Quantitative analysis and prognostic value of changes in spinal cord signal intensity on magnetic resonance imaging in patients with cervical compressive myelopathy

Orthopaedics and Rehabilitation Medicine
Faculty of Medical Sciences University of Fukui

Hideaki Nakajima, Kenzo Uchida, Naoto Takeura, Takumi Sakamoto, Kazuya Honjoh, Hisatoshi Baba
Background

Signal intensity on preoperative cervical spinal cord MRI has shown to be a potential predictor of outcome of surgery for cervical compressive myelopathy. However, the prognostic value of such signal remains controversial. One reason for the controversy is the lack of proper quantitative methods to assess MRI signal intensity.

The quantitative study based on 3D-MRI/\(^{18}\)F-FDG-PET fusion imaging showed no correlation with high signal intensity on T2-weighted images (WIs).

Study design/Objective

The present study was designed to quantify signal intensity and to correlate changes in intramedullary signal on MRI with clinical outcome and determine their prognostic value.

patients

N=148 (male: 96 cases, female: 52 cases)
...underwent decompressive surgery showing high intramedullary signal intensity of the spinal cord on sagittal T2-weighted MR images

Ave. Age: 69.6 yrs
CSM: 102 cases, OPLL: 46 case
Mean duration: 8.1 months
Methods

Quantitative analysis of MRI signal on both T1- and T2-WIs using the signal intensity ratio (SIR; calculated by the following equation) was done.

\[
SIR = \frac{\text{SI of sagittal cervical spinal cord lesion (0.05 cm}^2\text{)}}{\text{SI of sagittal normal cord between C7-T1 disc levels (0.3 cm}^2\text{)}}
\]

Correlations between SIR on T1- and T2-WIs and preoperative JOA score, JOA improvement rate, disease duration and MRI morphological classification (cystic or diffuse type) were analyzed. Multivariate regression analysis for JOA improvement rate was also analyzed. In a substudy, 25 patients underwent follow-up MRI starting from 6 months after surgery to analyze the relationship between changes in SIR on follow-up MRI and clinical outcome.

A lower preoperative JOA score was associated with a lower SIR on T1-WIs (A). On the other hand, there was no correlation between high intramedullary SI on T2-WIs and preoperative JOA score (B).
A lower postoperative neurological improvement was associated with a lower SIR on T1-WIs (A). However, there was no correlation between high intramedullary SI on T2-WIs and postoperative neurological improvement (B). Preoperative JOA score correlated with postoperative neurological improvement (C).
A longer duration of symptoms was associated with a lower SIR on T1-WIs (A). A similar relation was found between JOA neurological improvement rate and disease duration (C). However, there was no relation between disease duration and high intramedullary signal intensity on T2-WIs (B).
Based on MRI morphological classification of cervical spondylotic myelopathy, 28 patients were classified as “cystic type” and 120 patients were classified “diffuse type”. There was no difference in SIR on T1-WIs between the two groups (A). On the other hand, the SIR on T2-WIs was significantly higher in the cystic type compared with the diffuse type (B). There was no difference in JOA score between the two types (C)

Avadhani A, Rajasekaran S, Shetty AP. Spine J, 2010
The SIR on follow-up T1-WIs correlated significantly with postoperative JOA improvement rate (A). The high intramedullary signal intensity on follow-up T2-WIs also correlated with postoperative JOA improvement rate (B). The Δchange in SIR (follow-up minus preoperative) on T1-WIs correlated significantly with postoperative JOA improvement rate (C). The Δchange in SIR on T2-WIs correlated negatively with postoperative neurological improvement rate (D).
Sixty-two-year-old male

Duration: 30 months

Five of the 25 patients (20.0%) whose SIR on T1-WIs changed from ≥1 before surgery to <1 after surgery showed poor neurological improvement rate (33.3 ± 9.7%)

Figure shows a representative case with changes in SIR on T1-WI from >1 to <1 (1.12 to 0.98) and increased SIR on postoperative T2-WI (1.55 to 1.80).

The patient with CSM underwent surgery (C4 subtotal spondylectomy) and showed poor neurological improvement rate of 28.6% at follow-up.
While the MRI provides high specificity in the assessment of morphological changes and intramedullary state of the spinal cord, it is almost impossible to estimate potential recovery of the spinal cord on preoperative MRI without appropriate quantitative analysis. Furthermore, the signal intensity in each MRI is irregular since the sequence of parameters is individually selected for each patient. Our results also suggested that low intensity signal on preoperative T1-WIs was a significant predictor of poor postoperative neurological outcome. However, one of the main problems in assessing signal intensity on T1-WIs is that it is difficult to detect changes in signal intensity on T1-WIs compared with detecting changes in high signal intensity on T2-WIs.

Based on the results reported in the literature, a high intensity signal on T2-WIs in early-stage compressive myelopathy indicates edema and gliosis (which may be reversible), whereas a low intensity signal on T1-WIs represents myelomalacia and necrosis (which are considered irreversible). In our study, SIR on T1-WIs and postoperative neurological outcome correlated negatively with disease duration.
Conclusion

Quantification of MRI signal changes in patients with cervical compressive myelopathy was used in the present study to define intramedullary signal changes in relation to clinical outcome and prognostic significance. Low signal intensity in the preoperative T1-weighted images, but not T2-weighted images, seems to correlate with poor postoperative neurological outcome. Furthermore, decrease in signal intensity on postoperative T1-WIs and increase in signal intensity on postoperative T2-WIs can predict poor neurological outcome and represent ongoing pathological changes in the compressed spinal cord. Preoperative and postoperative SIR on MRI could be potentially useful for prediction of postoperative neurological outcome.

References


Financial Disclosure information
None of the authors has a financial interest or other relationship with commercial company or institution.