Structural Integrity Changes Following Severe Contusion Injury

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Introduction

Conventional magnetic resonance imaging (MRI) of the spinal cord is often limited to the measure of morphological changes due to the loss of contrast in MR following spinal cord injury (SCI). Therefore we set out to determine if can be used to probe white matter integrity and examine the response to different levels of physical activity.

Experimental

Sprague Dawley rats (16-week old, female) were assigned to 4 groups: Control (CTR, n=5), SCI (n=8), SCI + Cast immobilization (SCI+IMM, n=10), SCI + Treadmill (SCI+TM, n=9). SCI was induced using a standard method. Bilateral hindlimb cast immobilization was initiated at 8 days post-injury and maintained for 2 weeks. Treadmill training was performed 8 days post-injury for 2 weeks. *Ex Vivo* DTI was acquired at 17.6T 21 days post-injury with the following parameters: 4.5 x 4.5 mm^2 field of view, 35 x 35 μm^2 in-plane resolution, TR/TE= 3,500/21 ms, 400 µm slice thickness, 25 slices, 21 diffusion directions. Fractional anisotropy (FA) maps were analyzed by manual segmentation. Mean FA values from white matter in CTR were used to determine thresholds and define the preserved white matter area of the injured animals (Figure 1).

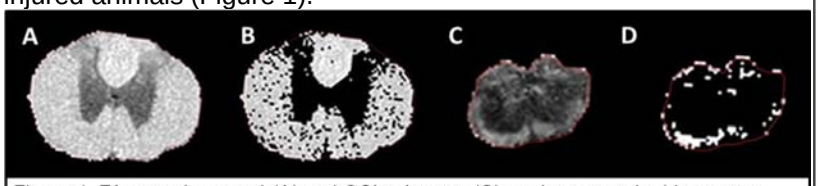

Figure 1. FA maps in control (A) and SCI epicenter (C), and preserved white matter map in control (B) and SCI epicenter (D)

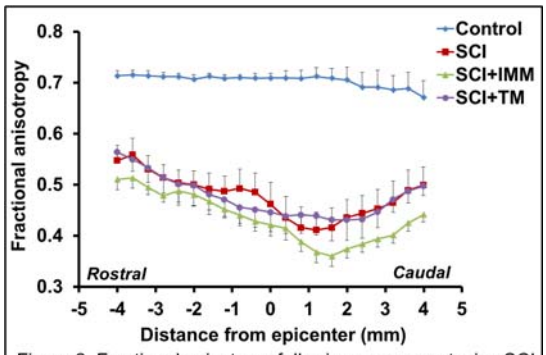

Figure 2. Fractional anisotropy following severe contusion SCI

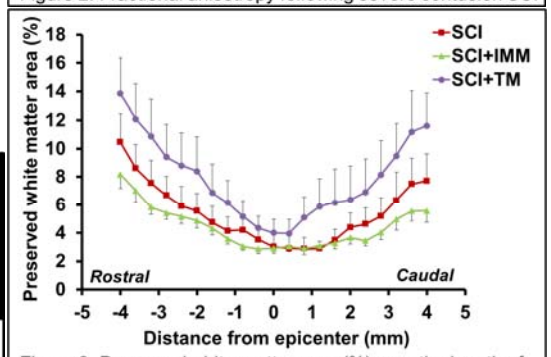

Figure 3. Preserved white matter area (%) over the length of spinal cord

Results and Discussion

FA was decreased over the length of spinal cord imaged in all injured groups (Figure 2). The lowest FA values were detected in the caudal region, not in the epicenter. Only 3.01 ± 2.87 % white matter was preserved in SCI at the epicenter (Figure 3) based on measurements using FA mapping. This was consistent with published histological findings by Basso et al[1]. Preserved white matter area at the epicenter was 2.90 ± 1.04 % in SCI+IMM, and 4.00 ± 2.86 in SCI+TM. Overall, the SCI showed a significantly greater preserved area compared to SCI+IMM over the length of spinal cord we imaged, as shown by statistical modeling of the profiles. Similarly, the SCI+TM had more preserved WM area than SCI.

SCI resulted in profound tissue damage as detected by MRI for over more than 1 cm. Severe tissue damage was extended beyond the epicenter region, particularly throughout the caudal region. Only a very small amount of tissue was preserved in this model of severe SCI (~3%). This is of particular interest in this model as our group previously showed that lower leg muscle mass did not decline by more than 30% after the initial insult and remain stable after 3 weeks. Likewise metabolism is decreased at 1 week but restored by 3 weeks post injury. These data support the fact that very little spared neuronal tissue is sufficient to initiate lower hind limbs recovery after thoracic injury.

Conclusions

Our data confirm that DTI can serve as a sensitive tool for quantitating spinal cord integrity.

Acknowledgements

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References

[1] Basso, D. M., *et al*., Experimental Neurology,139, 244-256 (1996).