The effects of surgery on locomotion in elderly patients with cervical spondylotic myelopathy

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Abstract

Purpose This study aimed to evaluate the effects of surgery on locomotor ability in patients with cervical spondylotic myelopathy (CSM) and compare the results between elderly and younger patients.

Methods A total of 369 consecutive patients who underwent expansive laminoplasty for CSM were prospectively analysed. Patients were divided into two age groups of ≥ 75 years (elderly group, 76 patients) and < 75 years (younger group, 293 patients). Locomotor ability was estimated using part of the functional independence measure (FIM). The sum of gait and stairs items [functional independence measure (locomotion), FIM-L; possible scores, 2–14] and neurological status were estimated using the Japanese Orthopaedic Association (JOA) score (possible score, 0–17). Pre-operative neurological anamnesis was reviewed, and the surgical results of elderly patients with or without co-existing neurological history were evaluated to determine the origin of locomotor disability.

Results Peri-operative FIM-L and JOA scores were significantly lower in the elderly group than in the younger group, and the opposite was true for improved FIM score. Cerebral infarction and previous lumbar surgery were identified as neurological co-morbidities in the elderly group. However, there was no significant difference in surgical results between elderly patients with and without co-existing neurological disorders.

Conclusions Decompression surgery can improve locomotor ability and decrease nursing care requirements among elderly patients with CSM. However, other neurological diseases can co-exist in elderly patients, making it difficult to diagnose the origin of locomotor disability. Therefore, detailed peri-operative work-up and timely decompression should be given priority to avoid progression towards fixed locomotor disability.

Keywords Cervical spondylotic myelopathy · Laminoplasty · Locomotion · Functional independence measure · Elderly

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Introduction

The elderly are the fastest-growing population sector in many advanced nations, and the increased expenses involved in their nursing care and medical treatments are becoming a social issue. Among age-related spinal disorders, cervical spondylotic myelopathy (CSM) is one of the most serious neurological diseases, causing gait abnormality and hand dysfunction with muscular atrophy and sensory disturbance. Decompression surgery has been the recommended treatment because of its high neurological recovery rate; however, elderly patients with CSM may present with co-existing neurological disorders, lack of

neurological recovery and a perceived risk of peri-operative complications [1–3]. Therefore, the option of surgical intervention, particularly in the elderly, requires conclusive proof of the origin of neurological impairment. Of various neurological impairments, locomotor disability may be the most important functional disability in regard to mortality [4, 5]. Furthermore, patients with locomotor disabilities, including those who are bedridden or wheelchair-dependent, require intensive nursing care for long periods. The objective prediction method, which considers the degree of care burden, is currently the only evaluation method to use the functional independence measure (FIM), and nursing care is closely related to FIM score [6, 7]. Therefore, this study aimed to use part of the FIM scoring method to assess post-operative locomotor ability and determine whether surgery improved locomotion relative to general neurological status in elderly CSM patients.

Patients and methods

Between January 2005 and December 2009, 451 consecutive patients with CSM treated by cervical posterior decompressive surgery who completed a minimum 2-year follow-up at a single institution were initially selected. Exclusion criteria were previous cervical surgery, posterior longitudinal ligament ossification, cervical disc herniation, rheumatoid arthritis, spinal or spinal cord tumour, cerebral palsy and trauma. Two elderly patients who died within

2 years of surgery were excluded. Eventually, 369 CSM patients (226 men and 143 women; average age, 65 years; range, 27–87 years; mean follow-up duration, 54.1 months; range, 24–97 months) who completed a follow-up period of at least 2 years were included. Informed consent was obtained from all patients, and the Ethics Committee of our institution approved the study.

The patients were divided into two age groups of ≥ 75 years (elderly group, 76 patients) and < 75 years (younger group, 293 patients). All patients underwent expansive laminoplasty from C3 to C7 and began post-operative rehabilitation 2 days after the surgery by wearing a headmaster collar for approximately 3 weeks. Locomotor ability was estimated using part of the FIM [6, 7] (i.e. the sum of gait and stairs items). Each item was scored from 1 to 7 according to the level of independence, where 1 represents total dependence and 7 indicates complete independence. Possible scores thus ranged from 2 to 14 (Table 1). Scores were measured before the surgery and at the time of discharge by physiotherapists and were assessed by an independent spinal surgeon. Improved locomotor score was calculated as post-operative – pre-operative locomotor score.

Patients' neurological status was assessed according to the Japanese Orthopaedic Association (JOA) scoring system [8]. The maximum total score for a healthy individual was 17 (Table 2). To evaluate the degree of post-operative symptomatic recovery, recovery rate (RR) and improved JOA scores were calculated as follows: (post-operative – pre-

Table 1 Locomotive score (=the sum of walk and stairs items using FIM)

Locomotion: walk	
7: Complete independence	The patient walks a minimum of 50 m without assistive devices
6: Modified independence	The patient walks a minimum of 50 m, but uses a cane, crutches, special adaptive shoes, or walker; or takes more than a reasonable amount of time to complete the activity; or there are safety considerations
5: Supervision or setup	The patient requires standby supervision, cueing, or coaxing to go a minimum of 50 m
4: Minimal assistance	The patient performs 75 % or more of walking effort to go a minimum of 50 m
3: Moderate assistance	The patient performs 50–74 % of walking effort to go a minimum of 50 m
2: Maximal assistance	The patient performs 25–49 % of walking effort to go a minimum of 15 m, and require the assistance of one person only
1: Total assistance	The patient performs less than 25 % of effort, or requires the assistance of two people, or walks to less than 15 m
Locomotion: stairs	
7: Complete independence	The patient safely goes up and down at least 12–14 stairs without depending on any type of handrail or support
6: Modified independence	The patient goes up and down at least 12–14 stairs but requires a side support, handrail, cane, or portable supports; or the activity takes more than a reasonable amount of time; or there are safety considerations
5: Supervision or setup	The patient requires standby supervision, cueing, or coaxing to go up and down at least 12–14 stairs
4: Minimal assistance	The patient performs 75 % or more of the effort to go up and down at least 12–14 stairs
3: Moderate assistance	The patient performs 50–74 % of the effort to go up and down at least 12–14 stairs
2: Maximal assistance	The patient performs 25–49 % of the effort to go up and down at least 4–6 stairs, and require the assistance of one person only
1: Total assistance	The patient performs less than 25 % of the effort, or requires the assistance of two people, or goes up and down fewer than 4 stairs

Table 2 Evaluation of cervical myelopathy using the scoring system proposed by the Japanese Orthopaedic Association (JOA) score

Motor function of the upper extremity	
0:	Impossible to eat with chopsticks or spoon
1:	Possible to eat with spoon, but not with chopsticks
2:	Possible to eat with chopsticks, but inadequate
3:	Possible to eat with chopsticks, awkward
4:	Normal
Motor function of the lower extremity	
0:	Impossible to walk
1:	Needs cane or aid on flat ground
2:	Needs cane or aid only on stairs
3:	Possible to walk without cane or aid but slowly
4:	Normal
Sensory function	
A Upper extremity	
0:	Apparent sensory loss
1:	Minimal sensory loss
2:	Normal
B Lower extremity (same as A)	
C Trunk (same as A)	
Bladder function	
0:	Complete retention
1:	Severe disturbance (sense of retention, dribbling incomplete continence)
2:	Mild disturbance (urinary frequency, urinary hesitancy)
3:	Normal

operative JOA score) $\times 100 / (17 - \text{pre-operative JOA score})$ and post-operative – pre-operative JOA score, respectively. In addition, age at surgery, duration of hospital stay, operative time and blood loss were assessed. The level of spinal cord involved was determined using magnetic resonance imaging (MRI) by ascertaining either signal intensity changes or the most compressed level of the cord. Level of lesion involved was evaluated by both MRI and neurological findings. The latter had priority over the former when clear discrepancies existed because the level of the lesion was not always consistent with the compressive lesion on images. Neurological status was assessed before and 1 year after the surgery. Patients' pre-operative neurological anamnesis that may have affected locomotor ability, including preceding thoracolumbar surgery and/or intracranial lesions, was assessed by reviewing medical records and clinical notes. Patients with preceding thoracolumbar surgery were reviewed until the final follow-up. The surgical results for elderly patients with or without co-existing neurological history were compared to assess the origin of locomotor impairment.

All medical records and clinical notes were reviewed and analysed in a blinded fashion. The data are presented

as mean with ranges. An unpaired *t* test, the Mann–Whitney *U* test, Chi-squared test and Fisher's exact probability test were used for statistical analyses. $p < 0.05$ was considered to be statistically significant.

Results

Patient characteristics are listed in Table 3. Mean age in the elderly and younger groups was 78.8 (75–87) and 61.9 (27–74) years, respectively. There was no significant difference in the gender and follow-up duration between the groups. Mean length of hospital stay was greater in the elderly group than in the younger group (36.3 vs. 28.4; $p = 0.007$). Locomotor score was significantly lower in the elderly group than in the younger group (10.1 vs. 13.0; $p < 0.0001$); both locomotor and JOA scores improved significantly after the surgery in the elderly group, although they were significantly lower than those in the younger group ($p < 0.0001$; Figs. 1, 2).

On the other hand, improvement in locomotor score was 2.1 (0–6) in the elderly group, which was significantly higher than that in the younger group [0.5 (–1 to –6); $p < 0.0001$]. However, there was no significant difference in improvement in JOA score between the two groups (Fig. 3). Lesion levels of the spinal cord for both groups are shown in Table 4. In the elderly group, the primary lesion was observed at C3–C4 in 43.4 % patients and at C4–C5 in 26.3 % patients. In the younger group, it was mainly observed at C5–C6 in 39.9 % patients.

The incidence of neurological co-morbidities in the study patients is shown in Table 5. The incidence of pre-operative cerebral infarction (13 %) and previous lumbar surgery (8 %) was significantly higher in the elderly group than in the younger group ($p < 0.0001$ and 0.0002, respectively). Three of six patients who previously underwent lumbar surgery were not diagnosed with CSM at that time. The rate of follow-up completion among patients who had undergone previous thoracolumbar surgery showed no age-related difference. Co-morbidities in elderly patients were cerebral infarction ($n = 8$), previous lumbar surgery ($n = 4$), cerebral infarction and previous lumbar surgery ($n = 2$) and subdural hematoma and previous thoracic surgery (both $n = 1$). Sixty patients had no co-existing neurological history. There was no significant difference in the surgical results for elderly patients with and without co-existing neurological disorders (Table 6).

Discussion

In an ageing society, many spinal disorders appear to be associated with age-related degenerative disease. Of these

Table 3 Patient demographics of two age groups

	Elder (<i>n</i> = 76)	Younger (<i>n</i> = 293)	<i>p</i> value
Mean age (years) (range)	78.8 (75–87)	61.9 (27 to 74)	<0.0001
Female: male	35:41	108:185	NS
Mean follow-up (months) (range)	54.5 (25–97)	53.1 (24 to 97)	NS
Mean operating time in min (range)	96.6 (55–182)	103.6 (43 to 212)	NS
Mean estimated blood loss in ml (range)	64.6 (5–544)	77.3 (5 to 767)	NS
Mean length of hospital stay (day) (range)	36.3 (12–140)	28.4 (8 to 103)	0.007
Mean JOA score (range)			
Pre-operative	8.4 (1–16)	9.4 (2 to 16)	0.0001
Post-operative	11.7 (5–17)	13.0 (5 to 17)	<0.0001
Recovery rate	40.8 (14–100)	49.2 (–50 to 100)	0.0014
Improved JOA score	3.3 (1–8.5)	3.5 (–1 to 10)	NS
Mean locomotion score (range)			
Pre-operative	10.1 (2–14)	13.0 (4 to 14)	<0.0001
Post-operative	12.2 (2–14)	13.5 (8 to 14)	<0.0001
Improved locomotion score	2.1 (0–6)	0.5 (–1 to 6)	<0.0001

NS not significant

Fig. 1 JOA scoring in elderly and younger patients. A significant difference was observed in pre- and post-operative JOA scores between the groups ($p \leq 0.0001$) **Fig. 2** FIM-L (locomotor) scoring in elderly and younger patients. A significant difference was observed in pre- and post-operative locomotor scores between the groups ($p < 0.0001$)

disorders, CSM is certainly one of the most significant in regard to the requirement for surgery, the aim of which is to improve or prevent gait and hand dysfunction, which are main characteristics that profoundly affect the patient's activities of daily living. Among various symptoms, lack of locomotion may be the most serious functional disability that is closely related to prolonged hospital stay, considerable nursing care and mortality. However, no reports have described improvements in locomotor function following decompression surgery; consequently, it remains unknown whether the burden of care for CSM patients can be decreased.

There are several peri-operative indicators of neurological impairment of locomotion. The Nurick classification [9] is a grading scheme for measuring the degree of walking difficulty in patients with myelopathy secondary to CSM. The 30-m walking test [10] and the 10-s stepping test [11] are reported to be suitable measures of CSM severity, and although both have proved reliable and useful, these tests vary among institutions and cannot be used to measure physical disability in relation to nursing care. The FIM scale assesses physical and cognitive disability with a focus on the burden of care (i.e. the level of disability indicates

Fig. 3 Improved FIM-L and JOA scoring in elderly and younger patients. Improved locomotor scoring was significantly higher in the elderly group than in the younger group ($p < 0.0001$), although there was no significant difference in improved JOA score between the groups

Table 4 Responsible lesion of cervical spinal cord

	Elder (=76)	Younger (=293)
C2–C3	2 (2.6 %)	0 (0 %)
C3–C4	33 (43.4 %)	45 (15.4 %)
C4–C5	20 (26.3 %)	87 (29.7 %)
C5–C6	14 (18.4 %)	117 (39.9 %)
C6–C7	6 (7.9 %)	41 (14.0 %)
C7–T1	1 (1.3 %)	3 (1.0 %)

Table 5 Co-existent neurological disorders

	Elder (=76)	Younger (=293)	p value
Intracranial lesion			
Cerebral infarction	10	2	<0.0001
Subdural hematoma	1	0	NS
Thoracic disorder			
Previous surgery	1	0	NS
Following surgery	1	1	NS
Lumbar disorder			
Previous surgery	6	2	0.0002
Following surgery	8	17	NS

Repetition (+)

NS not significant

the burden of care involved). The higher the FIM score, the shorter the required duration of nursing care. FIM has been used broadly in most countries and institutions to measure

various neurological diseases. In this study, the neurological co-morbidities seen in elderly CSM patients included cerebral infarction and/or other spinal disorders, sometimes confusing the origins of neurological impairment. In these circumstances, a uniform test should be available for assessing various neurological impairments. In this regard, it remains unknown whether FIM-L is superior to other tests.

Some authors have reported that surgical outcomes in elderly patients are worse than those in younger patients [1, 12, 13]. While irreversible functional deficits arising from a damaged spinal cord may occur in elderly patients, several recent articles have reported that elderly patients can achieve a reasonable degree of recovery after decompression surgery [14, 15]. We speculated that this controversy may have resulted from a difference in the severity of CSM symptoms and total pre-operative neurological impairment between younger and elderly individuals, in addition to differences in objective measurements among various studies. In general, irreversible age-related neurological impairment may include other spinal disorders, cerebral vascular disease, diabetic neuropathy, entrapment peripheral neuropathy and others. In some elderly patients, these neurological diseases may be co-existent and affect pre-operative objective measurement. In this series, there was no significant difference in surgical outcome between with and without co-existing neurological diseases in the elderly patients. This may indicate that the main origin of locomotor disability at the time of surgery is myelopathy due to cervical degenerative spondylosis; therefore, decompression surgery may improve locomotion even in those elderly patients with co-existing neurological diseases.

Machino et al. [15] stated that although the JOA scoring system and RR are simple and useful indicators, some crucial scientific limitations remain. The actual surgical outcome in patients with the same RR may differ according to pre-operative JOA score. In other words, the resumption of normal neurological function after surgery is strongly influenced by the severity of the pre-existing disease. These workers pointed out that there was no significant difference in JOA scores achieved between younger and elderly patients. Our study concurred with these authors in that JOA scores achieved by the elderly patients were not significantly inferior to those achieved by the younger patients. On the other hand, FIM scores achieved following the surgery were higher in the elderly patients, and there are several possible reasons for this. Since the younger patients had maintained their locomotor ability, their pre-operative FIM scores were originally high and improvement in locomotion scores was consequently low. On the other hand, the elderly patients had low pre-operative locomotor scores because of severe CSM. Another assumption is that recovery from long-tract signs such as

Table 6 Surgical results of the elder with or without co-exist neurological history

	With (<i>n</i> = 16)	Without (<i>n</i> = 60)	<i>p</i> value
Mean age (years) (range)	78.1 (75–85)	78.9 (75–87)	NS
Female: male	6:10	29:31	NS
Mean follow-up (months) (range)	63.1 (25–97)	52.3 (25–97)	NS
Mean operating time in min (range)	99.9 (63–162)	95.6 (55–182)	NS
Mean estimated blood loss in ml (range)	84.7 (5–544)	59.2 (5–500)	NS
Mean length of hospital stay (day) (range)	47.7 (15–109)	35.9 (12–140)	NS
Mean JOA score (range)			
Pre-operative	8.5 (5–14)	8.4 (1–16)	NS
Post-operative	11.7 (8–16)	11.8 (5–17)	NS
Recovery rate	39.4 (14–80)	41.5 (14–100)	NS
Improved JOA score	3.2 (1–6)	3.4 (1–8.5)	NS
Mean locomotion score (range)			
Pre-operative	10.0 (6–13)	10.2 (2–14)	NS
Post-operative	12.1 (7–14)	12.2 (2–14)	NS
Improved locomotion score	2.1 (0–5)	2.0 (0–6)	NS

NS not significant

gait disturbance may be more marked if the decompression area is large and cranial. The intervertebral levels involved, as determined by radiographic and electrophysiological analyses in elderly patients, were previously reported to be C3–C4 or C4–C5 [16–20], and the results of this study concur with this. If this theory is correct, elderly patients may achieve satisfactory recovery because the primary lesion can be located more cranially in these patients than in younger patients. In elderly patients with locomotor dysfunction arising mainly from CSM, locomotor function can be improved by a detailed peri-operative work-up and timely decompression surgery.

In general, the degree of gait disturbance increases with age in CSM patients. Some studies have presented results for recovery from severe gait disturbance using Nurick classification [21, 22]. A majority of patients with a Nurick score of 5 who were either bedridden or in a wheelchair at diagnosis improved by at least one point after the surgery. Although we did not evaluate the relationship between locomotor dysfunction severity and the degree of recovery, this study demonstrated that the degree of improvement in locomotor ability may be reasonable, even in elderly patients.

A co-existent neurological history is relatively common in elderly patients. A history of cerebral infarction (13 %) and previous lumbar surgery (8 %) co-existed at the time of cervical surgery. No patient with a history of cerebral infarction showed obvious hemiplegia or compromised locomotor function at the time of surgery. Mean estimated blood loss and length of hospital stay were greater in patients with a co-existing history than in those without, although the difference was not significant.

Descriptions of developmental combined cervical and lumbar spondylosis and tandem lumbar and cervical spinal

stenosis caused by osseous or developmental problems of the spinal canal are available in the literature [23–26]. However, degenerative changes in elderly patients, including thickening of the yellow ligament, facet joint hypertrophy and disc bulging, are more common causes of myelopathy compared with osseous or developmental problems. Tsutsumimoto et al. [27] described how 32.2 % patients surgically treated for CSM exhibited radiological evidence of lumbar canal stenosis that worsened with age. In our study, 50 % patients who had undergone previous lumbar surgery were not diagnosed with CSM at the time of lumbar surgery. In other words, we may be confusing the origin of locomotor impairment when we determine the appropriate surgery for multiple spinal lesions in elderly patients.

This study had several limitations. First, locomotor ability and neurological status were not compared between the elderly and younger groups with the same pre-operative score. In 221 (75 %) of the younger group patients, the FIM-L score was 14 or 13, and only 13 patients (4.4 %) scored 10 or less. Therefore, we could not select patients with the same pre-operative score in the younger group and compare data with those from the elderly group. Second, the assessment of locomotor ability was limited to objective indicators based on FIM and JOA scoring. Other evaluation methods such as the Nurick classification, the 30-m walking test and the 10-s stepping test were not used. Third, this study involved post-operative locomotor analysis that was performed at the time of discharge, approximately 1 or 2 months after the surgery. However, the time to discharge from the surgery varied among patients, and the effects of rehabilitation should have been considered while evaluating the recovery of locomotor ability.

Conclusions

Decompression surgery in elderly patients with CSM improves locomotor ability, and, as a result, may allow a decrease in the level of nursing care. However, in elderly patients, other neurological diseases can co-exist and confuse the origins of locomotor disability. Therefore, detailed peri-operative work-up and timely decompression should have priority in the measures to avoid progression toward fixed locomotor disability.

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