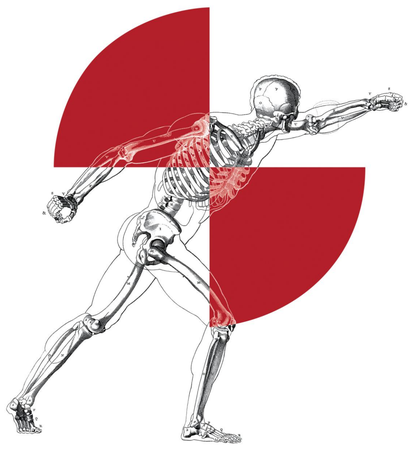

The Relationship of Brain Atrophy and Age to aid in Subdural Hematoma Injury Risk Prediction

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INTRODUCTION

- Elderly persons (>65 years) have an increased injury susceptibility to subdural hematoma (SDH) during both falls and motor-vehicle accidents. [1]
- Increased SDH occurrence with age may be a result of brain atrophy, quantified as decreasing brain parenchymal fraction (BPF), that leads to greater relative displacement during rotational motion.
- The purpose of this study is to develop a relationship of BPF and age that can be applied to experimental data to develop age-specific risk of SDH. Understanding loads leading to SDH and correlations with age could ultimately lead to additional brain injury criteria.
- Two software packages were used to evaluate BPF and the resulting relationships between BPF and age were compared to determine if systematic bias was present between software.

MATERIALS & METHODS

- Using the Alzheimer's Disease Neuroimaging Initiative (ADNI), 197 healthy subjects' (103 female, 94 male, average age 76.0 (SD 6.5) years, range 57-95 years) 3.0T T1-weighted magnetic resonance images (MRI) were downloaded for analysis.
- Default settings in the Statistical Parametric Mapping (SPM, 2014 release)[2] "Segment" function were employed to parse images into gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF) voxels. FreeSurfer (FS, 2013 stable release 11.4.2)[3] was used to reconstruct brain volumes using default run-through of the "recon-all" command.

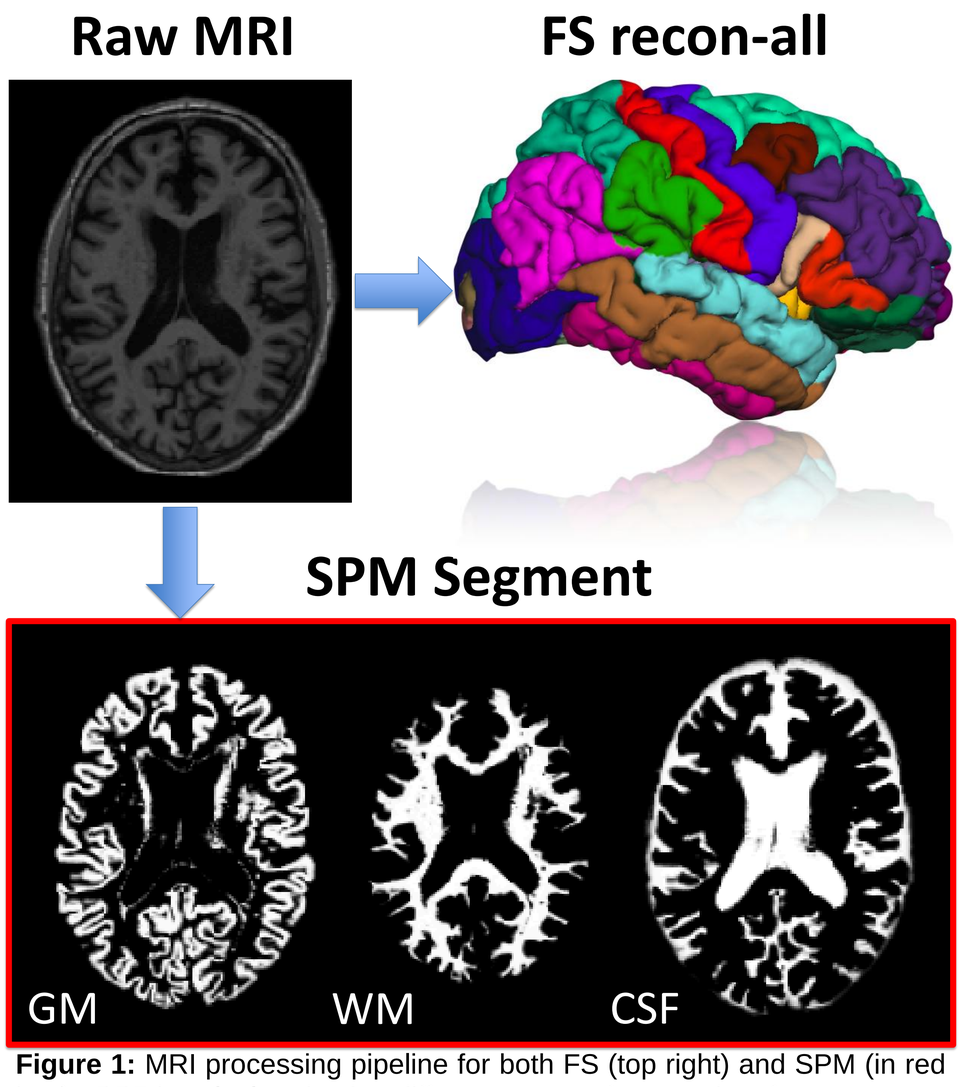


Figure 1: MRI processing pipeline for both FS (top right) and SPM (in red box). BPF is calculated using different outputs from each software.

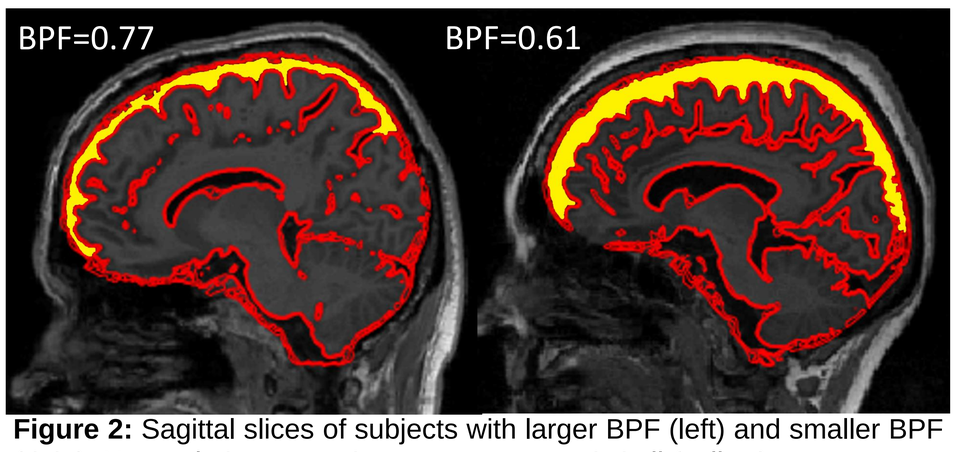
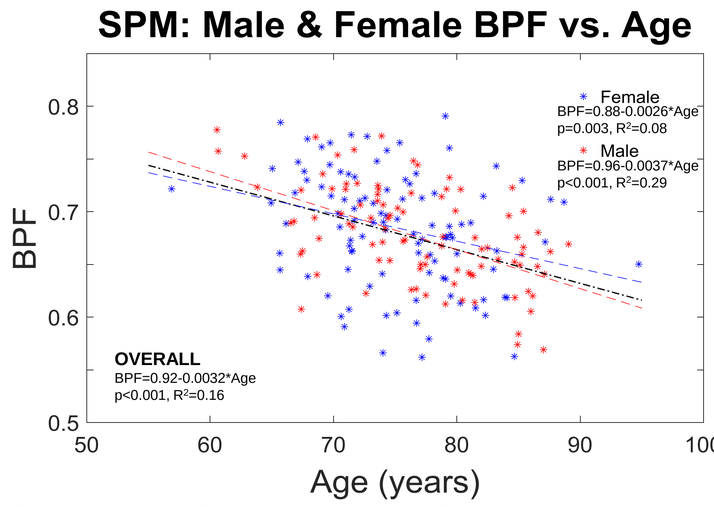


Figure 2: Sagittal slices of subjects with larger BPF (left) and smaller BPF (right). Note relative space between cortex and skull (yellow).

RESULTS & DISCUSSION



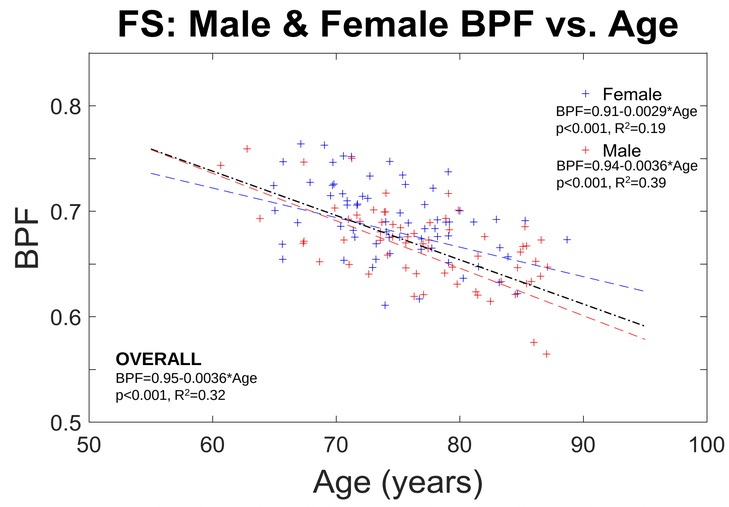
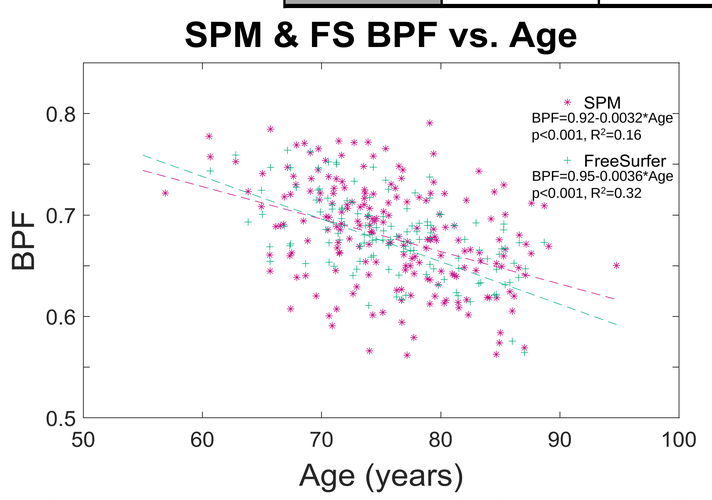


Figure 3: SPM (left) and FS (right) linear regression models of BPF vs. age for females (blue), males (red), and both (black).

- Male, female, and overall models showed a statistically significant decrease in BPF with age for both SPM (male p<0.001, female p=0.003, overall p<0.001) and FS (male p<0.001, female p<0.001, overall p<0.001).
- In SPM, BPF decreases 0.0037/year and 0.0026/year for males and females, respectively, but 0.0032/year when modeled together. In FS, males, females, and the overall distribution were modeled by BPF decrease of 0.0036/year, 0.0029/year, and 0.0036/year, respectively.
- Using analysis of variance techniques (ANOVA), an interaction term of Age*Sex was introduced into the regression equation for each software to determine the effect of sex on predicted relationship between age and BPF.
- It was found that sex did not have a significant effect on age as a predictor of BPF (SPM p=0.283, FS p=0.464). This was a similar result obtained by a study performed by Chard et al (n=27, average age 36.1 (SD 9.3) years, range 23-55 years). [4]

Table 1: Subject characteristics and average BPF values across sample when analyzed in SPM & FS.

			BPF±SD	
	Number	Age±SD (years)	SPM	FS
Male	94	77±6.7	0.68±0.05	0.67±0.04
Female	103	75±6.0	0.68±0.05	0.69±0.04
Overall	197	76±6.4	0.68±0.05	0.68±0.04



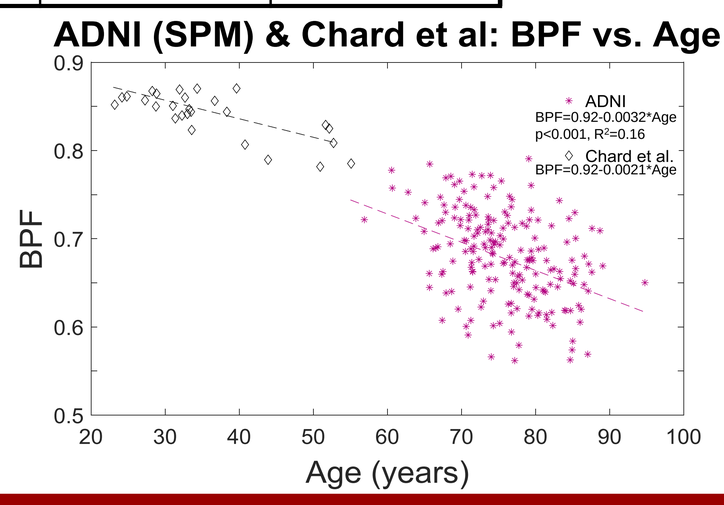


Figure 4: Linear regression models of BPF vs. age for SPM and FS (left), and overlaid plots (right) of older ADNI subjects analyzed in SPM12 and younger subjects (imaged at 1.5T) analyzed in SPM99 by Chard et al. [4]

- An interaction term of Age*Software indicated that SPM and FreeSurfer overall models were not significantly different in their prediction of BPF as a function of age (p=0.598).

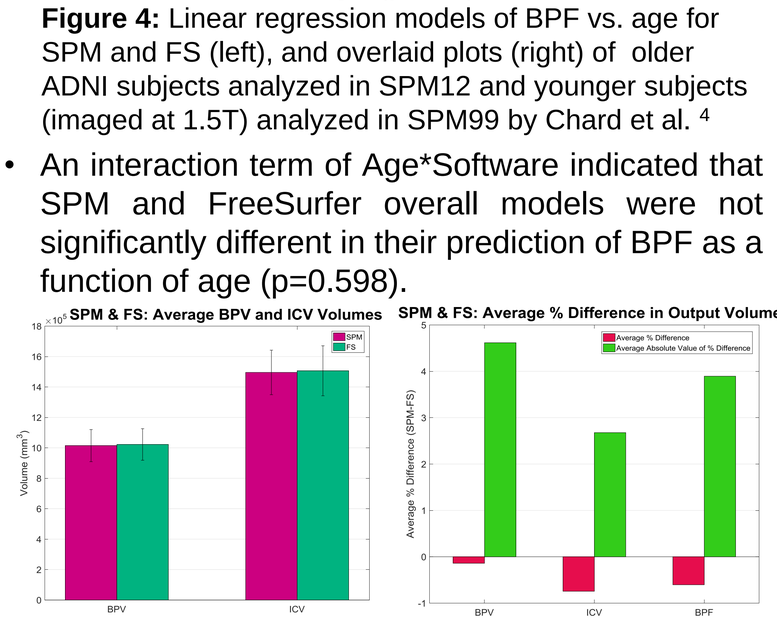


Figure 5: Average volumes comprising BPF (left) from both SPM (magenta) and FS (teal), and average percent differences (%diff) and average absolute value of %diff between each subject's BPV, ICV, and BPF measures in SPM and FS.

- Despite non-significant differences in BPF prediction, FS BPV, ICV, and BPF were, on average, larger than SPM volumes for the same subjects.

CONCLUSIONS

- The relationships of BPF vs. age were established for both elderly male and female subjects, and not found to be statistically different in either software.
- BPF decrease as a function of age can be modeled irrespective of sex to predict SDH as a function of age for older, injury-prone populations.
- Despite lack of statistical difference in BPF prediction between SPM & FS, differences in BPF are notable and require further investigation.
- Future studies will (1) evaluate validity of SPM and FS results using gold-standard manual measurement and (2) analyze the segmentation algorithms used by SPM and FS to determine their accuracy for use in investigating older adults.

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