Diffusion-weighted MRI as a biomarker in uncompensated vestibular patients - preliminary results.

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Target audience

ENT doctors, neurologists, neuroradiologists, researchers interested in vestibular research.

Purpose

After a sudden vestibular lesion, patients present with a syndrome of oculomotor and postural symptoms. However, during the first days, symptoms meliorate and patients cope with these effects, partially due to neuroplasticity. Most patients compensate rather quickly, while others with similar symptoms recover suboptimal or do not recover at all. This may be due to inadequate compensation mechanisms at specific brain regions responsible for the integration of vestibular signals. The aim of this pilot study was to gain a first insight in the process of neuroplasticity after a vestibular deficit. We therefore investigated group differences in diffusion parameters at certain regions of interest (ROIs) and tracts between vertigo patients and a healthy age and gender matched control group.

Methods

- *Data acquisition:* Multi-shell high angular resolution diffusion weighted (DW) data were acquired on a 3T scanner using a 32-channel head coil. We used a single-shot echo-planar imaging (EPI) sequence with the following parameters: voxel size 2.5 x 2.5 x 2.5 mm^3, acquisition matrix = 96 x 96, TR = 8100 ms, TE = 116 ms. Diffusion sensitizing gradients were applied at b-values of 700, 1000 and 2800 s/mm^2, along 25, 45 and 75 non-collinear directions, respectively. 10 images without diffusion weighting were acquired, of which 5 were acquired with reversed phase encoding, for the purpose of EPI distortion correction.
- *Data processing:* The DW images were corrected for EPI distortions using FSL's 'topup'-tool **[1]** and for motion and eddy-current distortions using FSL's 'eddy'-tool **[2]**. Diffusion tensors were estimated from the DW images using the weighted linear least squares estimator **[3]**. Fiber orientation distribution functions (fODFs) were obtained with constrained spherical deconvolution (CSD) **[4]** for the purpose of CSD fiber tractography **[5,6] (Fig1)**. From the fODFs, whole brain CSD tractograms were generated using the pipeline described in **[7]** and specific fiber bundles were extracted by means of ROI selection. From the whole brain tractograms color encoded track density imaging (TDI) were created to aid delineation of specific brain structures **[8]**. Investigated structures were: amygdala, superior temporal gyrus, hippocampus, parietal operculum 2 (OP2), cerebellar peduncles, corticospinal and corticobulbar tracts. For each brain structure, the average fractional anisotropy (FA) and mean diffusivity were calculated.

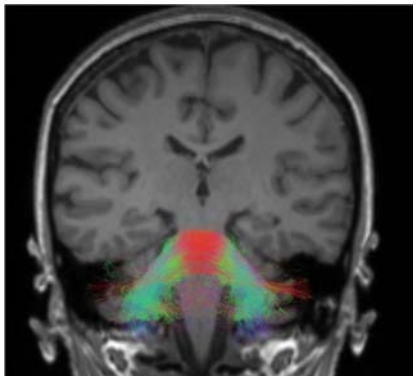

***Figure 1**: Visualization of tracts between the cerebellar peduncles of a healthy subject in the coronal plane, positioned on a 3D MPRAGE image.*

- *Subjects:* For this pilot study, five vestibular patients and five healthy control subject were included. The vestibular patients suffered all from similar symptoms of constant vertigo, existing for several months to years, and without proper evolution or recovery. Group differences for DTI parameters were measured by means of tractography and region of interest (ROI) analysis.

Results

For the vertigo patients, we found significantly reduced FA in the right OP2 region (Mann Whitney U test, $p = 0.009$) **(Fig. 2)** and the cerebellar peduncles (Mann-Whitney U test, $p = 0.03$) when compared to controls. For MD and the other regions, no significant differences could be found.

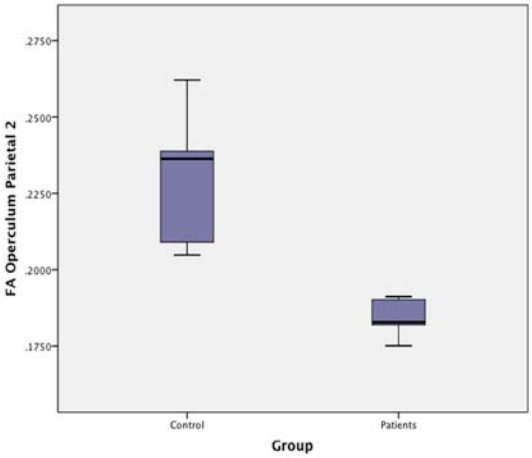

***Figure 2:** Boxplot showing statistically significant group differences (p = 0.009) in FA (dimensionless) for the right operculum parietal 2 region.*

Discussion

To our knowledge, this is the first study to use diffusion imaging methods in vestibular patients and to show a relation between diffusion parameters, representing brain connectivity and clinical symptoms of vertigo. Furthermore, it is not surprising to find a difference in the right OP2 region, since this region has recently been suggested as being the core of the human vestibular cortex **[9]**.

Conclusion

Reduced FA in the right OP2 region and of the cerebellar peduncles may explain the symptoms of continuous vertigo and inadequate compensation due to vestibular lesions. Thus, this pilot study suggests that diffusion parameters may serve as biomarkers for vestibular induced neuroplasticity and unravel the relationship between brain connectivity and vestibular complaints.

References

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