Correlations between diffusion-weighted and clinical parameters in uncompensated vestibular patients - a pilot study.

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Target audience: ENT doctors, neurologists, neuroradiologists, researchers interested in vestibular research.

Purpose: Most vestibular patients compensate rather well after an acute vestibular lesion. However, in clinical practice, we observe that some patients, for unknown reasons, do not compensate or compensate only partially resulting in longstanding complaints of dizziness, nausea, instability, etc. Vestibular testing, such as the standard electronystagmography (ENG), often confirms these symptoms by showing abnormal results but this is not always the case. For this reason, we hypothesize that longstanding vertigo and vestibular symptoms may be attributed to inadequate compensation mechanisms at specific brain regions responsible for the integration of vestibular signals. In this pilot study, we investigated possible correlations between diffusion parameters and clinical parameters from the ENG for a select group of patients, characterized by inadequate vestibular compensation.

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), mean diffusivity, axial diffusivity and radial diffusivity were calculated. *Vestibular testing:* The electronystagmography (ENG) protocol was recorded and analyzed by an 8-channel PC-based system. The protocol consisted of oculomotor evaluation, rotary chair and caloric testing, providing the following parameters: vestibulo-ocular reflex (VOR) gain and phase (rotation test), directional preponderance (DP), unilateral weakness (UW) and total caloric responsiveness (TCR) during classical warm and cold water caloric irrigation. *Subjects:* For this pilot study, five vestibular patients and five healthy control subject were included. All of them underwent both vestibular testing as well as an MRI scan, except for one subject who didn't undergo the vestibular testing. The vestibular patients suffered all from similar symptoms of constant vertigo, existing for several months to years, and without proper evolution or recovery.

Results: Significant negative correlations (Spearman Rank rs) were found between VOR phase and MD values of the right insular cortex (rs = -0.70, p = 0.04), right cingulate gyrus (rs = -0.73, p = 0.0026) **(Fig1)** and left cingulate gyrus (rs = -0.70, p = 0.04). A significant positive correlation was found between MD of the right insular cortex and TCR (rs = 0.73, p = 0.04). A significant positive correlation could be found between FA in the right cingulate gyrus (rs = 0.74, p = 0.04) and cerebellar peduncles (rs = 0.74, p = 0.04) **(Fig2)** with TCR. A significant positive association could also be found between gain and mean diffusivity of the right insular cortex (rs = 0.81, p = 0.008), left insular cortex (rs = 0.75, p = 0.02), the right superior temporal gyrus (rs = 0.80, p = 0.009) and left corticobulbar tract (rs = 0.78, p = 0.01).

Conclusion: This pilot study shows that quantities derived from diffusion-weighted imaging appear to be correlated with several clinical parameters from vestibular testing. This suggests that the cause of the symptoms of unresolved continuous vertigo is probably more situated at the central level than at the peripheral level. Thus, diffusion parameters may serve as biomarkers of specific types of vertigo. Obviously, larger series are necessary to further corroborate these findings.

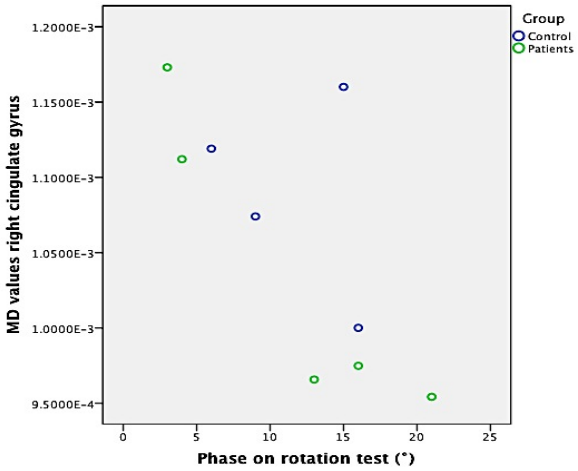

Figure 1: Scatterplot of the significant negative correlation between MD values of the right cingulate gyrus and the parameter phase of the rotation test (in °).

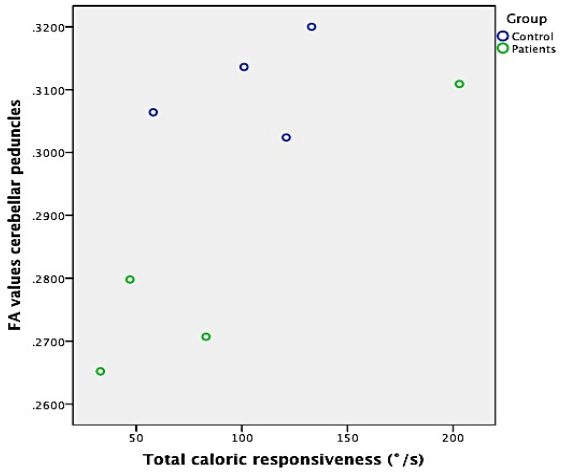

Figure 2: Scatterplot of the significant positive correlation between FA values of the tracts running between both cerebellar peduncles and total caloric responsiveness (in ° /s).

References

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