Title: Pervasive white matter fibre degeneration in ischemic stroke

Running title: White matter loss in stroke

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Abstract (167 words)

**Background and purpose.** We examined if ischemic stroke is associated with white matter degeneration predominantly confined to the ipsi-lesional tracts or with widespread bilateral axonal loss independent of lesion laterality.

**Methods.** We applied a novel “fixel”-based analysis, sensitive to fibre tract-specific differences within a voxel, to assess axonal loss in stroke (N=104, 32 women) compared to control participants (N=40, 15 women) across the whole brain. We studied microstructural differences in fibre density and macrostructural (morphological) changes in fibre cross-section.

**Results.** In stroke participants, we observed significantly lower fibre density and cross-section in areas adjacent, or connected, to the lesions (e.g., ipsi-lesional cortico-spinal tract). In addition, the changes extended beyond directly connected tracts, independent of the lesion laterality (e.g., corpus callosum, bilateral inferior fronto-occipital fasciculus, right superior longitudinal fasciculus).

**Conclusions.** We conclude that ischemic stroke is associated with extensive neurodegeneration that significantly affects white matter integrity across the whole brain. These findings expand our understanding of the mechanisms of brain volume loss and delayed cognitive decline in stroke.
Introduction (430 words)

Ischemic stroke leads not only to focal tissue destruction in the region of infarction but also can result in neurodegeneration remote to the site of insult. Loss of grey matter distal to the lesion site and disruptions to global functional connectivity have been documented, suggesting that stroke is associated with secondary neurodegeneration in the chronic stages. Focal lesions, especially ones overlapping with or adjacent to major white matter tracts, cause specific multi-domain behavioural deficits. Despite evidence that white matter is very susceptible to the deleterious effect of ischaemia, little is known about remote and regional white matter degeneration after stroke. Reports of white matter damage after stroke have been limited to the effect on specific tracts, often attributed to Wallerian degeneration of the corticospinal tract. Trans- and interhemispheric effects have mostly been studied in acute stroke and could be related to early, potentially reversible, functional brain changes such as in diaschisis. It is also possible that some of these changes pre-date the stroke, including brain degeneration. While whole-brain level changes in white matter in the chronic phase after stroke have been shown in a number of studies, some researchers have not found white matter differences in stroke participants compared to controls, likely due to the use of diffusion tensor imaging (DTI) metrics, such as fractional anisotropy (FA). These DTI metrics are non-specific voxel-averaged measures that do not account for complex microstructural fibre geometry and are known to lead to erroneous interpretations in locations where fibres are crossing.

In the current study, we examined white matter degeneration in a cohort of stroke participants at 3 months post infarct (chronic stage) compared to controls. We applied a novel fixel-based analysis that is sensitive to fibre tract-specific differences at a "fixel" level to assess axonal loss across all white matter fixels in the brain. The outcome metrics of this analysis are fibre density, fibre bundle cross-section, and their combined effect, fibre density and cross-section. Fibre density is a metric sensitive to the total intra-axonal volume of axons aligning with a specific fibre population in each voxel compartment. Fibre cross-section is sensitive to individual differences in macroscopic fibre-bundle cross-sectional size. Fibre density and cross-section is the product of the two, which is computed to assess the combined effect of both micro- and macro-structures. We hypothesised a decrease in all of the aforementioned metrics, both globally (e.g., bilateral major
projection and association fibres) and in the white matter tracts adjacent or connected to the lesion site (e.g., ipsi-lesional tracts).

Materials and methods (873 words)

Data availability

The data that support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available as CANVAS is a prospective, “live” study, with expected completion of data acquisition in mid-2020 for the 5-year scanning timepoint. All requests for raw and analysed data will be reviewed by the CANVAS investigators to determine whether the request is subject to any intellectual property or confidentiality obligations.

Participants

Participants with ischemic stroke confirmed clinically and radiologically were recruited within 6 weeks of stroke to the Cognition and Neocortical Volume after Stroke (CANVAS) study from the stroke units at three hospitals in Melbourne (Australia): Austin Hospital, Box Hill Hospital, and the Royal Melbourne Hospital. Each hospital’s ethics committee approved the study in line with the Declaration of Helsinki and the National Health Medical Research Council. Stroke severity on hospital admission was assessed with the National Institutes of Health Stroke Scale (NIHSS). Patients with first-ever (85.6%) or recurrent ischemic stroke (14.4%) in any vascular territory and of any aetiology were included. Patients diagnosed with primary haemorrhagic stroke, transient ischemic attack, venous infarction, or significant medical comorbidities were excluded from participation. Age-matched controls were selected from a database of volunteers who had previously undertaken MRI research at the Florey Institute of Neuroscience and Mental health and were of comparable age, sex and education to stroke patients. All participants had no history of dementia, neurodegenerative disorders, major psychiatric illnesses, or substance abuse. Informed consent was obtained from all participants.

The CANVAS study has 175 participants (of which N=40 Controls) across 4 time-points: at baseline, 3, 12 and 36 months. The number of available subjects per time-point differs, with the largest number of participants (N=165) available at 3 months. At 3 months the participants are past the acute stage, yet it is still relatively early after stroke, useful for identifying predictive biomarkers or disease progress and the possibility of successful interventions. Of 165 participants who completed scanning at 3 months, we had 144 (of which
N=40 Controls) with complete, usable diffusion data. Once successfully pre-processed, all data were used for the analysis, with no additional subjects excluded.

**Imaging data acquisition, processing and modelling**

All images were acquired on a Siemens 3T Tim Trio scanner (Erlangen, Germany) with a 12-channel head coil. Sixty diffusion-weighted images (b = 3000 s/mm²), and 8 volumes without diffusion weighting (b = 0), were obtained with 2.5 x 2.5 x 2.5 mm³ isotropic voxels. A high-resolution anatomical magnetisation prepared rapid acquisition gradient echo (MPRAGE) scan was collected (1 x 1 x 1 mm³ isotropic voxels) and used to compute intracranial volume using SPM12.

Pre-processing of diffusion-weighted images included denoising, removing Gibbs ringing artefacts, eddy-current distortion and motion correction, bias field correction and spatial up-sampling. Following these pre-processing steps, white matter fibre orientation distributions (FODs) were computed with Single-Shell 3-Tissue Constrained Spherical Deconvolution (SS3T-CSD), with group averaged response functions for white matter, grey matter, and CSF obtained from the data themselves 18,19, using MRtrix3Tissue (https://3Tissue.github.io), a fork of MRtrix3 20. All pre-processing was performed in the same way for both control and stroke patients. Note that the lesions in stroke participants were not explicitly masked out, but thanks to the SS3T-CSD method, they were automatically characterised as a mixture of WM-like, GM-like and CSF-like signal. WM-like, GM-like and CSF-like signals here refer not to the biological properties of genuine WM, GM and CSF but rather to the change in diffusion signal properties. The WM FODs accurately quantify the amount of ‘intact’ WM, while contributions of other (pathological) tissues, such as stroke lesions or white matter hyperintensities, and free water are accommodated in other model compartments 21. A population template was generated using FOD images from 30 (15 stroke and 15 control) participants, the distribution of lesions in stroke participants selected is shown in Figure I.

Stroke lesions were manually traced on the high-resolution FLAIR image. A stroke neurologist (AB) visually inspected and verified the manually traced images. Binary lesion masks were created and normalised to the MNI template using the Clinical Toolbox SPM extension 22. Lesion volumes were computed from the masks using FreeSurfer. Lesion maps were prepared using MRIcron software 23.

Automated segmentation of white matter hyperintensities (WMHs) was performed using the W2MHS toolbox (Wisconsin WMH Segmentation Toolbox) using FLAIR and T1
images as inputs \(^\text{24}\). Manual corrections were performed for a small subset of participants (N=18) to remove false positive voxels in the choroid plexus, brain stem and cerebellum.

Statistical analyses

We performed statistical comparisons of fibre density, fibre cross-section, and their combined measure for all white matter fixels between the stroke and control groups, controlling for age, education and intracranial volume, using connectivity-based fixel enhancement (CFE) \(^\text{25}\). Significant fixels (FWE-corrected p<0.05, non-parametric permutation testing over 5000 permutations) were then visualised on the population template. Statistical analysis steps were performed using MRtrix3 \(^\text{20}\).

To distinguish between ipsi-lesional and global (bilateral, contra-lesional or lateralised results that are independent of the lesion laterality) effects, we split the stroke group into left (N=40) and right (N=61) hemisphere strokes and repeated the analysis for each of the stroke groups compared to controls (N=40) separately, controlling for age, education and intracranial volume. This approach of splitting groups into left and right hemisphere has been previously used \(^\text{26}\).

Results (270 words)

Of the 165 participants who completed MRI scanning at 3 months, complete usable diffusion data were available from 104 stroke and 40 control participants (Table 1). The groups did not significantly differ in age, sex, or intracranial volume, but control participants were better educated. Stroke severity was generally mild (Mean NIHSS=3, range 0-13).

Whole stroke group vs. control

Whole-brain analysis revealed significant white matter loss in stroke participants compared to controls, manifesting both microstructurally and macrostructurally (Figure 1). Differences in fibre cross-section were mostly apparent in bilateral fibre bundles with an anterior-posterior orientation, such as the superior longitudinal fasciculus. The reductions in fibre density were mostly associated with inter-hemispheric connections (e.g., in the corpus callosum forceps minor and major) but were also present in the bilateral inferior fronto-occipital fasciculus. No increases in either fibre density or fibre cross-section (i.e., Stroke > Control) were observed.

Left- and right-sided stroke groups vs. control

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Additional analysis by infarcted hemisphere revealed that corticospinal tract changes were ipsi-lesional and manifested as a reduction in fibre cross-section, while inter-hemispheric connection loss, such as in the splenium of the corpus callosum, forceps major and minor, were evident in both left and right hemisphere strokes bilaterally and were due to a reduction in fibre density (Figure 2). In addition to the presence of bilateral changes, this analysis suggested that reductions in fibre density and the combined fibre density and cross-section in the right superior longitudinal fasciculus observed in the whole group analysis, were evident in left and right-sided stroke groups. This likely reflects the functional significance of the right superior longitudinal fasciculus tract and its vulnerability in stroke.

Discussion (1386 words)

This study investigated whole-brain differences in white matter fibre density and fibre cross-section in stroke participants 3 months post their clinical event compared to healthy controls. With respect to laterality, we observed three types of effects: ipsi-lesional, bilateral, and lateralised effects, independent of the lesion side (left, right). Specifically, we found evidence of typical Wallerian degeneration in the ipsi-lesional cortico-spinal tract and significant loss in the fibre density within the inter-hemispheric connections, including the corpus callosum, and bilateral inferior fronto-occipital fasciculi, indicative of microstructural fibre degeneration. Finally, we also observed a reduction in fibre bundle cross-section in the bilateral superior longitudinal fasciculi, with atrophy localised in the right hemisphere for participants with left- and right-sided strokes. This deterioration of micro- and macrostructure of the fibre bundles supports the notion that white matter degeneration after stroke is widespread.

The literature on global white matter degeneration in stroke, albeit using a tract-of-interest approach, is growing. Here, we report a whole-brain study that could show these various effects in the cortico-spinal tract, corpus callosum, and superior longitudinal fasciculus in one analysis, taking advantage of the greater specificity of the fixel-based analysis methodology and the SS3T-CSD modelling approach. Most prior studies have focused on motor recovery after stroke, and the utility of diffusion MRI in reconstructing the cortico-spinal tract to track motor damage and repair.\textsuperscript{8,9} The mechanism underlying the decline in the cortico-spinal tract was believed to be Wallerian degeneration characterised by demyelination, with subsequent loss of axons following oligodendrocyte cell death.\textsuperscript{27} Chen et al. recently postulated
that Wallerian degeneration can spread beyond the cortico-spinal tract and potentially to the corpus callosum and the limbic tracts. While cortico-spinal tract decline is mostly ipsi-lesional, other structures showing decline are often bilateral. For example, in addition to the ipsi-lesional effects in the cortico-spinal tract, Koyama and colleagues reported bilateral effects in the superior longitudinal fasciculus linking the integrity of the tract to cognition. Note that the superior longitudinal fasciculus is one of the major white matter tracts associated with greater behavioural deficits across multiple cognitive domains in subcortical strokes. Therefore, degeneration of the superior longitudinal fasciculus observed here could be indicative of the mechanism explaining cognitive decline and increased risk of dementia after stroke. Wang and colleagues found that transcallosal connection dysfunction in conjunction with ipsi-lesional cortico-spinal tract deficiency impacted on the motor functional impairment. Corpus callosum and superior longitudinal fasciculus disconnections were also observed in participants with lacunar infarcts.

Another significant advantage in using the fixel-based approach is that it allows us to differentiate between the loss of fibre density (i.e., reduction of the total intra-axonal volume of the fibre bundle) and cross-section (i.e., reduction in the overall cross-sectional area of the fibre bundle). The two metrics in our study revealed some dissociable results, which could indicate that various tracts are affected differently, or possibly showing different stages of neurodegeneration. It has been suggested that, in the case of fibre density, the number of axons or their individual volume within the tract may be reduced, but the macroscopic fibre cross-section could remain unchanged following axonal loss if the additional extra-axonal space is filled with extracellular matrix and cells related to inflammation or gliosis. After debris are cleared, the fibre bundle may then become atrophic, resulting in subsequent reductions of fibre-cross section. This would imply that fibre density reductions could precede fibre cross-section changes. Observed reductions in fibre cross-section in the ipsi-lesional cortico-spinal tract would then suggest more advanced neurodegeneration and atrophy, while the changes in fibre density could signal fibre abnormality before atrophy is evident.

The corpus callosum has also been shown to undergo Wallerian degeneration. Gupta and co-authors demonstrated significant region-specific area reductions in the corpus callosum consistent with atrophy. These changes were observed only after six months post-stroke, while significantly lower fractional anisotropy values were seen as early as six weeks after the onset of stroke. Thus, changes in fractional anisotropy were observed much earlier than atrophy. Since the fibre density measure used here shares some (albeit
limited) degree of common sensitivity to fractional anisotropy, it is possible that the effects in the corpus callosum and the inferior fronto-occipital fasciculi we report signal the early stages of degeneration, while the fibre cross-section reductions in the ipsi-lesional cortico-spinal tract and bilateral superior longitudinal fasciculus suggest more advanced atrophy.

Several previous studies linked cortical atrophy and white matter degeneration. For example, Cheng et al., demonstrated cortical atrophy and trans-callosal diaschisis after subcortical stroke. The extensive white matter degeneration demonstrated in the current study could underlie the observed total and regional brain volume loss after stroke that we have previously reported in this cohort.

While this study aims to describe the state of global white matter after stroke, there are some practical implications of our findings. First, white matter damage in contra-lesional hemisphere needs to be taken into account when assessing treatment outcomes. It also appears that independent of laterality of the stroke lesion, there is neurodegeneration of the right superior longitudinal fasciculus, associated with cognitive functions that are known to show decline after stroke. This study at the whole brain level therefore identifies specific regions for further investigating the effects of white matter degeneration on cognition. Finally, the finding of extensive white matter damage in stroke should be taken into account for future clinical trials and animal models, given the difference in grey-to-white matter ratio in humans and some animals used in stroke models.

**Limitations**

This study presents a snapshot of differences between stroke and control participants at one time-point (3 months post-stroke). It does not capture the transition from white matter neurodegeneration to cortical atrophy. These results call for a future longitudinal study tracking the fibre density and cross-section metrics over time to identify the pattern of the spread of white matter neurodegeneration.

We are also unable to identify the specificity of the white matter decline to stroke. It may be that these white matter degenerative changes are present in other diseases that are also associated with functional and cognitive decline. For example, corpus callosum atrophy specifically in the rostrum and the splenium, sparing the body, just like in our study, has also been observed in Alzheimer’s disease. Li et al. found that in people with hypertension disrupted fronto-parietal network connectivity mediates the effect of white matter structural decline in the superior longitudinal fasciculus on cognitive performance. In our stroke sample, there was a significantly higher prevalence of hypertension, Type 2 diabetes mellitus,
atrial fibrillation and hyperlipidemia compared to controls. This was also reflected in increased white matter hyperintensity load, suggesting that small vessel disease burden could have influenced our results. Although the results were the same when we repeated the analysis including white matter hyperintensity load, hypertension status and diabetes status as covariates (Figure II), and even though white matter hyperintensities (categorised as pathological tissue with a mixture of WM, GM and CSF properties using the SS3T-CSD approach) were not included in the white matter analysis here, it is still possible that small vessel disease burden as a result of increased vascular risk, could have had an effect on white matter integrity in our stroke sample. In our previous work, we hypothesised that vascular burden that accumulates even prior to stroke likely contributes to the neurodegeneration observed early after stroke. Given that stroke is associated with older age and increased vascular burden, it will be important to disentangle distinct and cumulative contributions of age, vascular burden and stroke to global white matter decline.

Finally, our study was conducted with participants with mild, predominantly middle cerebral artery (MCA) strokes. Given the wealth of literature suggesting that diaschisis is associated with lesion topography, especially in the MCA territory, it is important that future studies further investigate whether the reported results are applicable primarily to the MCA-specific stroke or are independent of stroke circulation. Similarly, we lacked the power to compare the effects of cortical versus subcortical lesions on white matter structure.

**Conclusions**

In this study, we report significantly lower white matter fibre density and cross-section in participants 3 months post stroke, compared to controls. The differences are widespread, affecting ipsi-lesional tracts as well as bilateral association fibres and inter-hemispheric connections, suggesting that stroke is associated with pervasive white matter neurodegeneration, possibly underpinning brain volume loss associated with stroke.
Acknowledgements
To perform the analysis reported in the manuscript, we used Spartan, the High Performance Computing (HPC) system operated by Research Platform Services at The University of Melbourne.

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Competing interests
None.

Declaration of authorship
All authors made a substantial contribution to the work reported in the manuscript.
NE - Design, imaging and statistical analysis, interpretation of results, manuscript preparation;
TD - Imaging pre-processing and analysis, critical revision of manuscript; MK – Preparation of imaging data, critical revision of manuscript; WK – white matter hyperintensity analysis, critical revision of manuscript; EW - Collection and preparation of data, critical revision of manuscript; AB - Design, interpretation of results, critical revision of manuscript.
References (30)


12. Muñoz Maniega S, Chappell FM, Valdés Hernández MC, Armitage PA, Makin SD,


### Tables and Figure legends

Table 1. Groups description.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stroke</th>
<th>Control</th>
<th>p-value</th>
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<tr>
<td>N</td>
<td>104</td>
<td>40</td>
<td>N/A</td>
</tr>
<tr>
<td>Age, Mean Years (SD)</td>
<td>69 (6)</td>
<td>68 (12)</td>
<td>p&gt;0.52</td>
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<tr>
<td>Sex (N Women)</td>
<td>32</td>
<td>15</td>
<td>p&gt;0.44</td>
</tr>
<tr>
<td>Total Intracranial Volume (TIV), Mean litres (SD)</td>
<td>1.51 (0.16)</td>
<td>1.53 (0.12)</td>
<td>p&gt;0.54</td>
</tr>
<tr>
<td>White Matter Hyperintensity (Median, range, % TIV)</td>
<td>0.37 (0.01-9.36)</td>
<td>0.27 (0.001-1.56)</td>
<td>p=0.032*</td>
</tr>
<tr>
<td>Education, Mean Years (SD)</td>
<td>12.6 (3.9)</td>
<td>15.4 (4.5)</td>
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<td>Handedness (N right)</td>
<td>95</td>
<td>36</td>
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<td>BMI, Mean (SD)</td>
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<td>26.55 (3.81)</td>
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<td>Family history of stroke</td>
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<td>15</td>
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<td>Baseline cholesterol</td>
<td>48</td>
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<td>Baseline Atrial Fibrillation</td>
<td>21</td>
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<td>Baseline T2DM</td>
<td>29</td>
<td>4</td>
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<td>Baseline hypertension</td>
<td>67</td>
<td>17</td>
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<td>PHQ-9, Mean (SD)</td>
<td>4.19 (4.31)</td>
<td>1.56 (1.89)</td>
<td>p&lt;0.01</td>
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<td>N with recurrent stroke, (%)</td>
<td>15 (14.4%)</td>
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<td>Oxfordshire classification (N)</td>
<td>LACI -16</td>
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<tr>
<td>PACI – 52</td>
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<td>Stroke type (N)</td>
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<td>Brain stem – 13</td>
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<td>Cerebellar – 10</td>
<td>PCA – 16</td>
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<td>MCA – 55</td>
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<td>Mixed – 8</td>
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<td>3 (0-13)</td>
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<td>NIHSS at 3 months, Median (range)</td>
<td>0 (0-7)</td>
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<td>Lesion volume, Mean litres (SD)</td>
<td>0.006 (0.011)</td>
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<td>N/A</td>
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</table>
TIV – Total intracranial volume; NIHSS – National Institutes of Health Stroke Scale, BMI - Body-mass-index T2DM - Type 2 diabetes mellitus, PHQ-9 Patient Health Quotient, LACI - lacunar infarcts, PACI - partial anterior circulation infarcts, POCI - posterior circulation infarcts; MCA – middle cerebral artery; PCA – posterior cerebral artery, ACA – anterior cerebral artery; T-tests for Age, Total Intracranial Volume, White Matter Hyperintensity; Education, PHQ-9; Chi-square for sex, handedness, BMI, family history of stroke, baseline cholesterol, baseline hypertension; Fisher exact test for baseline atrial fibrillation, baseline T2DM; Wilcoxon signed rank test for White Matter Hyperintensity; *Note that statistical analysis was performed on log(WMH/TIV) values.
Figure 1. Whole brain results for the Stroke < Control contrast. Images are shown in radiological orientation (left is on the right). Fibre tract-specific significant differences between Stroke participants and healthy control subjects for the fibre density (FD), fibre cross-section (FC) and combined fibre density and cross-section (FDC). Streamline segments are cropped from the template tractogram to include only those corresponding to fixel significant at FWE-corrected p-value <0.05. A. Significant streamline points are coloured by p-value. B. Significant streamline points are coloured by fibre direction (A-P, anterior-posterior: green; S-I, superior-inferior: blue; L-R, left-right: red).
Figure 2. Stroke laterality analysis results. A. Lesion overlay showing the number of participants with overlapping lesions in the left hemisphere (N=40) and right hemisphere (N=61). The scale 0 to 5 (purple to red) shows the number of participants with overlapping lesions in the brain region. Note that participants were grouped as having ‘left’ or ‘right’ sided stroke based on the most recent stroke that qualified them for the study, however, the lesion map also shows previous stroke lesions in participants with recurrent stroke that can be in the contralateral hemisphere; we show all lesion locations for completeness. B. Whole brain results for the comparison ‘Right hemisphere stroke vs. control’; and ‘Left hemisphere stroke vs. controls’. The results are shown on axial slices at FWE-corrected p-value <0.05, coloured by fibre direction (A-P, anterior-posterior: green; S-I, superior-inferior: blue; L-R, left-right: red) for the fibre cross-section (FC), fibre density (FD), and combined fibre density and cross-section (FDC) separately.
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