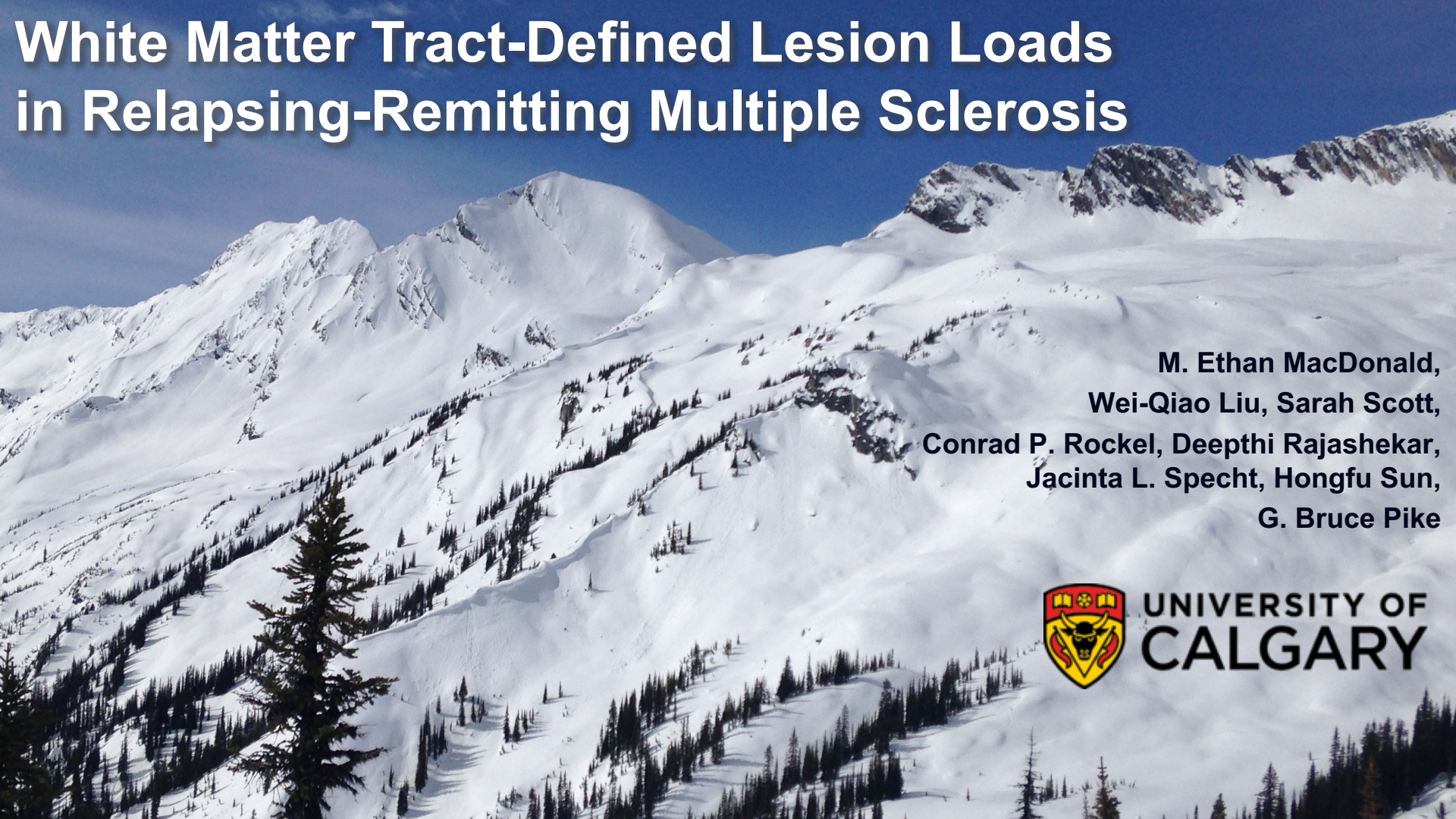
White Matter Tract-Defined Lesion Loads in Relapsing-Remitting Multiple Sclerosis



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Declaration of Financial Interests or Relationships

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I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

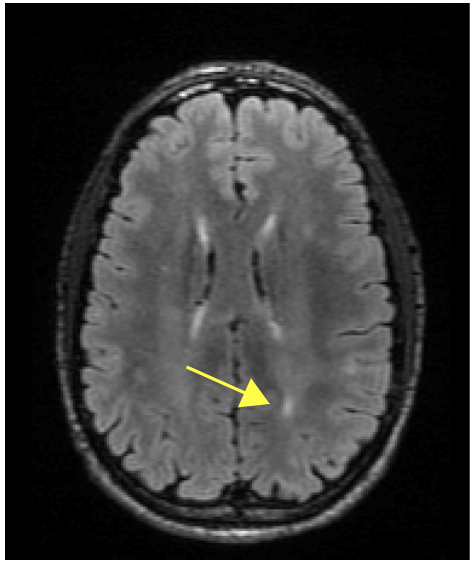
Background

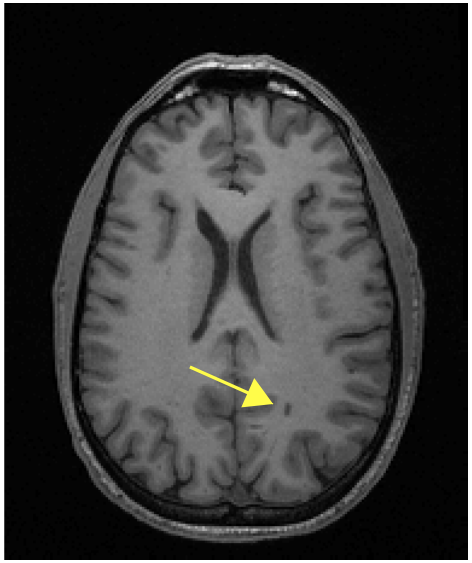
- Multiple Sclerosis MS is an immune-mediated degenerative disease affecting the central nervous system
- MS brain lesions are visible with MRI using T2-weighted fluid attenuated inversion recovery (FLAIR) and T1-weighted (T1w) image contrasts[1,2]
- Lesions are hyper-intense on FLAIR and hypo-intense on T1w images

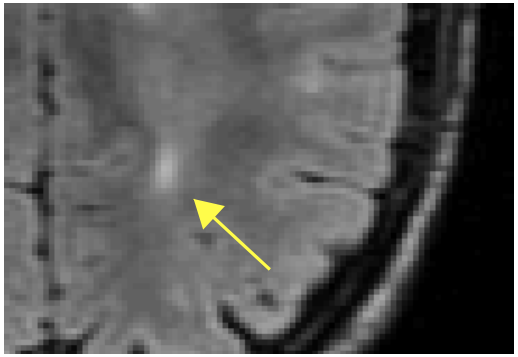
1. *Filippi, et al., Radiology, 2011*
2. *Louapre, et al., Rev Neurol, 2018*

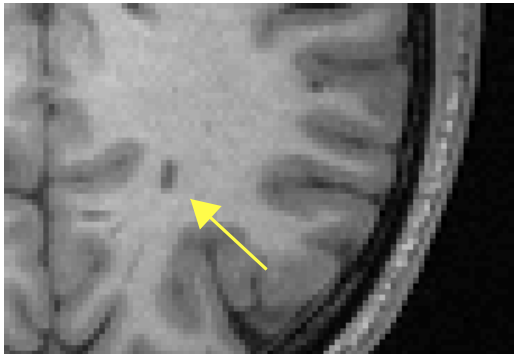
FLAIR

T1w









Motivation

- Lesion probability maps have been computed in the past to characterize how the lesions are distributed[3,4]
- We extend those findings by computing the lesion burden on a tract-by-tract basis
- We aim to determine the burden by computing number of lesions, total lesion volume and and lesions volume percent on a tract-by-tract basis

3. Altermatt, et al., Brain Topography, 2018
4. Kincses, et al., Multiple Sclerosis Journal, 2011

Image Data

207 relapsing remitting MS (RRMS) patients undergoing approved therapy:

(155-F, mean age 44, ranging 23-60; EDSS 2.218±41.4603, ranging 0.0-6.5)

Scanned with a 3 T MR Scanner (GE Discovery 750)

FLAIR parameters:

acquisition matrix 224x224x100, FOV of 240x240x180 mm3
TI/TR/TE/α of 2062 ms/7000 ms/129.4 ms/90°
echo train length of 160, acceleration factor of 2x2

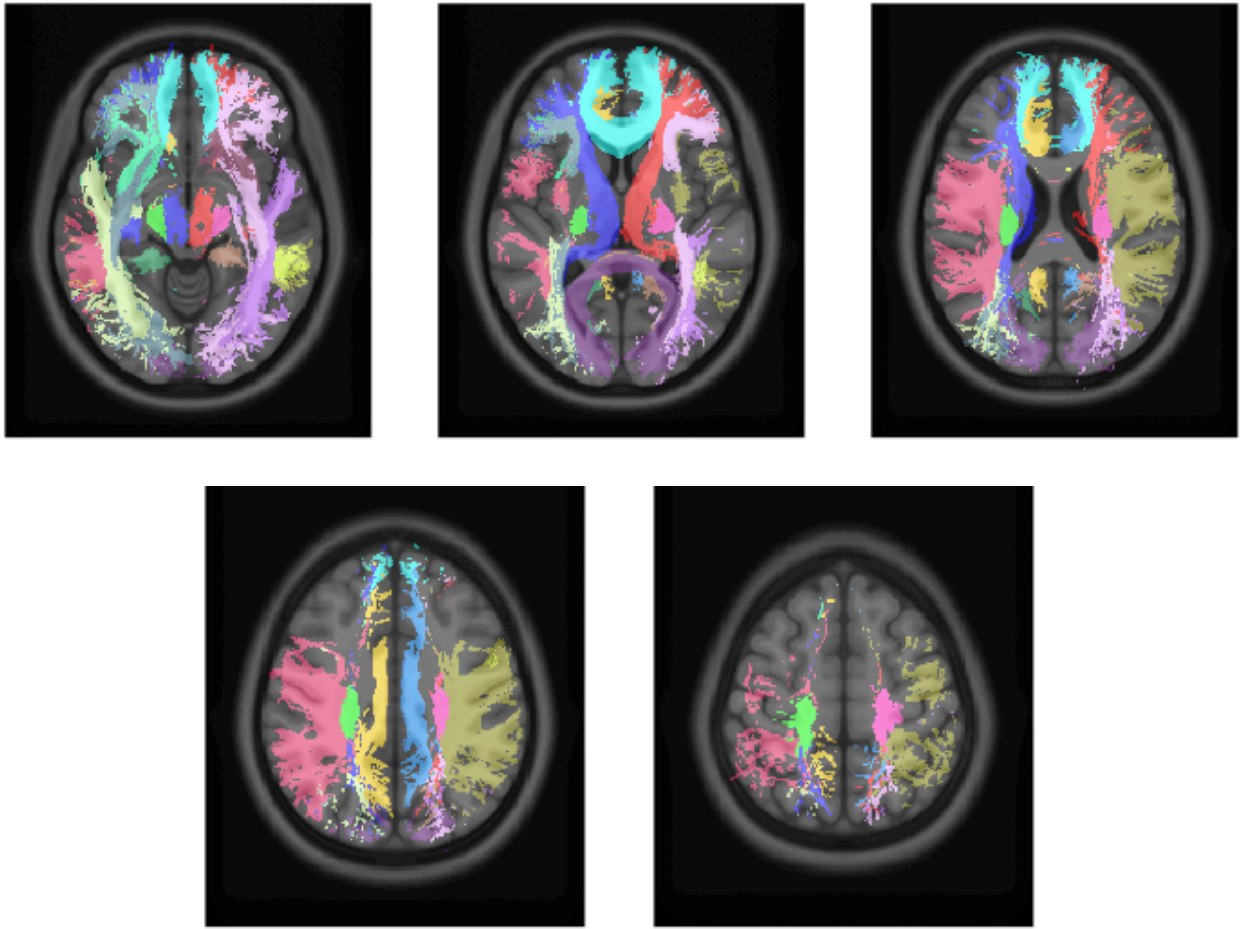
T1 parameters:

acquisition matrix 256x256x192, isotropic resolution 1 mm3
TI/TR/TE/α 650 ms/6.66 ms/2.93 ms/10° acceleration factor of 2

Image Processing

- White matter lesions were segmented with FreeSurfer on T1 and with the lesion prediction algorithm in the LST toolbox of SPM
- FLAIR images were registered to the T1 with a rigid transformation, and then registered to a standard space with ANTs Nonlinear Syn Transform
- The John Hopkins University DTI (JHUDIT) atlas was transformed back to the native space
- QA was performed by visually inspect all lesion masks and registrations

John Hopkins University Diffusion Tensor Imaging (JHUDTI) Atlas[5]



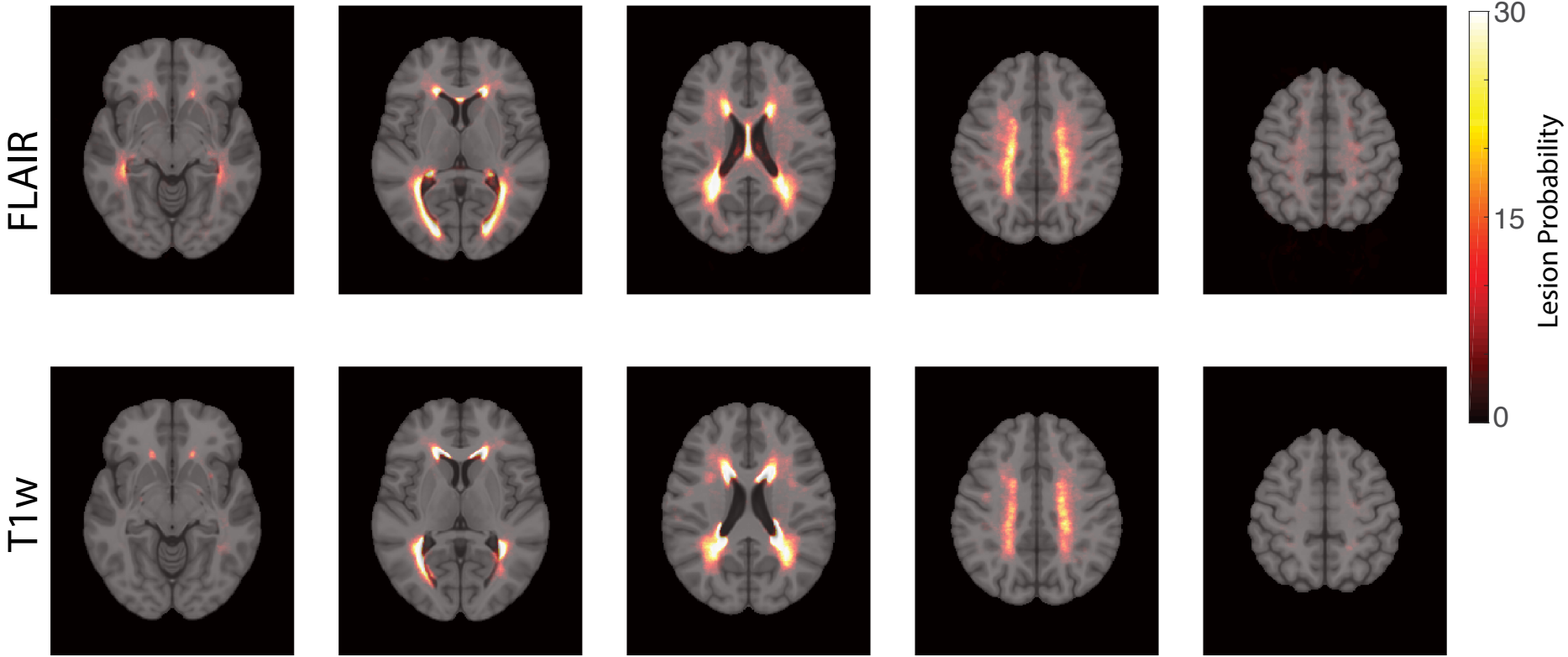
5. Hua, K., et al., NeuroImage, 2008.

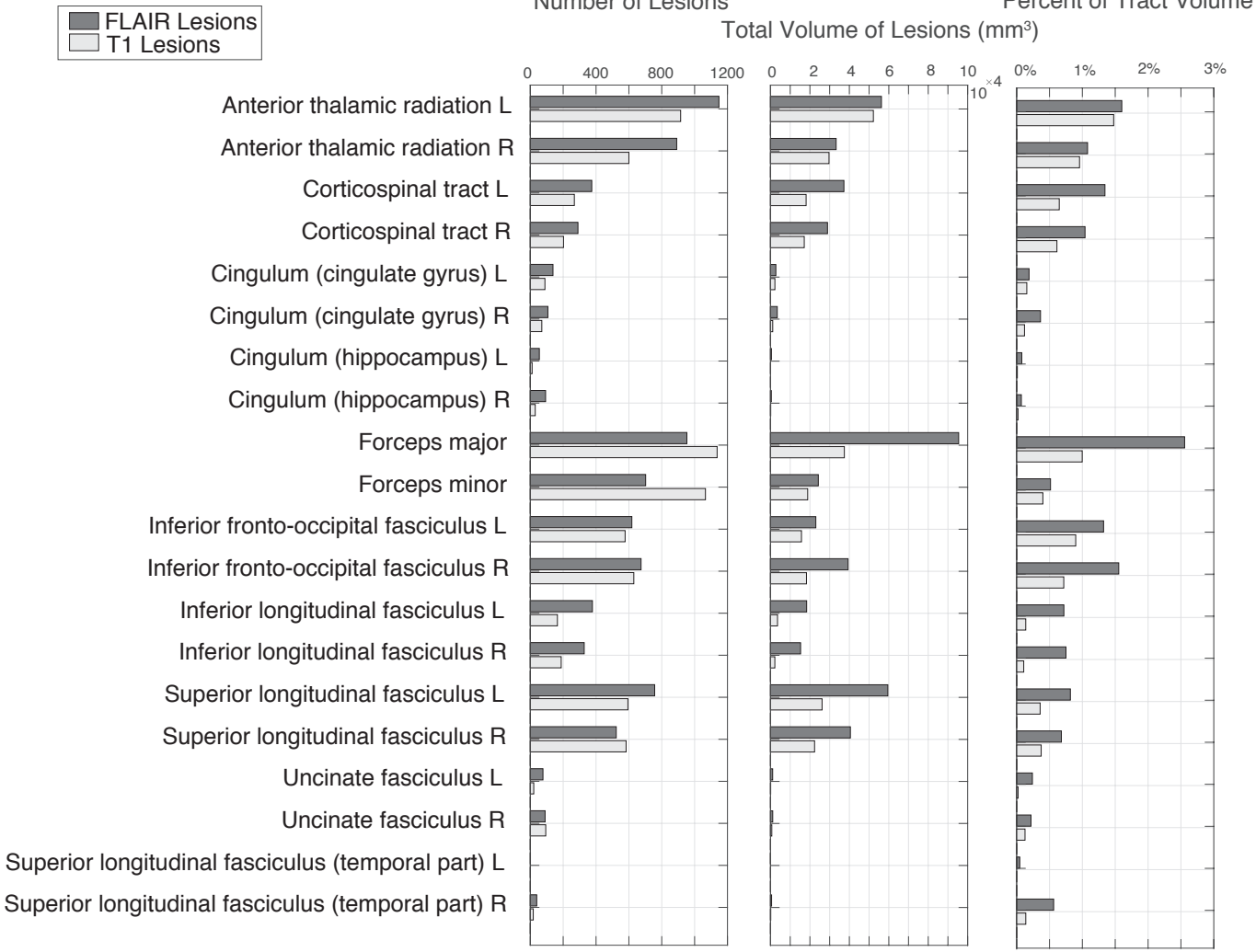
Analysis

- Lesion probability maps for both T1w and FLAIR lesions were calculated to determine the regional distribution of lesions

- Individual lesion counts, total lesion volume, and percent of tract volume, were calculated for each WM tract of the JHUDTI atlas

Lesion Probability Maps




FLAIR Lesions
T1 Lesions
Number of Lesions
Total Volume of Lesions (mm3)
Percent of Tract Volume
0
400
800
1200
0
2
4
6
8
10
×4
0%
1%
2%
3%
Anterior thalamic radiation L
Anterior thalamic radiation R
Corticospinal tract L
Corticospinal tract R
Cingulum (cingulate gyrus) L
Cingulum (cingulate gyrus) R
Cingulum (hippocampus) L
Cingulum (hippocampus) R
Forceps major
Forceps minor
Inferior fronto-occipital fasciculus L
Inferior fronto-occipital fasciculus R
Inferior longitudinal fasciculus L
Inferior longitudinal fasciculus R
Superior longitudinal fasciculus L
Superior longitudinal fasciculus R
Uncinate fasciculus L
Uncinate fasciculus R
Superior longitudinal fasciculus (temporal part) L
Superior longitudinal fasciculus (temporal part) R

Discussion

- FLAIR and T1w lesions have similar spatial distributions

- Higher lesion counts sometimes existed on the T1w images (i.e., forceps), whereas on FLAIR lesions were merged together

- The T1w lesions were smaller than those found on FLAIR, however, the acquisition resolutions were different and thus it is inappropriate to compare.

Conclusions

- This work confirms the predominance of MS lesion in the periventricular region but also provides a distribution within specific WM tracts[6]

- There are relatively higher lesion loads in the anterior thalamic radiation, corticospinal, the forceps major, forceps minor, Inferior fronto-occipital fasciculus, and the superior longitudinal fasciculus, while the uncinate fasciculus, superior longitudinal fasciculus, and the cingulum tracts have the lowest lesion burden.

6. Roosendaal, S.D., et al., NeuroImage, 2009

Future Work

- Future work will include determining whether subjects with lesions in specific tracts have impairments associated with the functions of those tracts [6]

- It will also include assessing other MRI-based lesion measurements available in these patients, including: MTR, QSM, DTI

- We will determine if there are differences in these parameters will help in lesion classification

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