Investigating structural connectivity in episodic migraine using graph theory

Ana Matoso*[1], Ana R Fouto[1], A. Ruiz-Tagle[1], I. Esteves[1], Gina Caetano[1], Patrícia Figueiredo[1], Rita G Nunes[1]

1. ISR-Lisboa and Department of Bioengineering, Instituto Superior Técnico – Universidade de Lisboa, Lisbon, Portugal

*anamatoso@tecnico.ulisboa.pt

INTRODUCTION

Migraine is one of the most prevalent diseases worldwide, affecting about 1 in every 6 people. Recently, many studies suggest that the causative mechanisms of migraine have a neural basis and thus the question has emerged: **whether and how the physical connections in the brain change in migraine patients, from a network perspective?**[1]

The human brain has developed plasticity to adjust to pain stimuli, as is the case of migraine, which can affect its wiring architecture. Therefore, the purpose of this project is **to investigate the structural connectivity changes in episodic migraine *without aura* using a graph theory framework** in order to uncover possible biomarkers for this disorder.

GOAL: *To identify biomarkers of episodic migraine using graph theory metrics applied to diffusion MRI*

METHODS

DWI Data:

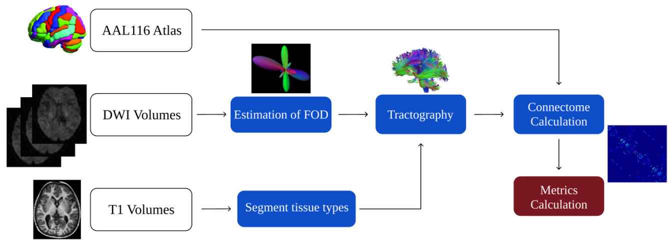
- 12 healthy controls: HC
- 14 migraine patients (female migraineurs without aura): M
- 3T Siemens Vida Scanner, with 64-channel receiver head coil
- b=400,1000,2000s/mm2 along 32,32,60 gradient directions, respectively
- 8 non-diffusion-weighted volumes

Graph theory metrics (MATLAB)[4]:

- Evaluating structural connectivity
- Basic metrics: Mean node strength (mean D), characteristic path length (L)
- Integration metric: global efficiency (GE)
- Segregation metrics: clustering coefficient (C), transitivity (T), modularity (Q)
- Centrality metrics: betweenness centrality (BC), eigenvector centrality (EC)

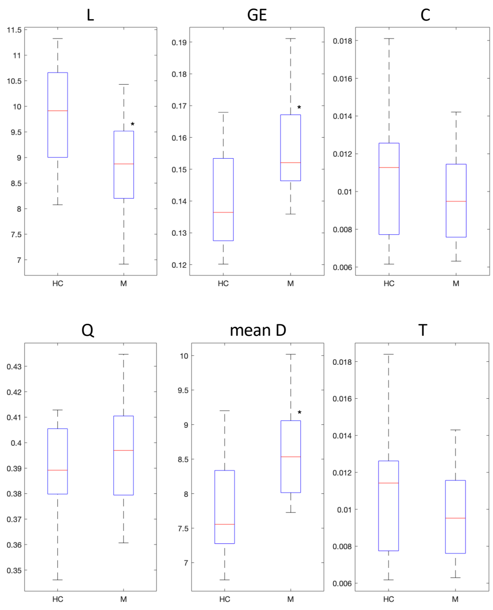
Data Analysis (FSL and MRTrix):

- Pre-processing (DESIGNER pipeline[2])
- Estimation of fibre density functions (FOD)
- Tissue segmentation into different tissue types
- Tractography (using spherical deconvolution)
- Determination of the connectome (according to AAL116 atlas[3])



RESULTS AND DISCUSSION

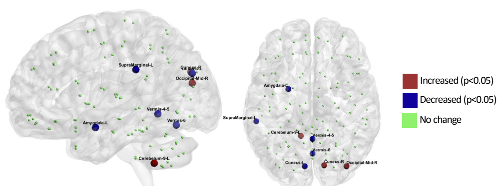
General metrics



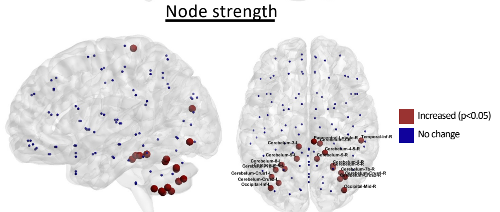
- **Mean D** and **GE** are significantly **increased** in migraine patients
- **L** is significantly **diminished** in migraine patients, meaning there are more short distance connections
- No significant changes in segregation measures: clustering coefficient, transitivity, modularity

Nodal metrics

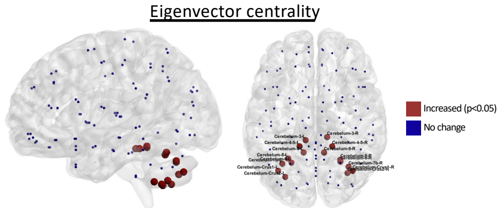
Betweenness centrality



Node strength



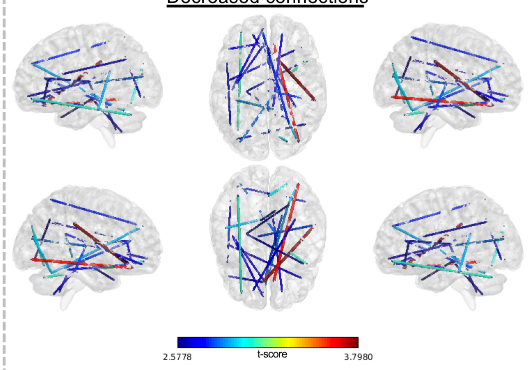
Eigenvector centrality



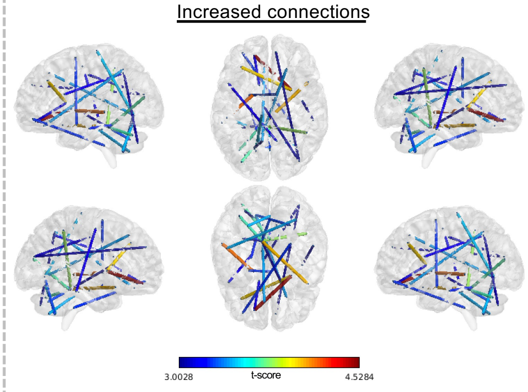
- The **betweenness centrality** shows some changes in various nodes, especially in the **Vermis 4-5** (decreased) and **left supramarginal** (increased) nodes
- **Node strength** tends to **increase** overall, especially in the **cerebellum, in the right inferior temporal node, in the right middle occipital node and in the right paracentral lobule**

Connectivity Analysis

Decreased connections



Increased connections



CONCLUSION

- The results suggest that in migraine, there are more short distance connections in white matter tracts increasing the efficiency of the network
- Additionally, the node strength increases overall, especially in the cerebellum region and in some cortical areas
- The cerebellum showed increased centrality and connectivity with cortical areas. Thus this region should be further studied

→ Though significant results have been found, there is still work to be done to uncover possible biomarkers and connectivity changes in migraine. Furthermore, a longitudinal study might also be of interest to investigate how the brain changes throughout the migraine cycle.

References: 1. J Hoffmann et al, Journal of Cerebral Blood Flow and Metabolism, 2019, 39(4): 573–594, 2. B Ades-Aron et al, Neuroimage, 2018, 183:532-543, 3. N. Tzourio-Mazoyer et al, NeuroImage,2002, 15(1): 273-289, 4. Rubinov M et al, NeuroImage, 2010, 52: 1059-69.

Acknowledgements: Portuguese Science Foundation, grants PTDC/EMD-EMD/29675/2017, LISBOA-01-0145-FEDER-029675 and UIDB/50009/2020.