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ORIGINAL PAPER

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Factors affecting the surgical results of expansive laminoplasty for cervical spondylotic myelopathy

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Abstract We studied the outcome of expansive laminoplasty in 37 patients with cervical spondylotic myelopathy. Patients were divided into two groups according to the recovery rate (RR) – a 'good' group (n=19), and a 'fair' group (n=18). Patients in the good group showed a greater pre-operative Japanese Orthopaedic Association (JOA) score, a greater compression ratio, and a larger Pavlov ratio (P<0.05). The presence of high signal intensity on MRI proved to be of no prognostic importance.

Résumé Nous avons étudié le résultat des laminoplasties d'expansion chez 37 malades atteint de myelopathie spondylotique cervicale. D'après le taux de récupération les malades ont été divisés en un groupe 'bon' (n=19) et un groupe 'juste' (n=18). Les Malades dans le groupe bon avaient un score JOA plus élevé en préopératoire, un plus grand taux de compression, et un ratio de Pavlov plus grand (P<0.05). La présence d'un signal de haute intensité sur l'IRM n'avait pas d'importance pronostique.

Introduction

There are many reports on the factors affecting the prognosis of surgery for patients with cervical myelopathy [1, 2, 4, 3, 5, 6, 7, 11, 12, 13, 14, 15, 16, 17, 19, 21, 22]. Some factors have been said to influence the results, but not all have been proved to be of prognostic value. The presence of a significant cervical kyphosis seems to affect prognosis adversely if the patient is treated by laminoplasty alone, as there may be no significant neurological improvement when the posterior cord is involved [1, 2, 19]. Accurate prediction of the likely surgical results is difficult in older patients but in general it seems to be worse than in the younger age group [4, 11, 15, 21]. It is often very difficult for patients to remember when their symptoms first appeared, but a longer history is also related to an incomplete recovery [4, 11]. The gender of the patient, a history of trauma, the pre-operative severity of the myelopathy, the width of the spinal canal and the presence of a high signal-intensity area in the spinal cord have not been proved to be of prognostic value. In addition, patients in previous studies were not similar in terms of the underlying disease and type of surgery. In our study we have tried to assess results in patients treated surgically who had similar disease characteristics and were treated by the same procedure. We also investigated the validity of various pre-operative factors as prognostic indicators.

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Materials and methods

Between 1993 and 1998, 113 patients with cervical myelopathy were treated surgically. We operated on patients with cervical myelopathy when myelopathy symptoms were present. These symptoms included motor weakness of the extremities, finger clumsiness, radiating pain, increased tendon reflexes, a gait disturbance for more than 3 months, and, in addition, when there was either evidence of cord compression on MRI or symptoms were aggravated by conservative treatment.

Forty-nine of the 133 patients had cervical spondylotic myelopathy involving more than three levels and were treated with 'open-door' laminoplasty from C3 to C7. Cord compression by a protruding bone spur along with either a bulging disc and pressure from the ligamentum flavum, or both, producing deformation of the spinal cord at three or more levels, was evident in these patients on a T2-weighted mid-sagittal MRI. Of these 49 patients, three were lost during follow-up and nine were followed for less than 2 years. Thus, there were 37 patients who were assessed after at least 2 years or more. There were 24 men and 13 women with an average age of 58 years (range: 41–82).

We did not include patients with ossification of the posterior longitudinal ligament, nor any patients with spondylotic myelopathy at less than three levels. Patients were excluded if they had acute cord compression caused by disc herniation beyond the margin of a bone spur, whether or not there was any significant canal narrowing. We also excluded patients with cervical kyphosis, as they were not treated with simple laminoplasty but with an anterior procedure with or without posterior laminoplasty in order to restore lordosis.

Table 1 Evaluation system for cervical myelopathy (Japanese Orthopaedic Association score)

Category	Score (points)
A. Motor function	
Upper extremity	
Unable to feed oneself	0
Unable to handle chopsticks; able to eat with spoon	1
Handles chopsticks with great difficulty	2
Handles chopsticks with slight difficulty	3
Normal	4
Lower extremity	
Unable to stand and walk by any means	0
Unable to walk without support on the level	1
Walks independently on the level but needs support on stairs	2
Capable of fast walking but clumsily	3
Normal	4
B. Sensory function	
Upper extremity	
Apparent sensory loss	0
Minimal sensory loss	1
Normal	2
Lower extremity	
Apparent sensory loss	0
Minimal sensory loss	1
Normal	2
Trunk	
Apparent sensory loss	0
Minimal sensory loss	1
Normal	2
C. Bladder function	
Urinary retention, incontinence	0
Sense of retention, dribbling, thin stream	1
Urinary retardation, polyuria	2
Normal	3

All patients underwent the same procedure using the expansive open-door laminoplasty from C3 to C7 as described by Hirabayashi [9]. Average follow-up was 42 months (range: 24–84). The scoring system of the Japanese Orthopaedic Association (JOA) was used for clinical assessment before and after surgery (Table 1). The recovery rate (RR) was calculated using the formula suggested by Hirabayashi et al. [8].

A plain lateral radiograph was used to measure the Pavlov ratio [18] (Fig. 1), and this was done at the level of the narrowest canal diameter. Pre-operative T1-weighted axial imaging with a Signa 1.5-tesla scanner (General Electric Medical Systems, Milwaukee, WI, USA) was used to determine the compression ratio (Fig. 2), and this ratio was measured at the maximum compression level. Pavlov and compression ratios were computed using a manual cursor technique on a PACS monitor (Picture Archiving and Communication System, Loral, USA) after modification of the contrast and magnification of the images to ensure accurate measurement.

Patients were divided into two groups according to their recovery rate: Nineteen patients with an RR of more than 50% (average: 73%) were classified into the good recovery group and 18 were included in the fair recovery group, according to Kohno et al. [11]. The pre-operative JOA score, age at surgery, gender, trauma history, duration of symptoms, Pavlov ratio, compression ratio and presence of signal change in the spinal cord on T2-weighted MRI, were then assessed to find any differences between the two groups.

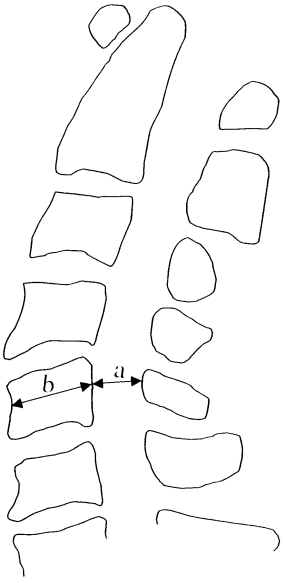

Fig. 1 Drawing demonstrating measurement of the Pavlov ratio=a/b: *a* Sagital diameter of the spinal canal, *b* sagital diameter of the vertebral body at the same level

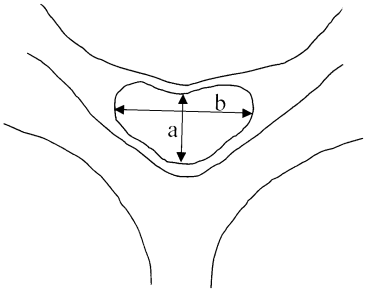

Fig. 2 Drawing demonstrating measurement of the compression ratio=a/b: *a* Smallest sagital diameter of the spinal cord, *b* broadest transverse diameter of the cord at the same level

Table 2 Pre-operative clinical data and measurements

Age at operation (years)	57.6±24.3 (range: 41–82)
Pre-operative JOA score	8.7±1.4 (range: 6–12)
Pavlov ratio	0.67±0.08 (range: 0.51–0.9)
Compression ratio	0.54±0.14 (range: 0.28–0.81)
Signal change on MRI	11 patients
Trauma history	7 patients

Plain lateral radiographs were used to determine whether or not the Ishihara index (cervical lordosis) [10] had been altered by the surgery and whether the laminoplasty remained open. MRIs were obtained post-operatively in some patients (n=25) and allowed measurement of the extent of the decompression achieved. However, we did not include the post-operative MRI findings in our analysis as we were trying to assess the value of various pre-operative factors as prognostic indicators.

We also assessed the significance of the duration of pre-operative moderate to severe symptoms in patients with a pre-operative JOA score of less than 9 (n=23). We distinguished these patients from those with mild pre-operative symptoms, as all patients (except one) with a pre-operative JOA score of more than 10 (n=14) made a good recovery. Pre-operative clinical data of patients is summarised in Table 2. Comparisons between the two groups were performed using the multiple regression and independent t-test. Correlation of the two variables was calculated using the linear regression test. The overall P value indicating statistical significance was set at 0.05.

Table 3 Comparative clinical data and measurements of patients in each group

	Good group Recovery rate ≥50%	Fair group Recovery rate <50%
Sex distribution	11 men, 8 women (Total 19 patients)	13 men, 5 women (Total 18 patients)
Age at surgery (years)		59.1±9.9
Symptom duration (months)	19.4±10.1	26.9±18.1
JOA score		
Pre-op.*	10.1±1.1	8.3±1.1
Post-op.*	15.2±0.7	11.4±1.5
Mean recovery rate*	73.1%	36.3%
Pavlov ratio*	0.70±0.05	0.63±0.09
Compression ratio*	0.60±0.10	0.46±0.15
Signal change on MRI	4 patients (21%)	7 patients (39%)
Trauma history	4 patients (21%)	3 patients (17%)

Recovery rate: ≥50%=good recovery group; <50%=fair recovery group
*Statistically significant difference is present between the groups (P<0.05) post-operative JOA score – pre-operative JOA score $\mathrm{RR}\,(\%)\ \frac{\text{post}-\text{op JOA score} - \text{pre}-\text{op JOA score}}{17\ (\text{full}) - \text{pre}-\text{op JOA score}} \times 100$

Table 4 Comparison of duration of symptoms of patients with pre-operative JOA score less than 9

*Statistically significant difference is present between the groups (P<0.05)

	Good group (Recovery rate ≥50%)	Fair group (Recovery rate <50%)
Sex distribution	4 men, 2 women (Total 6 patients)	10 men, 7 women (Total 17 patients)
Age at surgery (years)	60.8±10.8)	59.2±10.1
Symptom duration (months)*	13.5±3.6	27.1±18.7

Results

Comparative clinical date of the patients in each group is summarised in Table 3. Post-operative clinical improvement was observed in 33 patients (89.2%) (Table 3). Post-operative lateral radiographs revealed a statistically insignificant decrease of cervical lordosis using the Ishihara index at final follow-up (from 15.9±5.77 to 13.5±6.55). It was also evident on the final follow-up radiographs that the laminoplasty remained widely open. Among the pre-operative prognostic factors of gender, symptom duration, trauma history, and the presence of signal change in the cord, no significant statistical difference was shown between the two groups (P<0.05). Pre-operative JOA score, Pavlov ratio and compression ratio on MRI significantly affected post-surgical result (P<0.05). Data regarding symptom duration of patients with a pre-operative JOA score of less than 9 are summarised in Table 4, and this data shows there is a significant difference between the two groups (P<0.05).

Compression ratio showed a significant positive correlation with the Pavlov ratio (Y=0.948X–0.009, Y: compression ratio, X: Pavlov ratio, R=0.54, P=0.007).

Discussion

Although there are many reported studies of the prognostic factors in the surgical treatment of patients with cervical myelopathy, there are still controversies. One reason seems to be the heterogeneity of the patients studied. Fujiwara et al. [5] reported that the transverse area of the cord at the level of maximum compression provided the most reliable parameter in prognosis. However, patients in his study included those with spondylotic myelopathy, myelopathy due to soft disc herniation and those with ossification of the posterior longitudinal ligament. Other studies also show similar heterogeneity of the diagnosis of patients or methods of treatment [4, 3, 7, 11, 12, 14, 15, 16, 22]. We tried to include patients with similar disease characteristics. Patients were only included if they had spondylotic myelopathy at more than three levels and without either prominent disc protrusion or ossification of the posterior longitudinal ligament. In addition, only patients treated by a posterior open-door laminoplasty from C3 to C7 were included. Patients with cervical kyphosis were treated with either an anterior procedure alone or by a combined anterior and posterior approach in order to restore cervical lordosis. Published papers suggest that a significant neurological improvement is associated with posterior cord migration and that this, in turn, shows a significant correlation with the extent of pre-operative cervical lordosis [1, 2, 11, 19]. In our series, patients with kyphosis were excluded because we wanted to exclude the effect of the type of surgery on the surgical results.

Other studies report that the post-operative recovery of spinal cord function in the older age group is significantly inferior to that which occurs in younger patients [4, 5, 11,15]. However, other authors recommend surgical decompression for cervical myelopathy, even in patients over 75 years of age [13]. Our results support this

recommendation, as we did not find any statistically significant difference related to age in either group. In addition, surgical results in our older patients were not significantly different to those in younger patients. It has been reported also that older patients are likely to have problems at more levels [15]. Similar results in our study between the older and younger patients could be due partly to the selection of patients with myelopathy at more than three levels. In addition, duration of symptoms was not significantly different between patients over the age of 65 and those under 65 years of age. It is possible that the poorer results of older patients in other studies could be due to more levels of involvement and longer duration and greater severity of pre-operative symptoms. Some authors report that the duration of symptoms affects surgical results [4, 11], but it is very difficult for patients to remember when their symptoms began. In an attempt to clarify the duration of symptoms, our patients were not asked either when the neck pain began or when their symptoms began, but specifically when pain, weakness, or 'clumsiness' of their upper limb was first noted. No correlation was found between duration of symptoms and recovery rate. It was thought, therefore, that duration of symptoms did not affect results if patients had only mild symptoms before surgery. To test this hypothesis, patients were excluded if their pre-operative JOA score was greater than 10 in the analysis of the duration of symptoms and whose recovery rate from surgery was good. However, we did find that duration of symptoms affected the results of laminoplasty if patients had a pre-operative JOA score of less than 9.

High signal changes usually occurred at the level of constriction of the spinal cord, as previously reported [20], and there are several reports concerning the significance of a high signal-intensity area in the cord [11, 14, 15, 22]. Nakamura, Fujimura and Kohno et al. [11, 16] reported that a high signal intensity was a poor prognostic factor. However, Morio et al. [14] and Yone et al. [22] maintained that the presence or absence of a high-intensity area did not correlate with surgical results. In our study, patients more often showed signal changes in the spinal cord in the fair group than in the good group, but this difference was not statistically significant.

Fugiwara et al. [5] concluded that the influence of several other factors, such as the type of disease, age at surgery, multiplicity of involvement and chronicity of disease, proved to result from alterations in the transverse area of the spinal cord. We measured Pavlov and compression ratios because this was easy to do in the clinic and showed good reproducibility. It also appeared that these ratios could 'replace' measuring the transverse area of the cord if there was no acute compression by a prominent disc. Both of these ratios proved to influence the results of surgery.

The pre-operative JOA score and Pavlov and compression ratios are useful in predicting the prognosis in patients with cervical spondylotic myelopathy. The presence of a high signal-intensity area in the spinal cord in this study has not been shown to be of prognostic value. Duration of symptoms can help predict the prognosis if patients have more severe pre-operative symptoms. Thus, if symptoms are severe, it is necessary to operate as early as possible in order to improve surgical results. However, it is wiser to operate on patients when their clinical symptoms and radiological findings are still relatively mild.

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