matlab. To assess the reliability of fiber tracking, a separate investigator repeated measurements for this tract on both right and left sides with fiber tracking parameters held constant. Also, the tract-specific (TS) quantitative analysis of the relative generalized fractional anisotropy (rGFA) [= $(GFA_{UH} - GFA_{AH})/(GFA_{UH} + GFA_{AH})$] values of different segments of bilateral CSTs was derived to indicate the structural integrity in the various segments of CSTs. *Statistics Analysis* The one-way (post-stroke day) repeated measures of analysis of variance (RM ANOVA) was conducted using SPSS software, to investigate differences both in the motor function of the affected upper extremity assessed by FMA-UE and the rGFA values across the three testing time points. The correlations between these rGFA values at D30 and D90 after stroke with the FMA-UE scores at D90 and D180 were calculated by using Spearman rank correlation to examine the relationship between the earlier structural integrity of the affected CSTs and later motor function recovery of the affected upper extremity.

Results

First, there was no significant post-onset day main effect on the structural integrity of CST, indicated by rGFA values in all segments, across the three testing times ($p > .05$, Fig.1). In addition, the results showed that at D30, the rGFA values in the infract segment of the affected CST were highly correlated with the FMA-UE scores of the affected upper extremity ($N = 7$, $r = -.847$, $p = .016$). Moreover, the rGFA values in the IC segment of the CST at D30 were highly correlated with the FMA-UE scores at D180 ($N = 7$, $r = -.802$, $p = .030$, Fig.2).

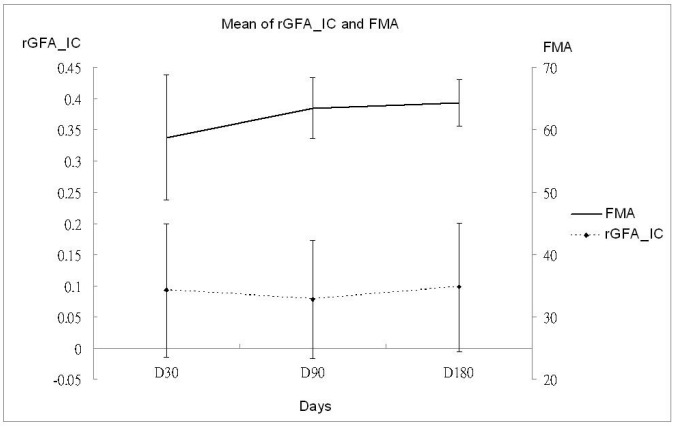

Fig. 1 There was no significant difference in rGFA over time ($p > .05$).

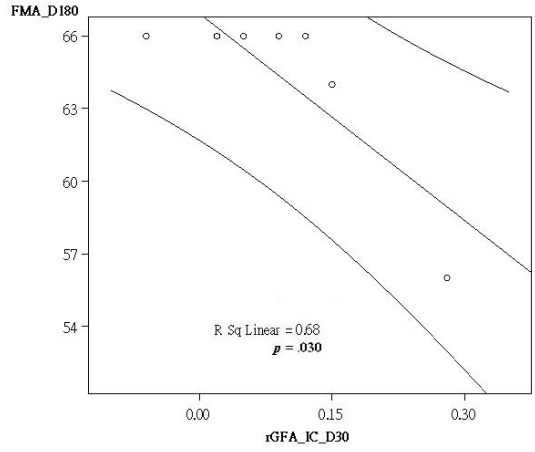

Fig. 2 The rGFA value of the IC segment at D30 was highly correlated with the motor outcome at D180 ($N = 7$, $r = -.802$, $p = .030$).

Discussion and Conclusions

The structural integrity of the affected CST was highly related to the motor function of the affected upper extremity and the motor recovery in later stage. Thus, the structural integrity of the affected CST early after stroke may serve as a valid indicator of late motor recovery. DSI tractography is an emerging imaging technique that can visualize and quantify subtle structural abnormalities of specific anatomic pathways. Longitudinal studies could be clinically useful to monitor changes in corticospinal tract over time and select patients who could benefit from early intervention to optimize motor outcome (Sivaswamy et al., 2008).

References

Sivaswamy, L., Rajamani, K., Juhasz, C., Maqbool, M., Makki, M., & Chugani, H. T. (2008). The corticospinal tract in Sturge–Weber syndrome: A diffusion tensor tractography study. *Brain and Development,* 30(7), 447-453.