Clinical application of electrode localisation after deep brain stimulation for Parkinson's disease and quantitative appraisal of patient outcomes

Hart MG[1], Buttery PC[2], Morris RC[1]

1: Department of Neurosurgery, Addenbrooke's hospital, Cambridge, UK 2: Department of Neurology, Addenbrooke's hospital, Cambridge, UK

Introduction

Accurate placement of deep brain stimulation electrodes with the intended target is believed to be a key variable related to post-operative outcomes.

However, methods with which to perform and verify electrode localisation based on neuroimaging data are not universally established.

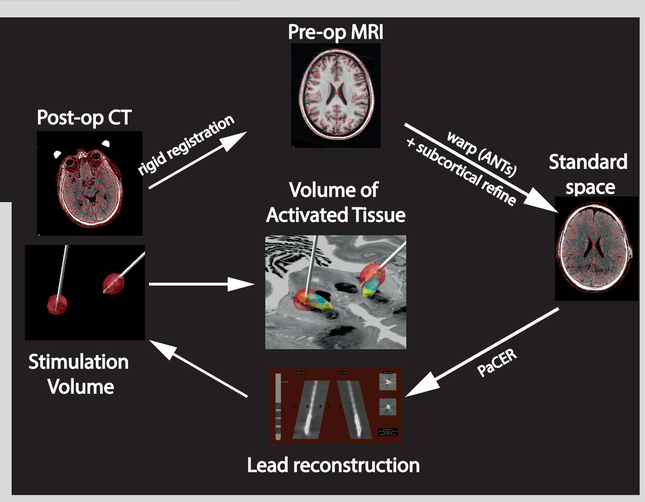
Aim: determine the applicability of applying post-op lead localisation to a standard clinical pathway using routinely acquired MRI data and open source

Methods

- Retrospective cohort study of a consecutive series of patients with Parkinson's disease that underwent DBS of GPi or STN between 2016-2017.
- Single stage procedure under general anaesthesia with electrodes by either St Jude/Abbott, Medtronic, or Boston Scientific.
- Planning used Medtronic® FrameLink software based on pre-operative 3 Tesla MRI data (MPRAGE and SWI sequences) with a stereotactic atlas.
- A Leksell frame was used in combination with pre-op and post-op CT imaging for trajectory planning and verification, respectively.
- Image processing was performed using the Lead-DBS toolbox (figure 1).

Institutional ethical approval was granted as a review of service study.

Figure 1 (right, top): overview of LEAD-DBS analysis pipeline
Rigid & non-linear registration with ANTs, lead localisation with Pacer (XX/YY) electrodes, DISTAL template, MNI standard space



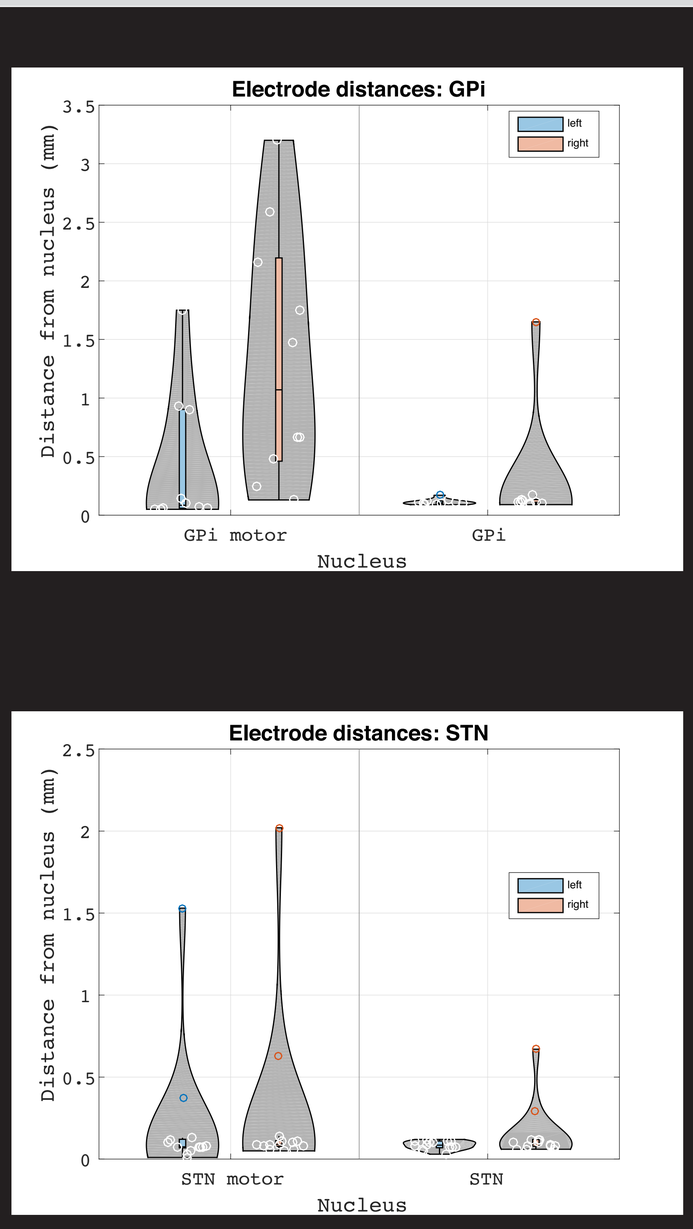


Figure 2 (above): distances of of nearest electrode contact to closest voxel of corresponding atlas nucleus (median and interquartile range). Contact defined as within nucleus if <0.5mm from closest voxel.

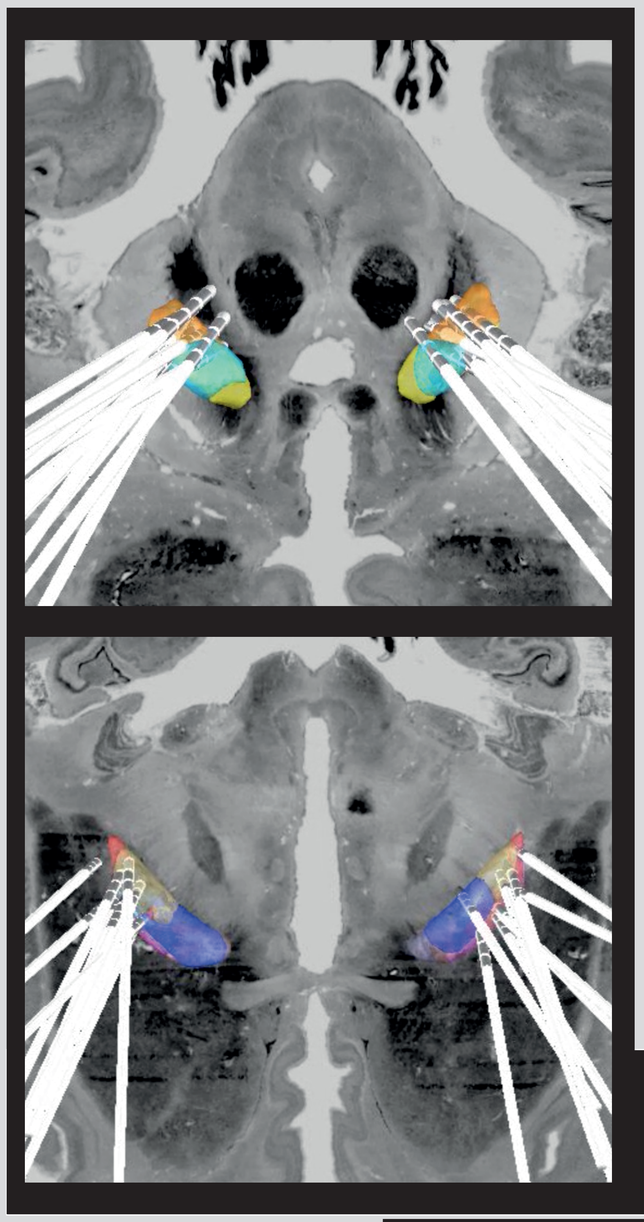
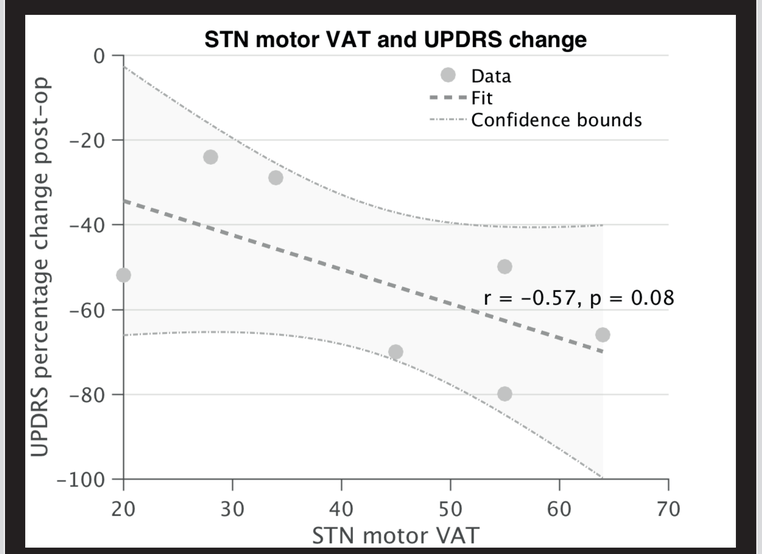


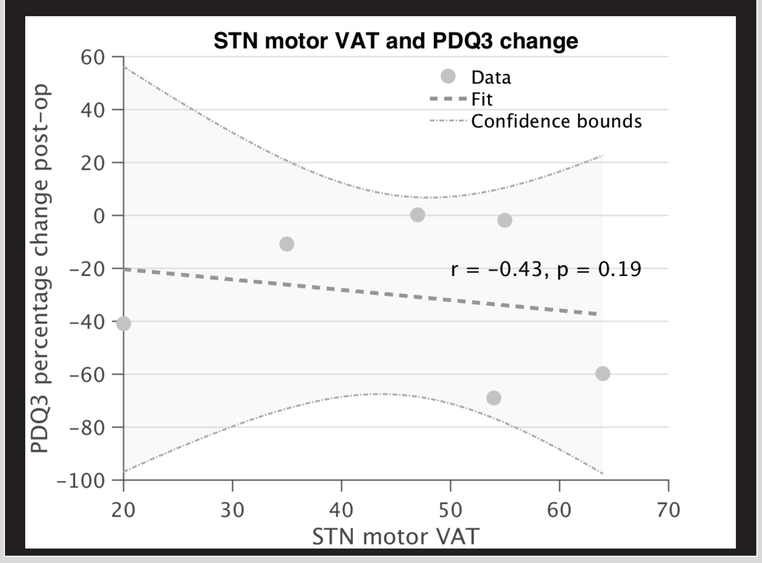
Figure 3 (left): group electrode localisation
Middle: subthalamic nucleus, **Lower:** globus pallidus internus
DISTAL template, BigBrain histological atlas

Results

- Overall 28 participants (17 STN, 11 GPi, 12 female).
- Mean age: 63 years, disease duration: 12 years, follow-up: 11 months.
- Exclusions: 4 registration errors (total analysed cohort 24 (14 STN, 10 GPi).
- **Clinical outcomes:** mean improvement UPDRS part III (motor scores) 50%, mean improvement in PDQ3 quality of life scores of 26%.
- **Electrode localisation:** electrode contact within atlas target nucleus in 46 of 48 total electrodes (19/20 GPi, 10/20 [7 left] GPi primary motor, 27/28 STN, 25/28 [13 left] STN motor), figures 2 & 3.

Figure 4 (below): volume of activated tissue in target nucleus and clinical outcome
Top: UPDRS3, **Lower:** PDQ3. Outcome at last follow-up. STN motor nucleus defined on DISTAL atlas, volume in cubic mm. r = Pearson correlation





Conclusions

- Our series demonstrates accurate lead placment and clinically meaningful improvements in validated outcomes, comparable with published studies using various alternative methodologies.
- Volume of target stimulation is correlated with clinical improvement, in support of accurate lead localisation methods.
- Image based post-op electrode localisation is feasible in routine clinical practice, using standard neuroimaging data.
- Future clinical applications of this pathway include prospective quality assurance of electrode location and quantitative audit of amendments to clinical care pathways.

UNIVERSITY OF CAMBRIDGE

www.mrmikehart.com
mgh40 [at] cam [dot] ac [dot] uk