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Clinical Study

Prognostic value of changes in spinal cord signal intensity on magnetic resonance imaging in patients with cervical compressive myelopathy

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Abstract

BACKGROUND CONTEXT: Signal intensity on preoperative cervical magnetic resonance imaging (MRI) of the spinal cord has been 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.

PURPOSE: To quantify signal intensity and to correlate intramedullary signal changes on MRI T1- and T2-weighted images (WIs) with clinical outcome and prognosis.

STUDY DESIGN: Retrospective case study.

PATIENT SAMPLE: Patients (n=148; cervical spondylotic myelopathy, n=102 and ossified posterior longitudinal ligament, n=46) who underwent surgery for cervical compressive myelopathy and had high signal intensity change on sagittal T2-WI MRI before surgery between 2006 and 2010.

OUTCOME MEASURE: Neurologic assessment was conducted with the Japanese Orthopedic Association (JOA) scoring system for cervical myelopathy. The rate of neurologic improvement was calculated with the use of preoperative and postoperative JOA scores.

METHODS: Quantitative analysis of MRI signal on both T1- and T2-WIs via use of the signal intensity ratio (SIR; signal intensity of lesion relative to that at C7-T1 disc level) was performed. Correlations between SIR on T1- and T2-WIs and preoperative JOA score, JOA improvement rate, disease duration, and MRI morphologic 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.

RESULTS: SIR on T1-WIs, but not SIR on T2-WIs, correlated with postoperative neurologic improvement. The disease duration correlated negatively with SIR on T1-WIs and JOA improvement rate but not with SIR on T2-WIs. SIR on T2-WIs of ''cystic type'' was significantly greater than of ''diffuse type,'' but SIR on T1-WI and JOA improvement rate were not different in the two types. Stepwise multivariate regression analysis indicated that SIR on T1-WIs and long disease duration were significant predictors of postoperative neurologic outcome. SIR on follow-up T1-WI and changes in SIR on T1-WI after surgery correlated positively with postoperative improvement rate. SIR on follow-up T2-WI and changes on T2-WI correlated negatively with postoperative neurologic improvement.

CONCLUSIONS: Our results suggest that low intensity signal on preoperative T1-WIs but not T2-WIs correlated with poor postoperative neurologic outcome. Furthermore, decreased signal

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intensity on postoperative T1-WIs and increased signal intensity on postoperative T2-WIs are predictors of poor neurologic outcome.

Keywords: Cervical myelopathy; Magnetic resonance imaging; Intramedullary spinal cord signal intensity; Quantitative analysis; Prognosis; Neurologic outcome

Introduction

It is important to assess spinal cord function in patients with cervical compressive myelopathy that is amenable to neurosurgical treatment. Most conventional tests focus on evaluation of neural conductivity across the damaged spinal cord [1] or morphologic and pathologic changes at the compressed cord that can be identified on magnetic resonance imaging (MRI). MRI is a valuable tool before surgical decompression because it visualizes not only the magnitude of spinal cord compression but also intramedullary signal intensity. Many authors have reported intramedullary changes in high signal intensity on T2-weighted imaging (WI) in patients with compressive spondylotic lesions of the cervical spinal cord [2–5]. The presence of intramedullary high signal intensity on T2-WI in patients with compressive myelopathy reflects chronic spinal cord compression lesion. However, the prognostic value of these imaging abnormalities remains controversial, especially with regard to signal intensity of the spinal cord on T2-WI. Intramedullary changes in high signal intensity on T2-WI can reflect a wide range of compressive pathologies and nonspecific histologic changes that have been related to different events, representing anything from mild, reversible changes such as gliosis and demyelination to severe, irreversible changes including cavitation or necrosis. A few studies have shown a clear correlation between high signal intensity of the spinal cord on T2-WI alone and poor prognosis after surgery and that poor prognosis correlates with low signal intensity of the spinal cord on T1-WI [6,7]. Other studies also showed that high signal intensity on T2-WI of the spinal cord and low T1-weighted signal intensity of the spinal cord can predict a poor surgical outcome. However, controversy exists in the reported results, mainly because of the lack of proper quantitative assessment method of these changes in signal intensity. 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.

Materials and methods

Patient population

Between 2006 and 2010, a total of 148 patients (CSM, n=102; OPLL, n=46) who underwent decompressive surgery at our hospital and showed high intramedullary signal intensity of the spinal cord on sagittal T2-weighted magnetic resonance imaging (MRI; 1.5 Tesla Signa System; General Electric, Milwaukee, WI) were assessed in this study. None of the patients had developmentally narrow canal on plain radiographs or multisegmental lesions on MRI. Exclusion criteria included a history of traumatic injury of the cervical spinal cord, malignancy, and infection. Among the 148 patients, 25 underwent follow-up MRI starting from 6 months after operation. Two senior surgeons (KU, HB) performed all operations, and they did not participate in the assessment of MRIs and statistical analysis. All examinations strictly followed the Ethics Review Committee Guidelines of Fukui University, and written informed consent was obtained from all patients.

Neurologic assessment was conducted by use of the Japanese Orthopedic Association (JOA) scoring system for cervical myelopathy (Table 1). The rate of neurologic improvement was calculated by the use of the following equation: [(postoperative JOA score−preoperative JOA score)/(17−preoperative JOA score)×100]. An improvement rate of 100% was the best possible postoperative recovery [8].

High-resolution MRI

MRI examination of the spinal cord was performed preoperatively using 1.5 Tesla Signa System (General Electric). T1-WIs and T2-WIs of sagittal views of the spinal cord were obtained using spin echo sequence system for T1-WIs and a fast spin echo sequence system for T2-WIs. Quantitative analysis was based on the method described previously [9]. T2-WIs of sagittal increased signal intensity values on the cervical spinal cord were obtained first because small changes in signal intensity on T1-WIs are difficult to visualize, and 0.05 cm^2 regions of interest (ROIs) were taken. The same spinal cord lesion of T1-WIs on T2-WIs were obtained on Centricity Picture Archiving and Communication Systems (General Electric Healthcare Japan, Tokyo, Japan), and 0.05cm^2 ROIs were taken. The signal intensity values for T2- and T1-WIs of sagittal views of the normal cord at cervical C7-T1 disc levels were obtained, and 0.3 cm^2 ROIs were selected. The signal intensity was measured automatically by the computer, and changes in signal intensity in the cord were qualitatively assessed on both T1-WIs and T2-WIs. For quantitative analysis of the signal, the signal intensity ratio (SIR) for both T1-WIs and T2-WIs was calculated by the following equation:

$$\mathrm{SIR} = \left[\text{SI of sagittal cervical and spinal cord lesion } \left(0.05\ \mathrm{cm}^2\right) \Big/ \text{SI of sagittal normal cord between C7 and T1 disc levels } \left(0.3\ \mathrm{cm}^2\right)\right]$$