Using SWI as a means to better visualize the caudate nucleus in Huntington's disease

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Introduction: Huntington's disease is a dominantly inherited degenerative disease of the central nervous system characterized by involuntary movements and accompanied by cognitive impairment. The pathological feature of HD is atrophy of the CN, chorea and neuronal loss. Severely affected regions of the brain are striatal neurons; spiny projection neurons and it also affects other regions of the brain including cerebral cortex and thalamic nuclei. Longitudinal changes in caudate volume have been documented in MRI studies in patients with symptoms and presymptomatic individuals who carry the gene mutation of HD (1, 2).

Methods: The SWI images from 8 subjects possibly affected by Huntington's disease were obtained using a 1.5T MRI scanner system. Informed consent was obtained in all cases. We used a program called 'SPIN' (signal processing in NMR) to find the edges of the caudate nucleus. The program allows the user to manually draw CN boundary and then it calculates the phase, the standard deviation of the phase and the area measured. The voxel dimensions in the images are 0.5mm x 0.5mm with a slice thickness of 2mm. The processed phase images from the SWI acquisition provided excellent contrast between gray matter (GM) and white matter (WM), iron-laden tissues, venous blood vessels, and other tissues with susceptibilities that are different from the background tissue. Starting from the top of the brain, we searched the transverse plane where the first hint of the head of the caudate was visible. This is called the marker slice. The caudate spans 11-14 slices from the marker slice to the end slice, with each slice being 2 mm thick. This set of slices included the head of the caudate down to the tail. The end slice was defined as the slice where the head of the caudate and the putamen blend together. The total number of pixels in all the slices where the caudate could be differentiated was summed. This is done for both the right and left side of the CN. The volume of the caudate is calculated as the number of pixels times the voxel volume.

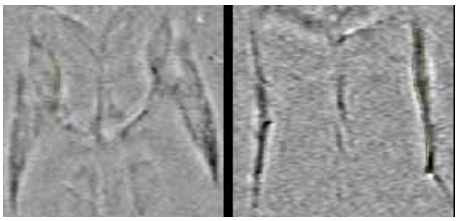


Fig: a Fig: b

Images showing (a) Head of the Caudate (b) Tail of the caudate in subjects with Huntington's disease

Results: The calculated volumes from the phase images ranged from 1.25cc - 3.5cc. We noticed that the phase increased toward the tail. The lowest phase occurred in the head of the CN and the highest phase occurred in the tail. This is also where the volume of the caudate seemed to be most significantly reduced compared to normal volunteers. Plotting the volume for both left and right sides of the CN versus the highest phase seen in all slices for the six cases with volumes less than 2.5cc suggests that as volume of the CN decreased, the iron content increased (see Figure 1). We plotted the slice no versus phase and observed an increasing phase as we go down the caudate from the head to the tail (see Figure 2).

Figure 1: Plot of Phase vs Volume

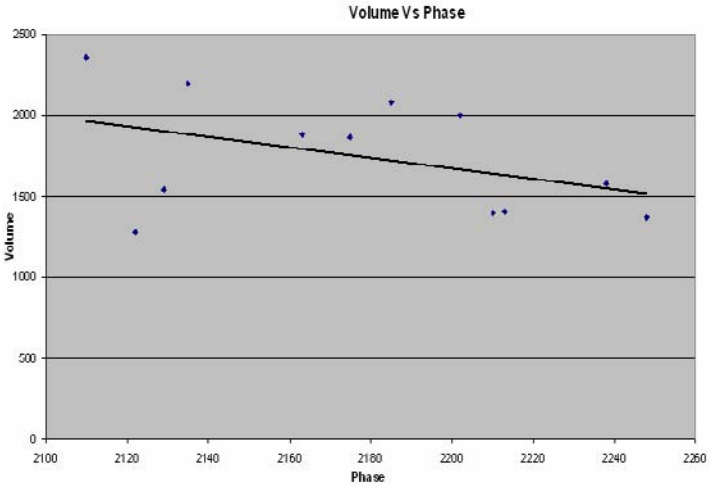
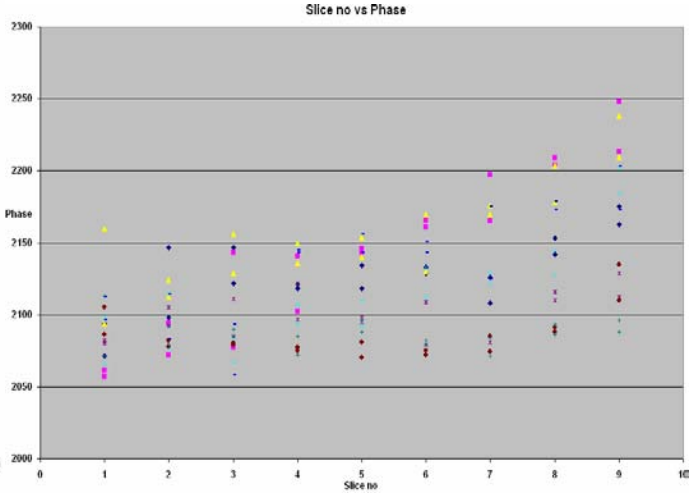


Figure 2: Plot of Slice no vs Phase



Discussion: From an earlier study in normal subjects, we concluded that the caudate nucleus volume had a mean value of 4cc with a SD of 1cc (3). These numbers become a mean of 3cc with a SD of 1cc for this set of 8 HD patients. The increase in iron content in the tail of the caudate also corresponded to the area where the highest volume changes appeared to take place, i.e., where atrophy was the highest. One explanation might be that as the CN loses neurons that the iron remains behind in the intact tissue. We might also ask if the iron itself has any implications in the progression of the disease or do these observations indicate that it could serve as another marker for neuronal loss? As far as the MR data is concerned, the best that we can say at this time is that there is a correlation with CN volume loss and iron content as determined from SWI phase images.

References: 1) E.H. Aylward et al, Rate of caudate atrophy in presymptomatic and symptomatic stages of Huntington's disease. *Mov. Disord 15.* (2000), pp. 552–560. 2) E. H. Aylward et al, Caudate volume as an outcome measure in clinical trials for Huntington's disease: a pilot study. Brain Research Bulletin,Vol 62, Issue 2, 15 December 2003, Pages 137-141. 3) Kilichan Gurleyik and E. Mark Haacke, Quantification of Errors in volume measurements of the caudate nucleus using magnetic resonance imaging. J.Magn.Reson.Imaging 2002;15:353-363.