Surgical Decompression for Cervical Spondylotic Myelopathy: Correlation Between Operative Outcomes and MRI of the Spinal Cord

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abstract

Forty-two patients who underwent decompressive surgery for cervical spondylotic myelopathy were studied. The pre– and postoperative magnetic resonance imaging (MRI) findings and the Japanese Orthopedic Association score were analyzed to evaluate whether the different appearances of intramedullary high-signal intensity on T2-weighted MRI are related to the surgical prognosis. Magnetic resonance imaging signal intensities were classified as type 0 if no intramedullary high-signal intensity on T2-weighted images was noted, type 1 if high-signal intensity involved only one segment, and type 2 if high-signal intensity extended over two segments. Statistical analyses of the recovery ratio showed that type 0 and type 1 intramedullary high-signal intensity indicates better prognosis than type 2.

Cervical spondylotic myelopathy, which may result from spinal cord compression, disturbed blood supply, or both, develops due to degenerative changes in the cervical spine after the middle years of life. In the past, the diagnosis of cervical spondylotic myelopathy was dependent on radiography, myelography, computed tomography (CT), and CT myelography. With the advent of magnetic resonance imaging (MRI), diagnostic imaging of spinal cord compression has developed markedly. Magnetic resonance imaging depicts anatomically how the spinal cord is compressed and reflects the pathological changes within the spinal cord by showing a change in the signal intensity of the spinal cord.

A number of authors have reported that intramedullary high-signal intensity is a predictor of poor recovery after surgical decompression. However, some authors have reported no correlation between the surgical outcome and intramedullary high-signal intensity. The relation between high-signal intensity changes and clinical symptoms is not clear due to the various types of disease, crisis pattern, and sampling bias, and postoperative clinical symptoms may vary depending on the type of surgery, anterior or posterior, performed. Therefore, we tried to determine whether the different preoperative appearances of intramedullary high-signal intensity on T2-weighted MRI are related to differences in surgical prognosis.

MATERIALS AND METHODS

Between January 1999 and January 2003, 42 (27 men and 15 women) consecutive patients with multilevel cervical compression myelopathy were treated by decompression surgery. Average age of patients was 57.5 years (range: 36-82 years). Eighteen patients underwent posterior decompression by laminectomy and lateral mass plate fixation; 7 underwent anterior decompression by corpectomy, excision of posterior longitudinal ligament, bone graft or titanium cage, and plate fixation; and 17 underwent both anterior and posterior procedures.

All patients underwent MRI examination preoperatively and 6 months postoperatively. Neurologic status was evaluated...
using the modified Japanese Orthopedic Association (JOA) score for clinical myelopathy and recovery was determined using Hirabayashi’s formula. One radiologist (S.K.) who was blinded to clinical status and one of the authors (C.A.P.) evaluated MRIs for intramedullary high-signal intensity, spinal cord deformity, and adequate decompression. Cord deformity was expressed by the ratio of the sagittal diameter divided by the transverse diameter of the spinal cord observed on T1-weighted transverse images at the site of maximal cord compression. Decompression was considered complete if the cord was free of any impingement or effacement according to axial and sagittal T1- and T2-weighted MRIs. Decompression was considered incomplete if either anterior or posterior cord impingement or effacement was identified.

After evaluation of all sagittal MRI sections through the cervical cord, the findings were classified into two major patterns. One pattern showed a high-signal intensity in one segment and in the other pattern, the high-signal intensity was extended over ≥2 segments. Patients were classified as type 0 if no intramedullary signal on T2-weighted MRI was noted, type 1 if the high-signal intensity was limited to one segment, and type 2 if the high-signal intensity was extended over ≥2 segments. Student t test was used for statistical analysis.

RESULTS

In 16 patients, no high-signal intensity was detected on T2-weighted MRIs (type 0), 13 patients with high-signal intensity were limited to one segment (type 1), and 13 patients demonstrated high-signal intensity extended over ≥2 or more segments (type 2). None of the patients demonstrated intramedullary low-signal intensity on T1-weighted sequences. The preoperative JOA type 0, 1, and 2 scores were 13.9±1.6, 12.69±0.99, and 10.2±0.9, respectively. The mean preoperative cord compression ratios of types 0, 1, and 2 were 49.02%±11.03, 41.13%±12.62, and 31.17%±9.11, respectively. Statistical

Figure 1: Cervical MRI of a 67-year-old man with 35% cord compression ratio and preoperative JOA score of 14 points. Preoperative sagittal T2-weighted image shows type 1 intramedullary high-signal intensity (arrow) (A). One year postoperative sagittal T2-weighted image shows residual intramedullary high-signal intensity. Recovery ratio was 72% (B).

Figure 2: Cervical MRI of a 52-year-old woman with 46% cord compression ratio, and preoperative JOA score of 12 points. Preoperative sagittal T2-weighted image shows type 1 intramedullary high-signal intensity (arrow) (A). Eight-month postoperative sagittal T2-weighted image shows withdrawal of the high-signal intensity. Recovery ratio was 78% (B).
analyses showed no significant difference in age, sex, duration of symptoms, and the surgical procedure between the three groups. However, the mean cord compression ratio and the preoperative JOA type 2 score were more severe than type 0 and type 1. Postoperatively, the mean cord compression ratio of type 0, 1, and 2 was 85.16%±10.13, 81.27%±10.26, and 66.32%±9.19, respectively.

Six months to 2 years postoperatively, the recovery ratio of all 42 patients was 57.3%±14.17. The recovery ratios of types 0, 1, and 2 were 66.14%±17.60, 71.5%±12.44, and 34.26%±12.48, respectively. Comparing the recovery ratio of the different types of high-signal intensity on T2-weighted images, a significant difference was found between types 2 and 1 (P<.001) and types 2 and 0 intramedullary high-signal intensity (P<.001); however, no significant difference was noted between types 0 and 1 (P=.232). Significant differences of the final JOA score were noted between type 2 and type 0 or type 1 intramedullary high-signal intensity (P<.001) (Table).

In 4 (15%) of 26 patients with intramedullary high-signal intensity, T2-weighted MRI demonstrated improved signal intensity after complete decompression. Of the 4 patients, 1 underwent anterior decompression, 1 underwent posterior decompression, and 2 underwent both anterior and posterior decompression. The mean recovery ratio was 77.53%±18.32. All 4 had type 1 intramedullary high-signal intensity on preoperative T2-weighted MRIs.

**DISCUSSION**

Cervical spondylosis is a degenerative disease in which its compressive effects result in cervical spondylotic myelopathy, which includes herniation of intervertebral disks, posterior osteophytes, and infolding of hypertrophied ligamentum flavum. These lesions cause impingement on the cervical spinal cord.

Surgical decompression of the narrowed spinal canal or spondylotic protrusion has been the treatment of choice for patients with cervical spondylotic myelopathy with neurological deficits. An improvement rate of 48%-87% after posterior or anterior decompression or a combination of both has been reported. In our series the improvement rate was 57.3%, which is compatible with past studies.

It has been speculated that a change in the signal intensity of the spinal cord observed on MRI reflects pathologic changes in the spinal cord according to autopsy studies of the pre-MRI period in patients with compression myelopathy. Takahashi et al reported that a change in high-signal intensity of the spinal cord reflected myelomalacia or cord gliosis secondary to long-standing compression of

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**TABLE**

| Mean JOA Scores, Cord Compression Ratio, and Recovery Rates in Intramedullary High-Signal Intensity |
|---------------------------------|-------|-------|-------|
|                                 | Type 0 (n=16) | Type 1 (n=13) | Type 2 (n=13) |
| Preoperatively                  |            |            |            |
| JOA score                       | 13.9±2.7   | 12.69±2.2  | 10.2±1.9   |
| Cord compression ratio (%)      | 53.12±10.12| 48.23±9.87| 34.57±8.13|
| Postoperatively                 |            |            |            |
| JOA score                       | 15.9±1.9   | 14.38±2.1  | 12.38±1.8  |
| Cord compression ratio (%)      | 85.16±11.13| 81.27±10.26| 66.32±9.19|
| Recovery rate (%)               | 66.14±22.14| 71.5±20.73 | 34.6±11.31 |

*Abbreviation: JOA=Japanese Orthopaedic Association.*
the spinal cord, which is an indicator of poor prognosis. Ramanauskas et al20 divided myelomalacia into three stages and speculated that in the early stage, a change in signal intensity of the spinal cord observed on MRI reflected cord edema, in the intermediate stage, a change reflected cystic necrosis of the central gray matter after prolonged cord edema, and cavity or syrinx in the late stage. Ramanauskas et al20 also reported that in the early and intermediate stages, the spinal cord showed a high-signal intensity on T2-weighted sequences, and that in the late stage, a low-signal intensity on T1-weighted sequences and high-signal intensity on T2-weighted sequences were noted, which is an indicator of poor prognosis. Al-Mefty et al21 reported that low-signal changes on T1-weighted sequences and high-signal changes on T2-weighted sequences indicated cystic necrosis or secondary syrinx. Mehalic et al9 reported that high-signal changes on T2-weighted sequences were nonspecific and indicated edema, inflammation, vascular ischemia, gliosis, or myelomalacia, which might be postoperatively reversible. Therefore, the controversy of predicting the value of intramedullary high-signal intensity on T2-weighted MRI might be attributed to the reversible and irreversible components of intramedullary high-signal intensity as a whole.

In this study, we subdivided intramedullary high-signal intensity into two types. In type 1, the high-signal intensity is located at one level, and in type two, high-signal intensity extended in two or more segments. This subdivision was based on our own observations and two other studies. Wada et al4,22 found a significant correlation between multisegmental areas of high-signal intensity on T2-weighted MRI and areas of low-signal intensity on T1-weighted images. This significant correlation supports the cavitation theory, because there is a general consensus that increased signal on T2 with decreased signal on T1 is suggestive of a cavity in the spinal cord. Therefore, it was concluded that most multisegmental areas of high-signal intensity on T2-weighted MRIs may represent irreversible changes in the spinal cord, such as cavitations or cystic necrosis. However, focal areas of high-signal intensity on T2-weighted MRI were not of a valuable prognostic factor because they represent minor pathologic changes of the central spinal cord, such as edema. In our study, the poor prognosis of multisegmental high-signal intensity on T2-weighted MRIs supports this subdivision of two types of intramedullary high-signal intensity.

**CONCLUSION**

Not all patients with intramedullary high-signal intensity on T2-weighted MRI have poor postoperative outcome. Patients with focal areas of high-signal intensity will have the same surgical outcome as those without intramedullary high-signal intensity. Therefore, independent of the decompressive procedure, age, sex, and duration of symptoms, patients with multisegmental areas of high-signal intensity in the cervical spinal cord will have poor surgical outcome.

**REFERENCES**

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