Detection of Brain Structural Alterations Due to Chronic Nicotine Abuse Using in vivo Diffusion Tensor Magnetic Resonance Imaging

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Long-term cigarette smoking can cause brain atrophy and cognitive impairment. Similar results were observed with chronic use of e-cigarettes. Therefore, it is essential to understand the brain's microstructural changes due to chronic nicotine use. Diffusion tensor magnetic resonance imaging (DT-MRI) can determine the brain’s structural integrity by measuring the diffusion properties of water in brain tissue. In this project, I hypothesized that in vivo DT-MRI could detect brain structural alterations caused by the chronic use of nicotine. DT-MRI data were acquired on nine C57BL/6 mice at the baseline and 12-day time points. Immediately after the baseline MRI acquisition, mice were injected intraperitoneally with nicotine solution once daily. Mean diffusivity (MD) and fractional anisotropy (FA) maps were computed from DT-MRI. ROI analysis was performed on MD and FA maps in the brain regions, including white matter: genu and splenium of corpus callosum (gcc, scc), fimbria (fi), and internal capsule (ic); and gray matter: cerebral cortex (ctx), hippocampus (hc), and caudoputamen (cp). Differences between baseline and 12-day time points were analyzed using a paired t-test. MD values did not reveal substantial differences between the two time points. However, FA measures in fi, ic, ctx, hc, and cp regions showed significant changes ($p<0.05$), indicating brain microstructural changes caused by nicotine use. This study demonstrated that DT-MRI is sensitive to detecting microstructural alteration in mouse brains resulting from chronic nicotine exposure. Specifically, the FA measure is more sensitive to detecting such changes and can serve as an image-based biomarker. In the future, these findings will be confirmed with histological studies.

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