

## Measures of quantitative MRI correlate with neurological outcomes in patients after acute spinal cord injury

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### Introduction

Acute spinal cord injury (SCI) is a devastating and common medical condition that afflicts primarily young individuals. One of the most striking consequences after acute SCI is neurological deficit due to progressive loss of tissue in the spinal cord, an extent which varies across subjects. MRI is considered as the best imaging modality for the evaluation of spinal cord injuries<sup>1</sup>. However there are few studies in the literature that have investigated acute SCI systematically using quantitative MRI. The goal of this study was to test the feasibility of using quantitative MRI to assess SCI outcomes; MRI images were collected at specific timepoints during a clinical trial of minocycline in acute SCI.

### Method

Fifty-two patients were randomized within 12 hours of injury to either intravenous minocycline or placebo treatment, twice a day, for 1 week. All patients were 16 years or older, had motor complete or motor incomplete or central cord injury involving cervical or thoracic spine, and were able to provide informed consent. MR imaging was performed at a single site using a 1.5T scanner (Avanto or Sonata, Siemens Medical Systems, Germany) within 24 hours (day 1) of injury, and at day 7, week 4, and week 52 after the injury. MRI protocols included: sagittal spin echo (SE) T1-weighted (T1W) (TR=433 ms, TE=13 ms); sagittal fast SE T2W (TR=3340 ms, TE=95 ms) and sagittal short time inversion recovery (STIR) MRI (TR=4360 ms, TE=70 ms) with FOV=240x240 mm<sup>2</sup>, slice thickness=3 mm, and matrix=896x896. Axial images included T1W MRI (TR=433 ms, TE=13 ms), 3D gradient echo imaging (GRE) (TR=433 ms, TE=13 ms) or T2W MRI (TR=4360 ms, TE=109 ms) with FOV=240x240 mm<sup>2</sup>, matrix=512x512, slice thickness=2 mm for GRE and 3 mm for T1W and T2W MRI.

Maximum canal compromise (MCC) and maximum spinal cord compression (MSCC) was quantified on the sagittal

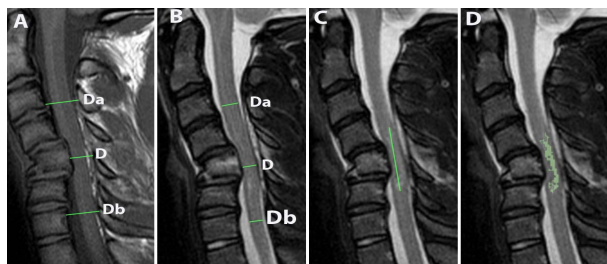


Fig1: MRI measures of MCC, MSCC (A, B):  $D/[(Da+Db)/2]$ , T2 lesion length and area (C, D) at day 1 of acute SCI at C5.

T2 lesion length and area correlated with motor, sensory, and total ASIA score at day 1 ( $p < 0.01$ ) and week 52 ( $p < 0.01$  or 0.05), and with sensory and total score at day 7 ( $p < 0.01$  or 0.05). In addition, T2 lesion length correlated with sensory and total score at week 4 ( $p < 0.01$ ). Negative MSCC (cord swelling) correlated with motor score at day 7 ( $p < 0.05$ ), with sensory, motor and total score at week 4 ( $p < 0.01$  or 0.05), and with motor score at week 52 ( $p < 0.05$ ). The MCC was not correlated with any neurological outcome over time ( $p > 0.05$ ). Longitudinally, both the length ( $p < 0.01$  or 0.05) and area ( $p < 0.01$ ) of T2 lesion at day 1 predicted motor, sensory, and total ASIA score at week 52; the correlation of lesion area with motor score was the strongest (Fig. 2).

### Discussion

This prospective study showed that MRI protocol compliance was 74% to 90% within 1 year of acute SCI. It suggests that MSCC may be an indicator of motor outcome 7 days after SCI and T2 lesion length or area be a sensory measure at subacute SCI (day 7 and week 4). In addition, while we confirm reports that T2 lesion length predicts neurological outcomes<sup>1,3,4</sup>, we found that T2 lesion area was the best predictor of motor outcome 52 weeks following SCI. These findings suggest that quantitative MRI could be an invaluable tool to evaluate injuries in the spinal cord. It may also indicate that neurological deficit could be driven by different aspects of pathological processes over time, which may require targeted treatment strategies to improve recovery after acute SCI.

### References

- [1] Lammertse D et al. *J Spinal Cord Med.* 2007; 30: 205-214.
- [2] Fehlings MG, et al. *Spine* 1999; 24: 605-13.
- [3] Firoz M, et al. *Radiology* 2007; 243: 820-27.
- [4] Boldin C, et al. *Spine* 2006; 31:554-9.

T1W and T2W images respectively using a reported method<sup>2</sup>. The length and area of overall T2 hyperintensity on the sagittal T2W MRI were assessed using a semi-automatic region-growing program implemented in Osirix (version 3.6) (Fig. 1). Neurological outcomes were evaluated using the American Spinal Injury Association (ASIA) score at sequential timepoints. The relationship of MRI measures with ASIA score was analyzed using Pearson Correlation ( $p \leq 0.05$  as significance).

### Results

MRI scans were available from 48 patients at day 1, 45 patients at day 7, 41 patients at week 4, and 36 patients at week 52. Both T2 lesion length and area correlated with motor, sensory, and total ASIA score at day 1 ( $p < 0.01$ ) and week 52 ( $p < 0.01$  or 0.05), and with sensory and total score at day 7 ( $p < 0.01$  or 0.05). In addition, T2 lesion length correlated with sensory and total score at week 4 ( $p < 0.01$ ). Negative MSCC (cord swelling) correlated with motor score at day 7 ( $p < 0.05$ ), with sensory, motor and total score at week 4 ( $p < 0.01$  or 0.05), and with motor score at week 52 ( $p < 0.05$ ). The MCC was not correlated with any neurological outcome over time ( $p > 0.05$ ). Longitudinally, both the length ( $p < 0.01$  or 0.05) and area ( $p < 0.01$ ) of T2 lesion at day 1 predicted motor, sensory, and total ASIA score at week 52; the correlation of lesion area with motor score was the strongest (Fig. 2).

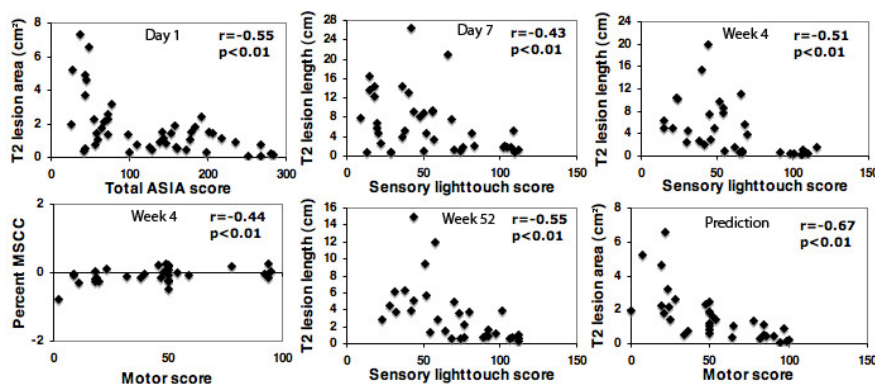


Fig2: The strongest correlations between MRI indices and ASIA score at day 1, day 7, week 4, week 52, and between day 1 MRI and week 52 motor score (bottom right panel).