Axial and Radial Components of the Diffusion Tensor in the Myelin Mutant Shaking Pup

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INTRODUCTION

Despite advances in several quantitative MR imaging methods targeted to white matter (WM), including diffusion tensor imaging (DTI), the microstructural specificity of these techniques remains an open question. It has been suggested [1] that axial (longitudinal) and radial (transverse) components of the diffusion tensor may be relatively specific for the axonal substrate and the myelin sheath, respectively. We sought to test this hypothesis in the shaking pup (*sh* pup), a canine mutant noted for its profound dysmyelination with relative preservation of axons.

MATERIALS AND METHODS

Three *sh* pups and three healthy control dogs underwent DTI on a 3T scanner (GE Signa) equipped with an 18 cm-diameter quadrature T/R coil (Medical Advances). To avoid problematic EPI distortion, DTI was obtained using the multishot FSE sequence, Periodically Rotated Overlapping Parallel Lines with Enhanced Reconstruction (PROPELLER) [2]. Diffusion gradients were applied in six directions with b=1000 sec/mm^2. Diffusion-weighted image data were fit with a single diffusion tensor model and fractional anisotropy (FA) calculated. Axial diffusivity was defined as the diffusivity in the direction of the major eigenvector, radial diffusivity as the mean of diffusivities in the directions of medium and minor eigenvectors. Whole-brain averages of axial and radial diffusivity were compared between *sh* pups and controls (gray-white segmented and region-of-interest data pending).

RESULTS

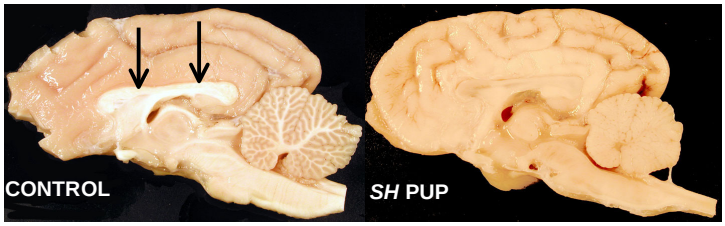

Fig. 1. Gross specimens of midsagitally cut brains from representative control dog and *sh* pup. There is profoundly reduced WM volume in the *sh* pup, most apparent in the corpus callosum (arrows).

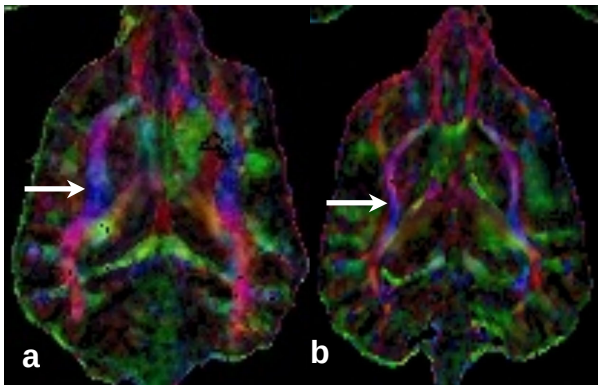

Fig. 2. Color-coded maps of diffusion tensor anisotropy and major eigenvector orientation for axial sections in a control dog (a) and *sh* pup (b). Color brightness is proportional to FA and hue indicates local fiber orientation (blue=superior-inferior, red=anterior-posterior, green=left-right). There is substantially diminished thickness, but only mild loss of anisotropy, of the corticospinal tracts (arrows) in the *sh* pup.

DISCUSSION AND CONCLUSION

Given the profound paucity of myelin with relative preservation of axons in the *sh* pup, one would expect a myelin-specific parameter to be substantially abnormal while an axon-specific parameter would retain nearly normal values. We found that this was indeed the case for the radial and axial components, respectively, of the diffusion tensor, as previously observed in shiverer mice [1]. We conclude that tensor components indeed convey more specific and relevant information in this context than a "summary" parameter such as FA. Light microscopic and electron micrographic correlation with the tensor data is pending. Whether the specificity of these parameters is sufficient to reliably quantitate axonal and myelin integrity in the face of such confounding factors as inflammation, edema, and gliosis requires additional studies.

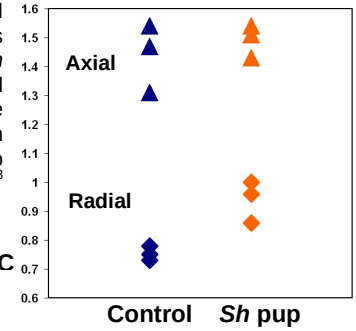

Fig. 3. Axial and radial diffusivities for 3 controls and 3 *sh* pups. The *sh* pups show increased radial diffusivity, while the axial diffusivities remain similar, compared to controls. (ADC x 10^{-3} mm^2/sec)

REFERENCES

1. Song S-K, *et al*., *Neuroimage* 2002;31:1429-1436.
2. Pipe JG, *et al*., *Magn Reson Med* 2002;47:42-52.