Visual analysis of fractional anisotropy and mean diffusivity of white matter tracts in stroke patients using tract-based spatial statistics

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BACKGROUND

- Diffusion Tensor Imaging (DTI) is an MRI-based neuroimaging technique that provides a visual representation of white mater tracts by mapping water diffusion *in vivo*
- Previous studies have shown that FA increases from baseline in the first 2 years post-stroke[1] and MD increases slightly at the chronic stage[2]
- Fractional anisotropy (FA) measures the degree of directionality of water movement, with a higher FA value indicating a more intact white matter tract
- Radial diffusivity (RD) measures water diffusion lateral to the main tract direction
- Mean diffusivity (MD) is the vector sum of all water directions

PURPOSE

- To understand the effects of stroke on white matter tracts, especially how the hemisphere contralateral to stroke location is affected in terms of FA, MD, and RD

PARTICIPANTS

- 68 stroke patients whose data was collected from a study funded by the National Institute of Health, conducted at Sunnybrook Health Sciences Centre, Toronto (n=45) and the Chicago Medical Center (n=23)
- 27 normal control subjects collected from the FIBA study conducted at Sunnybrook Health Sciences Centre

METHODS

- FA, MD, and RD maps were generated using FMRIB's Diffusion Toolbox, part of FSL[3,4,5,7,8,9,10]
- Voxelwise statistical analysis of FA, MD, and RD data was carried out using TBSS, part of FSL[4,6] which allows voxel-by-voxel comparison of white matter tracts between patients and controls
- Stroke subgroups were analyzed in comparison to controls using visual analysis
- White Matter Tracts were identified using the John Hopkins atlas

RESULTS

Table 1 - Demographics

	n	Age (SD)	Sex (% males)	YOE (SD)	days post stroke (SD)
Stroke	68	64.2 (12.7)[a]	55.9[b]	14.5 (3.2)[a]	435.9 (248.9)
Normal Controls	27	70.3 (6.8)	44.4	16.2 (3.1)	N/A
Left Stroke	19	67.7 (14.3)	52.6	14.8 (2.9)	431.3 (137.1)
Right Stroke	21	61.3 (9.8)	66.7	14.3 (2.9)	431.8 (373.8)
Bilateral Stroke	24	65.6 (13.6)	45.8	14.3 (3.7)	400.1 (192.4)
Frontal Stroke	36	63.1 (13.0)	52.8	14.0 (2.8)	434.6 (192.1)
Left Frontal Stroke	10	64.3 (14.8)	40.0	14.5 (2.8)	432.4 (148.2)
Right Frontal Stroke	9	60.1 (9.7)	77.8	14.9 (2.7)	441.2 (209.6)
Bilateral Frontal Stroke	17	63.9 (13.9)	47.1	13.3 (2.8)	432.3 (215.4)
Other Stroke (non-frontal, non-subcortical)	24	67.9 (12.9)	58.3	15.2 (3.4)	337.8 (232.7)

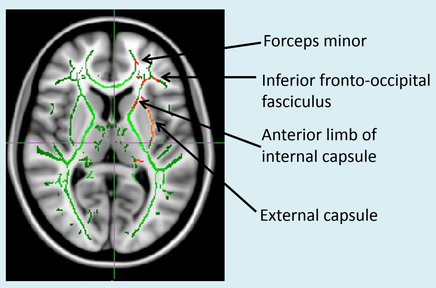
[a] Significantly different than controls, $p<0.05$
[b] Not significantly different than controls, $x^2(1)=0.31$

FRACTIONAL ANISOTROPY

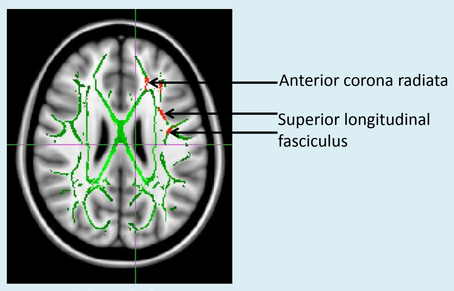
- In patients with right hemispheric stroke it was found that there was an increase in FA on the contralateral (left) hemisphere

LEGEND: INTERPRETING DTI IMAGES

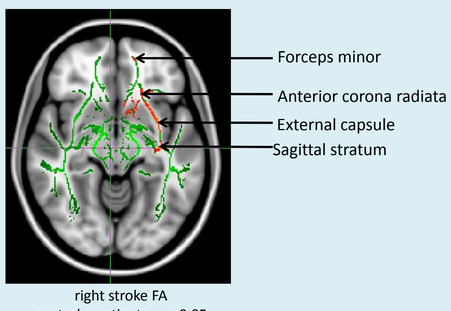
Green	-	Not significant
Yellow, Red, Orange	-	Significant difference between patients and controls



right stroke FA
control < patients, p < 0.05



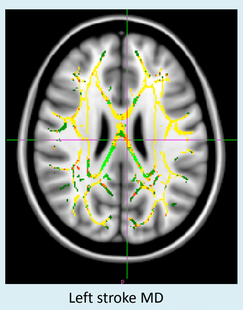
right stroke FA,
control < patients, p < 0.05



right stroke FA
control < patients, p < 0.05

MEAN DIFFUSIVITY

- Patients had an increase in MD in both hemispheres when stroke was contained to one region


Left stroke MD
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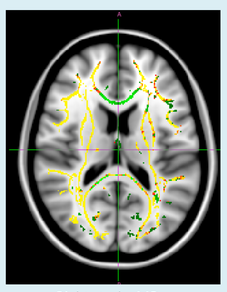
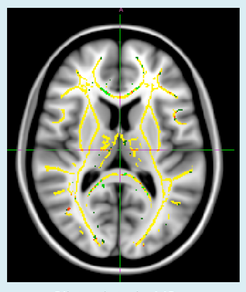
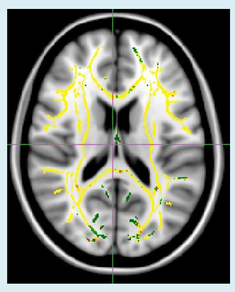
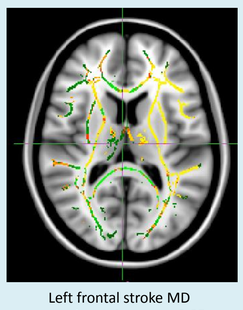
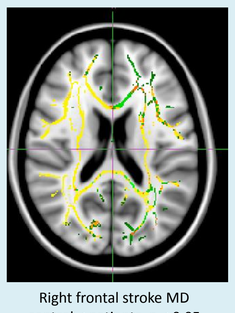
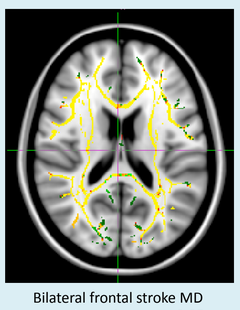

Right stroke MD
control < patients, p < 0.05

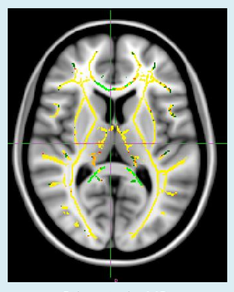

Bilateral stroke MD
control < patients, p < 0.05


Frontal stroke MD
control < patients, p < 0.05


Left frontal stroke MD
control < patients, p < 0.05

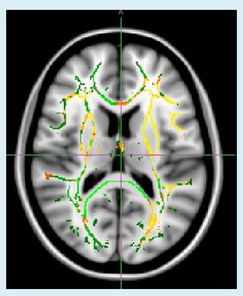

Right frontal stroke MD
control < patients, p < 0.05


Bilateral frontal stroke MD
control < patients, p < 0.05


Other stroke MD
control < patients, p < 0.05

RADIAL DIFFUSIVITY

- Patients had an increase in RD in both hemispheres when stroke was contained to one region


Left stroke RD
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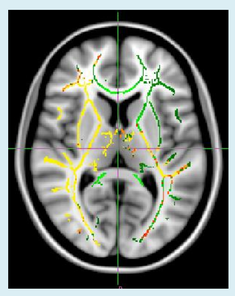
Right stroke RD
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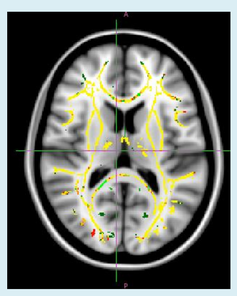
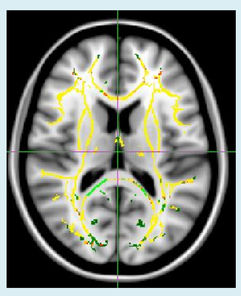
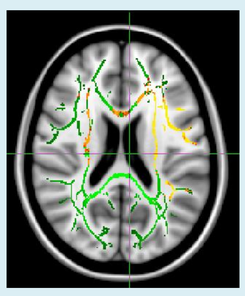
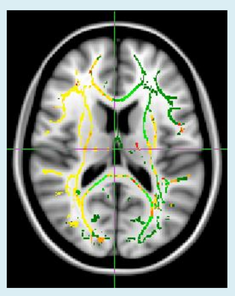
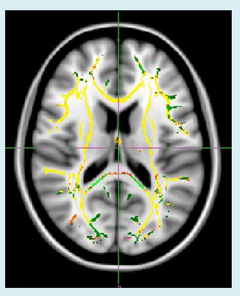
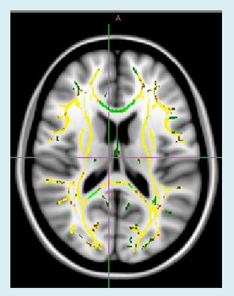

Bilateral stroke RD
control < patients, p < 0.05


Frontal stroke RD
control < patients, p < 0.05


Left frontal stroke RD
control < patients, p < 0.05


Right frontal stroke RD
control < patients, p < 0.05


Bilateral frontal stroke RD
control < patients, p < 0.05


Other stroke RD
control < patients, p < 0.05

DISCUSSION

- This study suggests that stroke contained in one hemisphere can lead to changes in the microstructural integrity of the contralateral hemisphere
- The white matter integrity may improve in the hemisphere contralateral to stroke, possibly to compensate for the integrity loss in the ipsilateral hemisphere
- The increase in RD may be the main cause for the increase in MD, meaning stroke may increase lateral water diffusion throughout the white matter tracts of the brain

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