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Is extensive cervical laminoplasty an effective treatment for spinal cord sarcoidosis combined with cervical spondylosis?

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Abstract

Main problems: Patients with neurosarcoidosis **are** usually **initially** treated with steroid administration even **when** they have concomitant cord compression on MRI. Operative intervention may be indicated in **patients with** spinal cord sarcoidosis **requiring either** tissue biopsy for diagnosis or associated with progressive neurologic symptoms. However, there have been no previous reports describing clinical outcomes of laminoplasty for spinal cord sarcoidosis. The objectives of this study are to investigate whether extensive cervical laminoplasty is an effective treatment for spinal cord sarcoidosis combined with spondylotic changes and/or cervical spinal canal stenosis.

Methods: Open-door laminoplasty was performed **in** three patients with spinal cord sarcoidosis. All patients received intensive corticosteroid therapy after the operation. Magnetic resonance imaging (MRI) was performed in all patients before and after the operation.

Results: Operative outcomes were not satisfactory and the clinical courses of the patients fluctuated after corticosteroid therapy. **Daily life activities** were not significantly improved after **treatments in any of the three patients**, and in the long term follow up period the clinical course of one patient was one of inexorable deterioration to a state of quadriplegia.

Conclusions: The possibility of spinal cord sarcoidosis should be included in the differential diagnosis, when a distinct high signal intensity area **is observed within the spinal cord** on T2-weighted MR images in patients with spondylotic changes. Laminoplasty is not an effective intervention for treatment of spinal cord sarcoidosis even **when** patients have spondylotic changes and/or a constitutionally narrowing

cervical spinal canal. **P**atients with neurosarcoidosis should be treated first with steroid administration even **when** they have concomitant cord compression on MRI.

Key words: sarcoidosis, spinal cord, cervical spine, laminoplasty, spondylosis

Introduction

Sarcoidosis is a multisystem, noncaseous granulomatous disease of unknown cause. Central nervous system involvement occurs in only about 5% of patients²⁸, **but when** sarcoidosis affects the nervous system **it** most commonly involves the brain and peripheral nerves. About 6% to 8% of cases with central nervous system involvement show spinal cord lesions.^{10,23} Spinal cord involvement is rare, occurring in only 0.3-0.4% of patients with systemic sarcoidosis.^{1,26} Thus, intramedullary neurosarcoidosis is a rare neurological manifestation, especially as an initial presentation.¹⁰ Neurological symptoms are usually myelopathy and focal weakness. Patients usually present with paraparesis, quadraparesis, hypesthesia, **as well as** bowel, bladder, and sexual dysfunction,^{7,19} **symptoms** which are often **also** observed in patients with cervical spondylotic myelopathy.

Magnetic resonance imaging (MRI) is the most useful technique for detecting neurosarcoidosis.^{4,11,12,20,21} Commonly, MRI of spinal cord sarcoidosis shows spinal cord swelling on T1-weighted images and **similar** high intensity **areas** on T2-weighted images.^{10,15,22,25} **When** spondylotic changes and developmental spinal stenosis are coexistent at the same portion of the spinal cord is sometimes difficult **for surgeons** to make **a** differential diagnosis from cervical spondylotic myelopathy.

Management of spinal cord sarcoidosis remains controversial **but** corticosteroid therapy **has been shown to improve the** neurological status and **suppress** inflammation and granuloma formation.¹⁹ Operative intervention may be indicated **when** tissue biopsy **is necessary** for diagnosis or **sarcoidosis** is associated with progressive neurological symptoms.¹¹ **When** cervical spondylosis **is** combined with spinal sarcoidosis causing myelopathy, operative decompression by laminoplasty might

be indicated. However, there have been no previous reports describing **the** clinical outcomes of laminoplasty **in such cases**. This **paper** presents three **patients with** spinal cord sarcoidosis combined with cervical spondylosi **and describes** the clinical outcomes of **treatment** with open-door laminoplasty combined with steroid therapy.

Case Report

Case 1. A 56-year-old woman first noticed numbness in her bilateral hands 6 months before admission to our institution. **She** developed a progressive weakness in her lower extremities and a gait disturbance one month later **followed by** urination **difficulties**. **She** was admitted to our hospital in January 2003.

Neurological examination revealed decrease in light touch and pin prick sensation in both the upper and lower extremities. Deep tendon reflexes were hyperactive in both **the** upper and lower extremities. A manual muscle strength test of the lower extremities was completely unremarkable, **while** that of the flexor and abductor of the right fingers decreased to 3/5. Neurological examinations were otherwise normal. The angiotensin-converting enzyme (ACE) level was **within the** normal range.

Plain radiograph of **the** cervical spine showed spondylotic changes at C4/5, 5/6 levels. A T2-weighted MR image showed a developmental canal stenosis and a hyperintense intramedullary signal extending from C4 to C6 (Fig.1-A).

The patient was diagnosed with cervical spondylotic myelopathy and open door laminoplasty was performed, because spondylotic changes were observed **in** the same area as **the** T2-weighted MR image revealed high signal intensity. After the operation, the patient complained of spasm at the right upper and lower extremities. Subsequent MRI revealed enlargement of the high signal intensity area on the T2-weighted image

(Fig.1-B). However, no space occupying lesion such as epidural hematoma was observed. Gadolinium DTPA (Gd) enhanced T1-weighted MR images showed a spotty enhancement at the C5/6 level (Fig.2-A). Intravenous methylprednisolone (8480 mg/day) was administered according to the NASCIS (National Acute Spinal Cord Injury Study) regimen, **because** spinal cord injury was suspected.

Enlarged bilateral hilar lymph nodes were detected by chest radiography and computed tomography (CT). The pathological diagnosis of sarcoidosis was confirmed upon finding non-caseating granuloma with giant cells of biopsied scalene lymph nodes. A daily dose of methylprednisolone (1000mg/day) was given for three days. No clinical deterioration in either motor or sensory symptoms appeared, although marked reduction in enlargement of the spinal cord (Fig.1-C) and in **the** abnormally enhanced lesion (Fig.2-B) was observed 7 months after the operation.

Case 2. A 58-year-old woman noted a slowly progressive weakness in her lower extremities, and both clumsiness and numbness in her bilateral hands three months before admission to our institution. She was diagnosed with cervical spondylotic myelopathy and admitted to our hospital in March 2001.

Neurological examination revealed a decrease in light touch and pin prick **sensation** in both upper and lower extremities. Deep tendon reflexes were hyperactive in triceps tendon reflex (TTR) and in **the** lower extremities, and Hoffman's, Trömner's and Babinski's signs were positive bilaterally. A manual muscle strength test of both upper and lower extremities decreased to 4/5 besides(right word?) **the** deltoid muscle. Neurological examinations were otherwise normal. Blood biochemical analyses including ACE were normal, although the cerebrospinal examination revealed **a** higher

protein content.

Plain radiograph of **the** cervical spine showed spondylotic changes at C4/5 level. A T2-weighted MR image revealed an area of high signal intensity extending from C2 to Th1 (Fig.3-A). Gd-enhanced T1-weighted MR images showed a focal enhancement at the C4/5 level (Fig.4-A).

The patient was diagnosed with cervical spondylotic myelopathy **with** sarcoidosis, as **confirmed** by a lymph node biopsy. Surgical decompression was performed before steroid therapy, because there was a spinal canal stenosis relative to the swollen spinal cord, spondylotic changes were observed at C4/5 level, and the patient **had** developed progressive weakness in both **the** upper and lower extremities.

Mild improvement in motor function of the hand appeared after the operation and the patient was discharged 4 weeks after the operation. However, spasticity and numbness of the limbs were exacerbated and gait disturbance worsened 7 weeks after the operation **and** the patient was admitted to the Department of Neurology at our institution.

MRI at the time of admission showed spinal cord swelling from **the** lower medulla oblongata to T1 on the T1-weighted image and high signal intensity within **the** spinal cord that was more extensively enlarged than preoperatively on the T2-weighted image (Fig.3-B). Gd-enhanced T1-weighted MR images also showed stronger enhancement at C4/5 level postoperatively than preoperatively (Fig.4-B).

Intravenous methylprednisolone (1000mg/day) was given for 3 days. A slight reduction in numbness was observed after the steroid therapy. MRI performed 2 weeks after the steroid therapy showed a marked decrease in the high signal intensity area on T2-weighted image (Fig.3-C). A marked reduction in the abnormally enhanced lesion

was also observed (Fig.4-C). The clinical course of the patient fluctuated, but her ability to participate in daily life activities slowly decreased until she was unable to stand three years after the operation.

Case 3. A 59-year-old man noted a slow progressive weakness in his lower extremities, and both clumsiness and numbness of the right hand two months before admission. The patient was admitted to another hospital and since Gd-enhanced T1-weighted MR images demonstrated a spotty intramedullary enhancement, neurosarcoidosis was suspected and the patient was transferred to our hospital.

Neurological examination revealed a decrease in light touch and pin prick **sensation** in the right upper extremity. Deep tendon reflexes were hyperactive in both upper and lower extremities, and Hoffman's, Trömner's and Babinski's signs were positive bilaterally. A manual muscle strength test of both finger abductors decreased to 4/5. Neurological examinations were otherwise normal. Blood biochemical analyses including ACE were normal.

Plain radiograph of cervical spine showed spondylotic changes at C3/4 and C4/5 levels. A T2-weighted MR image revealed an area of high signal intensity extending from C3 to C5 (Fig.5-A). Gd-enhanced T1-weighted MR images showed a focal enhancement at the C3/4 level (Fig.6-A).

The patient was diagnosed with cervical spondylotic myelopathy combined with sarcoidosis as diagnosed by lymph **node** biopsy. Surgical decompression was performed before steroid therapy, because there was a spinal canal stenosis relative to the swollen spinal cord and spondylotic changes were observed at C3/4 and C4/5 levels.

Mild deterioration in motor function of the hand appeared after the operation,

although gait disturbance remained unchanged. The patient was transferred to the Department of Neurology at our institution.

MRI at the time of admission showed a smaller high signal intensity region than preoperatively on the T2-weighted image (Fig.5-B). Gd-enhanced T1-weighted MR images showed the same enhancement at C3/4 level as preoperatively (Fig.6-B).

Intravenous methylprednisolone (1000mg/day) was given for 3 days. Few significant changes were observed after the steroid therapy. MRI performed 6 weeks after the steroid therapy showed almost the same high signal intensity area as postoperatively on T2-weighted image (Fig.5-C). No reduction in the abnormally enhanced lesion was observed (Fig.6-C). Activities of daily life were not significantly improved after the treatments.

Discussion

Several reports have described MRI findings of spinal cord sarcoidosis.^{3,9,10,11,13,25} Typical findings reveal both focal and diffuse hyperintensity on T2-weighted image, sometimes misdiagnosed as myelomalacia when patients have spondylotic changes and/or a narrowing of the spinal canal.

There is no known cure for neurosarcoidosis. Treatment is implemented to reduce symptoms and can possibly lead to remission. **A literature review** of histologically proven intramedullary sarcoidosis **showed that 50% of patients** who underwent a more extensive resection **suffered** a post operative deterioration in neurological function.¹⁶ **In contrast, the deterioration** was only seen in 28% of limited biopsy patients. **As a result of these findings**, a limited laminectomy and biopsy or subtotal resection are usually performed, when tissue diagnosis **is** required in patients with **no** history of

sarcoidosis **in order to** differentiate an inflammatory from a neoplastic lesion.¹¹

However there is no consensus on the pharmacological treatment of neurosarcoidosis.

High doses of corticosteroid therapy are recommended for initial treatments, but the most appropriate points for tapering off and discontinuing treatment after response have not been standardized.¹⁴ Immunosuppressive agents are occasionally used to supplement corticosteroids, although a clinical response cannot be guaranteed.²⁷

Laminoplasty has **also** been used to manage the decreased space occupied by the spinal cord caused by spondylotic bars, intervertebral disc hernia, ossification of the posterior longitudinal ligament, and/or a constitutionally narrowing cervical spinal canal.⁵ **When** dynamic factors further reduce the functional diameter of the spinal canal, **this contributes** to the development of cervical myelopathy.^{8,17} Changes to the text appear in light gray in the paper. laminoplasty **becomes** a feasible posterior decompression procedure for the cervical spinal cord **as an attempt** to manage multisegmental cord compression. However, this procedure is sometimes **inadequately** performed **in** patients with a spinal canal stenosis relative to the swollen spinal cord **such as that** observed in intramedullary spinal cord diseases **like** neurosarcoidosis, multiple sclerosis, **or** intramedullary tumor.

In patient 1, laminoplasty was performed before neurosarcoidosis was diagnosed, **however** symptoms deteriorated soon after the operation. With corticosteroid therapy the progression of symptoms **was halted** and then slightly improved. **Patient 2 and 3** showed cervical canal stenosis caused by spondylotic changes **and** surgical decompression before steroid therapy **was selected for treatment**, because we believed enlarging the cross-sectional area of the spinal canal would be a more effective treatment than **administering** only steroid therapy **due to** spinal canal stenosis relative

to the swollen spinal cord. The symptoms of patient two significantly improved soon after the operation, **however**, the clinical course **fluctuated** after corticosteroid therapy. In patient three, the symptoms improved **slightly** after the operation and then progressively deteriorated even after **corticosteroid** therapy. **Daily life activities** were not significantly improved **in any of the three patients** after the treatment, and in the long term follow up period, the clinical course of patient two was one of inexorable deterioration to a state of quadriplegia.

Decompression surgery including laminoplasty has been considered safe and effective for enlarging the cross-sectional area of the spinal canal. However, as shown in this study, the effects of laminoplasty **are** not predictable **in** the treatment of spinal cord sarcoidosis even when patients have spondylotic changes and/or a constitutionally narrowing cervical spinal canal. It has been reported that a long interval from the onset of disease to the initiation of corticosteroid therapy contributes to poor functional recovery¹; however poor results were achieved in **all** our three patients even with the rapid administration of corticosteroid therapy. **Thus** laminoplasty is not an effective intervention for the treatment of spinal cord sarcoidosis with or without spondylotic changes. The possibility of spinal cord sarcoidosis should be included in the differential diagnosis, when a distinct high signal intensity area within the spinal cord on T2-weighted MR images is observed in patients with spondylotic changes. **Patients** with neurosarcoidosis should be treated first with steroid administration even if they have concomitant cord compression on MRI.

References

1. Bogousslavsky J, Hungerbuhler JP, Regli F, et al (1982) Subacute myelopathy as the presenting manifestation of sarcoidosis. *Acta Neurochir (Wien)* **65**: 193-197.
2. Chiba K, Toyama Y, Matsumoto M, et al (2002) Segmental motor paralysis after expansive open-door laminoplasty. *Spine* **27**: 2108-2115.
3. Chitoku S, Kawai S, Watabe Y, et al (1997) Multiple intramedullary spinal sarcoidosis: case report. *Surg Neurol* **48**: 522-525; discussion 525-526.
4. Dumas JL, Valeyre D, Chapelon-Abric C, et al (2000) Central nervous system sarcoidosis: follow-up at MR imaging during steroid therapy. *Radiology* **214**: 411-420.
5. Fukui K, Kataoka O & Sho T (1990) Pathomechanism, pathogenesis, and results of treatment in cervical spondylotic myelopathy caused by dynamic canal stenosis. *Spine* **21**: 1148-1152.
6. Gero B, Sze G & Sharif H (1991) MR imaging of intradural inflammatory disease of the spine. *AJNR Am J Neuroradiol* **12**: 1009-1019.
7. Hayat GR, Walton TP, Smith KR, Jr., et al (2001) Solitary intramedullary neurosarcoidosis: role of MRI in early detection. *J Neuroimaging* **11**: 66-70.
8. Holmes A, Han ZH & Dang GT (1996) Changes in cervical canal spinal volume during in vitro flexion-extension. *Spine* **21**: 1313-1319.
9. Jaster JH, Dohan FC, Jr., Bertorini TE, et al (1997) Solitary spinal cord sarcoidosis without other manifestations of systemic sarcoidosis. *Clin Imaging* **21**: 17-22.
10. Junger SS, Stern BJ, Levine SR, et al (1993) Intramedullary spinal sarcoidosis: clinical and magnetic resonance imaging characteristics. *Neurology* **43**: 333-337.
11. Kayama S & Kikuchi S (1993) Intramedullary spinal cord sarcoidosis. Report of

two cases. *Spine* **18**: 2118-2120.

12. Koike H, Misu K, Yasui K, et al (2000) Differential response to corticosteroid therapy of MRI findings and clinical manifestations in spinal cord sarcoidosis. *J Neurol* **247**: 544-549.
13. Levivier M, Brotchi J, Baleriaux D, et al (1991) Sarcoidosis presenting as an isolated intramedullary tumor. *Neurosurgery* **29**: 271-276.
14. Lower FE, Broderick JP, Brotl TG, et al (1997) Diagnosis and management of neurological sarcoidosis. *Arch Intern Med* **157**: 1864-1868.
15. Manabe Y, Sakai K, Takahashi K, et al (1999) An MR image of spinal cord sarcoidosis. *Neurol Res* **21**: 755-757.
16. Mathieson CS, Mowle D, Ironside JW, et al (2004) Isolated cervical intramedullary sarcoidosis--a histological surprise. *Br J Neurosurg* **18**: 632-635.
17. Miyata K, Marui T, Miura J, et al (2006) Kinetic analysis of the cervical spinal cord in patients after spinous process-splitting laminoplasty using a kinematic magnetic resonance imaging technique. *Spine* **31**: E690-697.
18. Morio Y, Teshima R, Nagashima H, et al (2001) Correlation between operative outcomes of cervical compression myelopathy and mri of the spinal cord. *Spine* **26**: 1238-1245.
19. Nagai H, Ohtsubo K & Shimada H (1985) Sarcoidosis of the spinal cord. Report of an autopsy case and review of the literature. *Acta Pathol Jpn* **35**: 1007-1022.
20. Nesbit GM, Miller GM, Baker HL, Jr., et al (1989) Spinal cord sarcoidosis: a new finding at MR imaging with Gd-DTPA enhancement. *Radiology* **173**: 839-843.
21. Rieger J & Hosten N (1994) Spinal cord sarcoidosis. *Neuroradiology* **36**: 627-628.
22. Sauer MK, Panitch HS & Kristt DA (1991) Myelopathic nerosarcoidosis:

- Diagnostic value of enhanced MRI. *Neurology* **41**: 150-151.
23. Scott TF (1993) Neurosarcoidosis: progress and clinical aspects. *Neurology* **43**: 8-12.
 24. Seichi A, Takeshita K, Kawaguchi H, et al (2004) Postoperative expansion of intramedullary high-intensity areas on T2-weighted magnetic resonance imaging after cervical laminoplasty. *Spine* **29**: 1478-1482; discussion 1482.
 25. Sherman JL & Stern BJ (1990) Sarcoidosis of the CNS: comparison of unenhanced and enhanced MR images. *AJNR Am J Neuroradiol* **11**: 915-923.
 26. Slade WR, Jr. (1979) Sarcoid of the nervous system. *J Natl Med Assoc* **71**: 1205-1208.
 27. Sodhi M, Pearson K, White ES, et al (2008) Infliximab therapy rescues cyclophosphamide failure in severe central nervous system sarcoidosis. *Respir Med* (Epub ahead of print).
 28. Stern BJ, Krumholz A, Johns C, et al (1985) Sarcoidosis and its neurological manifestations. *Arch Neurol* **42**: 909-917.
 29. Wada E, Yonenobu K, Suzuki S, et al (1999) Can intramedullary signal change on magnetic resonance imaging predict surgical outcome in cervical spondylotic myelopathy? *Spine* **24**: 455-461.

Figure legends

Figure 1. Magnetic resonance images **from Patient 1**. Sagittal (**A**) and axial (**a**) T2-weighted MR image show developmental canal stenosis and hyperintense intramedullary signal extending from C4 to C6. **B, b**: MR image taken after operation reveals enlargement of high signal intensity area. **C, c**: MR image taken after corticosteroid therapy shows marked reduction of high signal intensity area in enlargement of spinal cord.

Figure 2. Gadolinium DTPA (Gd) enhanced T1-weighted MR images **for Patient 1**. **A, a**: After operation, spotty enhancement is seen at the C5/6 level. **B, b**: An abnormally enhanced lesion remains 7 months after treatments.

Figure 3. Magnetic resonance images **from Patient 2**. Sagittal (**A**) and axial (**a**) T2-weighted MR image reveal area of high signal intensity extending from C2 to Th1. **B, b**: MR image taken after operation shows higher signal intensity within more extensively enlarged spinal cord than preoperatively. **C, c**: MR image performed 2 weeks after steroid therapy shows markedly decreased high signal area.

Figure 4. Gadolinium DTPA (Gd) enhanced T1-weighted MR images **from Patient 2**. **A, a**: Preoperative MR image shows focal enhancement at C4/5 level. **B, b**: MR image after operation reveals stronger enhancement of high signal intensity at C4/5 level postoperatively than preoperatively. **C, c**: MR image taken after steroid treatment reveals marked reduction in abnormally enhanced lesion.

Figure 5. Magnetic resonance images **from Patient 3**. Sagittal (**A**) T2-weighted MR image reveals area of high signal intensity extending from C3 to C5. **B, b**: MR image taken after operation shows smaller high signal intensity region than preoperatively. **C, c**: MR image performed 6 weeks after steroid therapy shows almost same high signal

area as postoperatively.

Figure 6. Gadolinium DTPA (Gd) enhanced T1-weighted MR images **from Patient 3.**

A, a: Preoperative MR image shows focal enhancement at C3/4 level. **B, b:** MR image after the operation shows same enhancement at C3/4 level as preoperatively. **C, c:** MR image taken after the steroid treatment reveals no reduction in abnormally enhanced lesion.

Fig. 1 Magnetic resonance images from Patient 1.
a Sagittal and axial T2-weighted MR image show developmental canal stenosis and hyperintense intramedullary signal extending from C4 to C6. **b** MR image taken after operation reveals enlargement of high signal intensity area. **c** MR image taken after corticosteroid therapy shows marked reduction of high signal intensity area in enlargement of spinal cord

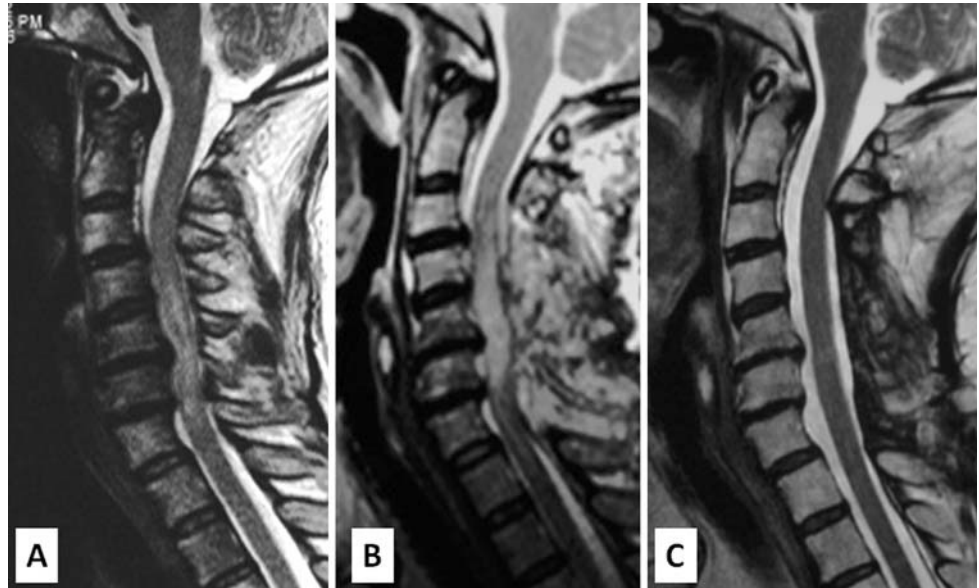


Fig. 2 Gadolinium DTPA (Gd)-enhanced T1-weighted MR images for Patient 1.
a After operation, spotty enhancement is seen at the C5/6 level. **b** An abnormally enhanced lesion remains 7 months after treatments

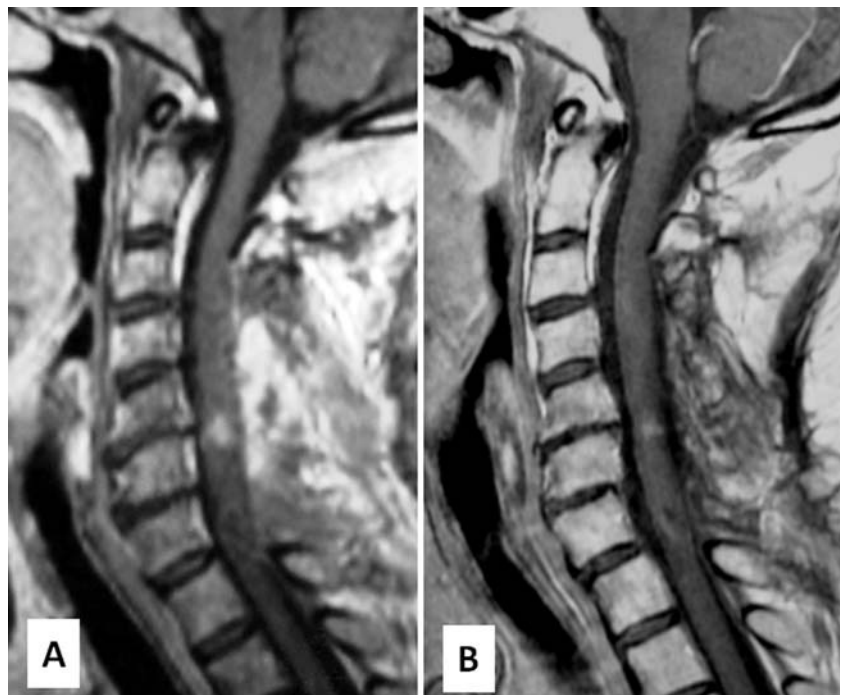


Fig. 3 Magnetic resonance images from Patient 2. **a** Sagittal and axial T2-weighted MR image reveal area of high signal intensity extending from C2 to Th1. **b** MR image taken after operation shows higher signal intensity within more extensively enlarged spinal cord than preoperatively. **c** MR image performed 2 weeks after steroid therapy shows markedly decreased high signal area

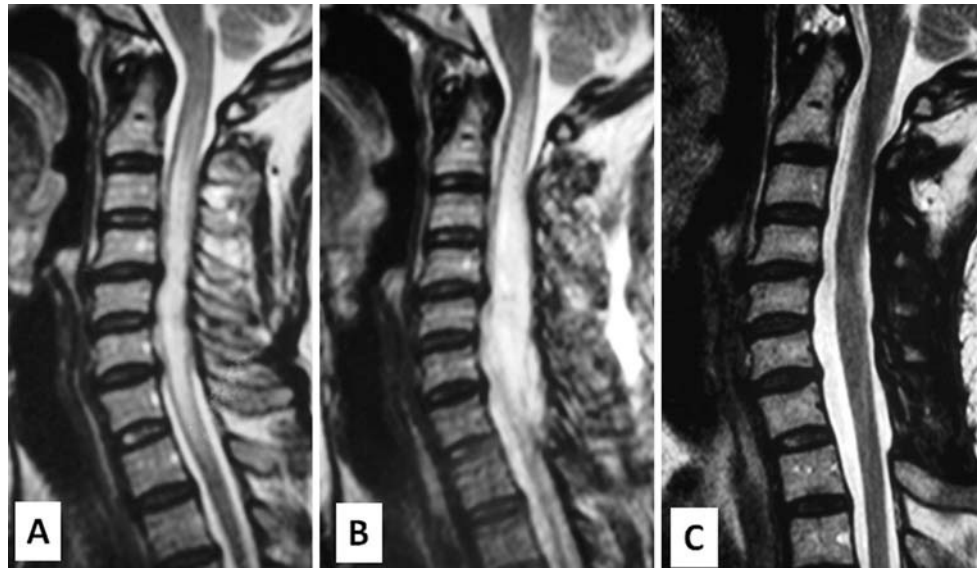


Fig. 4 Gadolinium DTPA (Gd)-enhanced T1-weighted MR images from Patient 2. **a** Preoperative MR image shows focal enhancement at C4/5 level. **b** MR image after operation reveals stronger enhancement of high signal intensity at C4/5 level postoperatively than preoperatively. **c** MR image taken after steroid treatment reveals marked reduction in abnormally enhanced lesion

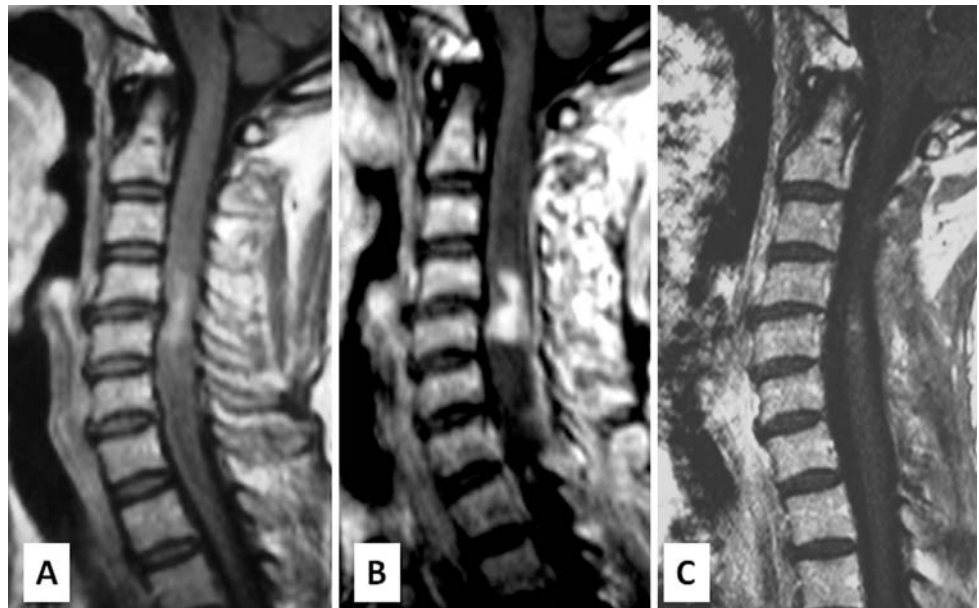


Fig. 5 Magnetic resonance images from Patient 3. **a** Sagittal T2-weighted MR image reveals area of high signal intensity extending from C3 to C5. **b** MR image taken after operation shows smaller high signal intensity region than preoperatively. **c** MR image performed 6 weeks after steroid therapy shows almost same high signal area as postoperatively

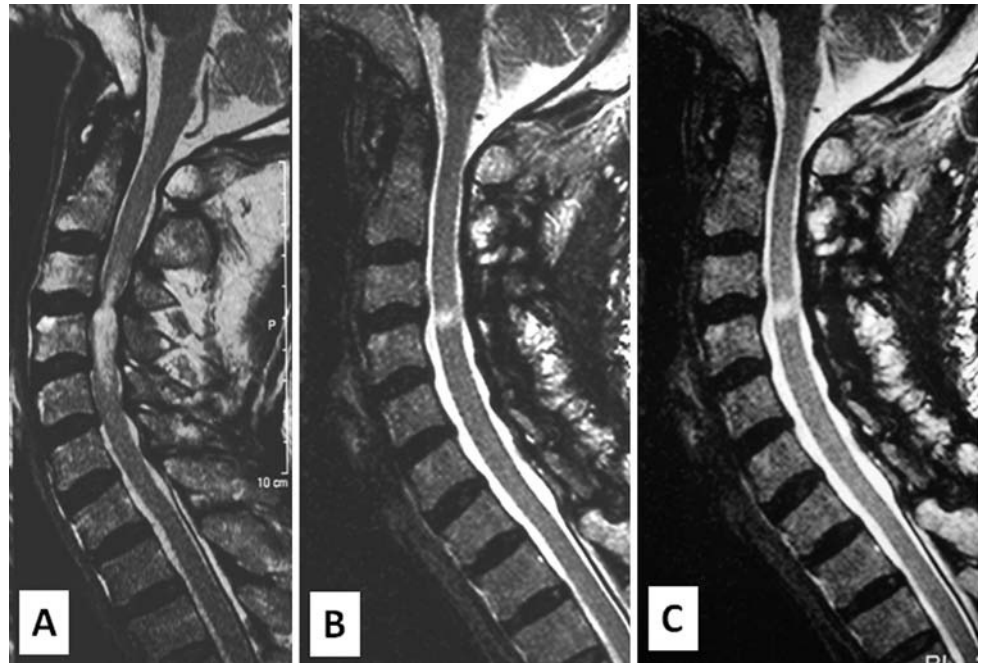


Fig. 6 Gadolinium DTPA (Gd)-enhanced T1-weighted MR images from Patient 3. **a** Preoperative MR image shows focal enhancement at C3/4 level. **b** MR image after the operation shows same enhancement at C3/4 level as preoperatively. **c** MR image taken after the steroid treatment reveals no reduction in abnormally enhanced lesion

