Assessment of Surgical Outcomes in Patients with Degenerative Cervical Myelopathy Using the 25-Question Geriatric Locomotive Function Scale: A Longitudinal Observational Study

Hiroki Takeda[1], Takehiro Michikawa[2], Sota Nagai[3], Soya Kawabata[3], Kei Ito[3], Daiki Ikeda[3], Nobuyuki Fujita[3] and Shinjiro Kaneko[1]

1) Department of Spine and Spinal Cord Surgery, School of Medicine, Fujita Health University, Toyoake, Japan
2) Department of Environmental and Occupational Health, School of Medicine, Toho University, Tokyo, Japan
3) Department of Orthopaedic Surgery, School of Medicine, Fujita Health University, Toyoake, Japan

Abstract:

Introduction: Locomotive syndrome caused by degenerative musculoskeletal diseases is reported to improve with surgical treatment. However, it is unclear whether surgical treatment is effective for the locomotive syndrome developing in patients with degenerative cervical myelopathy (DCM). Thus, this study primarily aimed to longitudinally assess the change in locomotive syndrome stage before and after cervical spinal surgery for patients with DCM using the 25-question geriatric locomotive function scale (GLFS-25). A secondary objective was to identify factors associated with the postoperative improvement in the locomotive syndrome stage.

Methods: We retrospectively reviewed clinical data of patients undergoing cervical spine surgery at our institution from April 2020 to May 2022 who had answered the Japanese Orthopaedic Association Cervical Myelopathy Assessment Questionnaire, visual analog scale, and GLFS-25 preoperatively and at 6 months and 1 year postoperatively. We collected demographic data, medical history, preoperative radiographic parameters, presence or absence of posterior longitudinal ligament ossification, and surgical data.

Results: We enrolled 115 patients (78 men and 37 women) in the present study. Preoperatively, using the GLFS-25, 73.9% of patients had stage 3, 10.4% had stage 2, 9.6% had stage 1, 6.1% had no locomotive syndrome. The stage distribution of locomotive syndrome improved significantly at 6-months and 1-year postoperatively. The multivariable Poisson regression analysis revealed that better preoperative lower extremity function (relative risk: 3.0; 95% confidence interval: 1.01-8.8) was significantly associated with postoperative improvement in the locomotive syndrome stage.

Conclusions: This is the first study to longitudinally assess the locomotive syndrome stage in patients with DCM using GLFS-25. Our results indicated that patients with DCM experienced significant improvement in the locomotive syndrome stage following cervical spine surgery. Particularly, the preoperative lower extremity function was significant in postoperative improvement in the locomotive syndrome stage.

Keywords:

Degenerative cervical myelopathy, Locomotive syndrome, 25-question geriatric locomotive function scale, Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire

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Introduction

Degenerative cervical myelopathy (DCM) is primarily characterized by cervical spondylotic myelopathy (CSM) and ossification of the posterior longitudinal ligament (OPLL)[1]. CSM mainly occurs due to intervertebral disc degeneration, bulging posterior elements, and spinal instability resulting from age-related degenerative changes, while OPLL has a genetic background[1]. The severity of DCM is commonly assessed by the Nurick scale, Japanese Orthopaedic Association (JOA) score, or modified JOA score from the medical providers' perspective[2]. Contrarily, patient-

Corresponding author: Nobuyuki Fujita, nfujita2007@gmail.com
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oriented tools for assessing DCM severity vary from the simplest visual analog scale (VAS), the 36-Item Short-Form Health Survey and the EuroQol-5 Dimensions for assessing general health-related quality of life, the Neck Disability Index for patients with neck pain, and the Myelopathy Disability Index and the European Myelopathy Scale to assess highly specific scales for cervical myelopathy[2]. The JOA Cervical Myelopathy Assessment Questionnaire (JOACMEQ), originally developed to measure clinical outcomes in patients with cervical myelopathy[3,4], has also been reported as a reliable tool for surgical outcomes of the cervical spine[5].

With the recent increase in the aging population globally, the number of older patients with DCM is also increasing[6]. Since this population essentially faces a high risk for a sudden decline in health and physical function and is highly vulnerable to various stresses[7], older DCM patients require urgent clinical attention. Sarcopenia and frailty are commonly used to diagnose age-related illnesses worldwide[7,8]. Sarcopenia refers to the age-related loss of muscle mass resulting in declining muscle strength and physical function and can impact the postoperative cervical alignment and clinical outcomes[9]. Meanwhile, frailty is a geriatric syndrome representing an increased risk of a catastrophic decline in health and function and is also described as an indicator to predict adverse events following surgery for DCM[10]. In Japan, the concept of locomotive syndrome was developed to assess impairments in motor functions involved in locomotion resulting from age-related musculoskeletal dysfunction[11]. Thus, degenerative musculoskeletal diseases, such as lumbar degenerative disease, hip osteoarthritis, and knee osteoarthritis, have been reported to be closely associated with the locomotive syndrome[12-16], and the locomotive syndrome stage of patients with these diseases was significantly improved by surgical treatment[12,13,15-17].

Recently, a cross-sectional study assessed patients with CSM using the patient-oriented 25-question geriatric locomotive function scale (GLFS-25), one of the diagnostic tools for the locomotive syndrome, and found that most surgically-treated patients with CSM were diagnosed with locomotive syndrome[18]. Additionally, the GLFS-25 scores for these patients were significantly correlated with their JOA scale and JOACMEQ scores. However, the effectiveness of surgical treatment for the locomotive syndrome developing in patients with DCM akin to other degenerative musculoskeletal diseases remains unclear. Therefore, we conducted this study to longitudinally assess the locomotive syndrome stage of patients with DCM before and after cervical spinal surgery using the GLFS-25. Secondarily, we aimed to identify factors associated with this improvement in the locomotive syndrome stage following cervical spinal surgery.

Materials and Methods

Study participants

We retrospectively reviewed the clinical data of patients who had undergone cervical spine surgery at our institution from April 2020 to May 2022 and had filled out the JOACMEQ, VAS, and GLFS-25 scores preoperatively and at 6 months and 1 year postoperatively. We excluded patients who were operated on for cervical disc herniation, atlantoaxial subluxation, retro-odontoid pseudotumor, and drophead syndrome.

This study was approved by the institutional ethical review board that approved the opt-out consent method based on this study's retrospective design. The principles of the Declaration of Helsinki were followed throughout the study course.

Data collection

We collected patient data regarding age, sex, body mass index (BMI), medical history, preoperative radiographic parameters, presence or absence of OPLL, American Society of Anesthesiologists physical status score (ASA), and details of surgical procedures, such as surgical time and surgical blood loss. Medical history included the presence of diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, cerebrovascular disease, cancer, osteoarthritis of the knee or hip joint, lumbar spinal disorders, fracture of lower extremities, peripheral artery disease, and neurological disorders. Radiographic parameters comprised C2-7 angle at neutral, cervical range of motion, C7 slope, C2-7 sagittal vertical axis, and the ratio of cervical lordosis to C7 slope (CL/C 7S). The surgical procedures included posterior decompression alone, posterior decompression with posterior fusion, anterior cervical discectomy and fusion, and anterior cervical discectomy and fusion with posterior fusion.

We also collected the preoperative and postoperative (6 months and 1 year) scores for JOACMEQ, VAS, and GLFS-25. The JOACMEQ includes five domains: cervical spine function, upper extremity function, lower extremity function, bladder function, and quality of life[3,4]. VAS was employed to assess neck and shoulder stiffness, chest tightness, arm and hand numbness, and chest-to-toe numbness[3,4]. Stages of the locomotive syndrome were determined by the total score of GLFS-25: stage 0: score≤6, stage 1: ≥7, stage 2: ≥16, and stage 3: ≥24[19].

Statistical analysis

The comparisons before and after surgery were made using the McNemar Bowker test, Wilcoxon signed-rank test, or Fisher's exact test, as appropriate; p-values of <0.05 were considered statistically significant. Suppose the chi-square test, McNemar Bowker, or Wilcoxon signed-rank tests were used twice, a p-value of 0.025 (0.05/2) will be used for statistical significance.

Additionally, we constructed a Poisson regression model,

Table 1. Baseline Characteristics.

Patients		n=115
Gender		Male: 78 Female: 37
Age (years)		67.8±12.2
Body mass index (kg/m^2)		24.1±3.9
Medical history	Diabetes mellitus	42 (36.5%)
	Hypertension	67 (58.2%)
	Dyslipidemia	27 (23.5%)
	Cardiovascular disease	21 (18.3%)
	Cerebrovascular disease	8 (7.0%)
	Cancer	7 (6.1%)
	Lumbar spinal disorders	19 (16.5%)
	Osteoarthritis of the knee or hip joint	2 (1.7%)
	Fracture of lower extremities	4 (3.5%)
	Peripheral artery disease	4 (3.5%)
	Neurological disorders	3 (2.6%)
Radiographic parameter	C2–7 angle (neutral) (°)	11.0±13.5
	Cervical range of motion (°)	31.0±15.2
	C7 slope (°)	23.8±9.6
	C2–7 sagittal vertical axis (mm)	28.5±12.8
Ossification of posterior longitudinal ligament		25 (21.7%)
Surgical procedure	Posterior decompression alone	72 (62.6%)
	Posterior decompression+posterior fusion	16 (13.9%)
	Anterior cervical discectomy and fusion	25 (21.7%)
	Anterior cervical discectomy and fusion+posterior fusion	2 (1.7%)
ASA	1	13 (11.3%)
	2	92 (80.0%)
	3	10 (8.7%)
Surgical time (min)		140.0±61.7
Surgical blood loss (ml)		65.0±114.3

ASA, American society of anesthesiologists physical status

which included age, sex, BMI, OPLL, surgical procedure, ASA, and preoperative score in each domain of JOACMEQ. We defined improvement in the locomotive syndrome as one or more of the locomotive syndrome stages decreased one year after surgery. We used Poisson regression to identify factors associated with improvements in the locomotive syndrome stage following cervical spine surgery for patients with DCM and estimated their relative risk (RR) and 95% confidence intervals (CIs) for improvement in the locomotive syndrome. Poisson regression was performed using the STATA16 software (Stata Corporation, College Station, TX, USA). To evaluate whether the preoperative score of lower extremity function in JOACMEQ could discriminate between cases without improvement of locomotive syndrome one year after surgery from ones with improvement, we calculated the area under the curve based on the receiver operating characteristic curve and decided the cutoff point as the maximum value of the Youden index (sensitivity+specificity −1).

Results

A total of 115 patients were enrolled in this study; baseline patient characteristics are shown in Table 1. Table 2 presents scores for all patient-reported outcomes at baseline and follow-up after surgery. All domains of JOACMEQ, except bladder function, showed favorable surgical outcomes. Only one VAS item "numbness in arms or hands" showed higher improvement at 6 months and 1 year postoperatively than that of preoperative values. Likewise, the overall GLFS-25 scores improved significantly at 6 months and 1 year postoperatively, which was mostly contributed by 20/25 items on the GLFS-25 (Table 3). However, the following five items showed no significant change before and after surgery-"pain in the back or buttocks," "pain or numbness in lower limbs," "difficulty standing up from a chair," "walking distance without rest," and "difficulty using public transportation" (Table 3). Preoperatively, using the GLFS-25, 73.9% of patients had stage 3, 10.4% had stage 2, 9.6% had stage 1, and 6.1% had no locomotive syndrome (Fig. 1). The stage-wise distribution of locomotive syndrome improved significantly at 6 months and 1 year postoperatively (Fig. 1).

Table 2. Data of Patient-reported Outcome and Radiographic Parameters at Baseline and Follow-up after Surgery.

		Median (25%–75%tile)			p value *	
		Preoperation	6POM	1POY	Preoperation vs. 6POM	Preoperation vs. 1POY
JOACMEQ	Cervical spine function	65 (40–85)	80 (65–100)	80 (60–100)	<0.001	0.002
	Upper extremity function	74 (53–95)	84 (68–95)	84 (71–95)	<0.001	<0.001
	Lower extremity function	59 (27–75)	59 (45–91)	59 (41–84)	<0.001	0.001
	Bladder function	75 (53–88)	81 (59–94)	81 (56–94)	0.073	0.28
	Quality of life	45 (32–56)	48 (35–63)	49 (37–63)	<0.001	0.001
		Mean±SD			p value *	
		Preoperation	6POM	1POY	Preoperation vs. 6POM	Preoperation vs. 1POY
GLFS-25		41.9±25.4	33.9±24.4	32.9±24.4	<0.001	<0.001
Visual Analog Scale	Stiffness in neck or shoulders	42.9±31.3	41.1±29.2	38.9±28.9	0.26	0.044
	Tightness in chest	9.8±21.3	8.4±19.6	9.1±17.8	0.69	0.87
	Numbness in arms or hands	62.9±29.4	46.1±31.9	45.2±31.3	<0.001	<0.001
	Numbness from chest to toe	34.9±34.5	33.9±24.4	29.2±30.4	0.034	0.084
Radiographic parameters	C2–7 angle (neutral) (°)	11.0±13.5	6.8±12.8	6.6±13.7	<0.001	<0.001
	C7 slope (°)	23.8±9.6	21.7±8.1	22.6±8.6	0.001	0.115
	C2–7 sagittal vertical axis (mm)	28.5±17.7	29.8±15.3	32.1±16.3	0.005	<0.001

JOACMEQ, JOA Cervical Myelopathy Assessment Questionnaire; GLFS-25, 25-Question Geriatric Locomotive Function Scale; 6POM, 6 months after surgery; 1POY, 1 year after surgery; SD, Standard deviation
*Wilcoxon signed-rank test.

We explored the factors associated with this improvement in the locomotive syndrome stage following cervical spinal surgery by using the Poisson regression model (Table 4). Univariate analysis showed that age of >75 years (RR: 0.3; 95% CI: 0.1-0.6) and better preoperative status on the cervical spine function (RR: 3.0; 95% CI: 1.1-8.4), lower extremity function (RR: 3.5; 95% CI: 1.3-9.6), and bladder function (RR: 3.5; 95% CI: 1.1-11.1) in JOACMEQ were associated with postoperative improvements in locomotive syndrome stage. However, after adjusting for age and sex, only good status on lower extremity function (RR: 3.0; 95% CI: 1.01-8.8) was significantly associated with postoperative improvement in the locomotive syndrome stage. Next, we compared the score of five question items in the lower extremity function domain of JOACMEQ between the group with and without improvement in locomotive syndrome after cervical spine surgery (Fig. 2). The score of cases with improvement was significantly higher than that without improvement in Q3-3 "Do you have difficulty in going up the stairs?" (Fig. 2). In addition, we have assessed the predictive ability of the sensitivity and specificity of preoperative lower extremity function in JOACMEQ in locomotive syndrome after cervical spine surgery (Fig. 3). The area under the curves of lower extremity function was 0.63 (95% confidence interval=0.51-0.75) (Table 5). The cutoff values for the score of lower extremity function were estimated at 41 (sensitivity=85.7%, specificity=39.1%), suggesting low predictive ability of this cutoff value (Table 5).

Since this study included the patients with the other diseases affecting lower extremity function, such as osteoarthritis of the knee or hip joint, lumbar spinal disorders, fracture of lower extremities, peripheral artery disease, and neurological disorders, we have compared the prevalence of these disorders between the group with and without improvement in locomotive syndrome after cervical spine surgery (Supplementary Table 1). Statistical analysis did not show a significantly higher prevalence of these diseases in cases without improvement compared with cases with improvement (Supplementary Table 1).

Finally, we determined whether CL/C7S, an indicator of global sagittal alignment[20], affected the lower extremity function in JOACMEQ. The statistical analysis showed no correlation between these variables (Supplementary Figure 1). In addition, we have compared the score of CL/C7S between the groups with and without improvement in locomotive syndrome after cervical spine surgery (Supplementary Table 2). The two groups did not significantly differ (Supplementary Table 2).

Discussion

The present study showed that GLFS-25 scores of patients with DCM significantly improved following cervical spine surgery, along with the cervical spine function, upper extremity function, lower extremity function, and quality of life in JOACMEQ. Although the postoperative improvement in the locomotive syndrome stage of the patient within the first year was not drastic, it was statistically significant. We also identified that the preoperative lower extremity function on JOACMEQ was associated with postoperative improve-

Table 3. Data of 25-Question Geriatric Locomotive Function Scale at Baseline and Follow-up after Surgery (n=115).

		Preoperation	6POM	1POY	Preoperation vs. 6POM	Preoperation vs. 1POY
Q 1	Pain in neck or upper limbs	2.23±1.19	1.63±1.11	1.66±0.99	<0.001	<0.001
Q 2	Pain in back or buttocks	1.13±1.14	1.09±1.03	1.17±1.06	0.634	0.789
Q 3	Pain or numbness in lower limbs	1.43±1.24	1.23±1.15	1.27±10.9	0.102	0.214
Q 4	Painful to move body in daily life	1.91±1.18	1.51±1.02	1.42±1.08	0.001	<0.001
Q 5	Difficulty getting up from bed or lying down	1.26±1.19	0.91±0.94	0.89±0.99	0.003	0.001
Q 6	Difficulty standing up from a chair	1.01±1.20	0.80±0.89	0.80±0.95	0.107	0.047
Q 7	Difficulty walking inside the house	1.25±1.31	0.81±1.05	0.86±1.09	<0.001	0.001
Q 8	Difficulty putting on and taking off a shirt	1.26±1.28	0.93±1.17	0.84±1.00	0.006	<0.001
Q 9	Difficulty putting on and taking off pants	1.49±1.32	1.00±1.17	0.98±1.05	<0.001	<0.001
Q 10	Difficulty using the toilet	0.94±1.21	0.65±1.00	0.63±1.00	0.014	0.005
Q 11	Difficulty washing the body in the bath	1.42±1.32	0.91±1.17	0.95±1.11	<0.001	<0.001
Q 12	Difficulty going up and down stairs	1.97±1.43	1.53±1.29	1.47±1.33	0.001	<0.001
Q 13	Difficulty walking briskly	2.34±1.52	1.97±1.42	1.89±1.47	0.002	0.001
Q 14	Difficulty keeping yourself neat	1.30±1.31	0.98±1.12	0.96±1.13	0.006	0.002
Q 15	Walking distance without rest	1.97±1.39	1.72±1.31	1.70±1.38	0.028	0.03
Q 16	Difficulty going out to visit neighbors	1.34±1.37	1.07±1.27	1.13±1.29	0.009	0.03
Q 17	Difficulty carrying objects weighing approximately 2 kg	1.74±1.43	1.50±1.46	1.42±1.41	0.068	0.017
Q 18	Difficulty using public transportation	1.63±1.51	1.47±1.47	1.52±1.51	0.129	0.393
Q 19	Difficulty doing simple tasks and housework	1.49±1.37	1.20±1.36	1.17±1.27	0.019	0.009
Q 20	Difficulty doing load-bearing tasks and housework	1.97±1.41	1.69±1.48	1.60±1.45	0.014	0.002
Q 21	Difficulty performing sports activity	2.57±1.40	2.22±1.48	2.17±1.44	0.004	0.002
Q 22	Refrain from meeting friends	2.07±1.51	1.70±1.39	1.57±1.51	0.003	<0.001
Q 23	Refrain from joining social activities	2.62±1.44	2.10±1.54	1.90±1.59	0.001	<0.001
Q 24	Fall-related anxiety	1.63±1.42	1.31±1.31	1.31±1.31	0.011	0.019
Q 25	Anxiety about being unable to walk in the future	1.96±1.38	1.59±1.36	1.67±1.39	0.004	0.030

6POM, 6 months after surgery; 1POY, 1 year after surgery
*Wilcoxon signed-rank test.

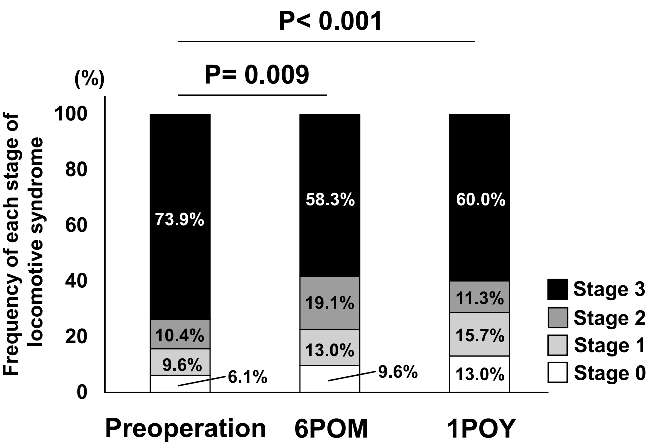

Figure 1. The distribution of different stages of the locomotive syndrome in the study sample preoperatively and at 6 months and 1 year postoperatively. The McNemar Bowker test was used for statistical analysis.

ment in the patient's locomotive syndrome stage.

The locomotive syndrome staging was originally made based on the stand-up test, two-step test, and GLFS-25[11]. In 2020, stage 3 of the syndrome was added, representing the progressive deterioration in mobility function with hindered social participation[21]. Yoshimura et al. recently reported that stage 3 locomotive syndrome was a sensitive indicator of future disability and mortality, and each value of the risk tests for stage 3 increased the risk of poor prognosis[19]. In the present study, the locomotive syndrome stage of the patient was assessed using the GLFS-25 score alone. The absence of the other two tests is the biggest limitation of this study in determining the locomotive syndrome stage. However, considering that GLFS-25 was reported to be moderately effective in determining the locomotive syndrome stage[22], our staging procedure can be considered acceptable. Within these limits, our study observed favorable results for cervical spine surgery in patients with DCM with locomotive syndrome concerning future disability and mortality.

Kato et al. reported that approximately 80% of patients with degenerative musculoskeletal diseases, including lumbar degenerative disease, hip osteoarthritis, and knee osteoarthritis, had stage 3 locomotive syndrome before surgery, and surgical treatment reduced the prevalence of stage 3 to around 40% at 1 year postoperatively[23]. Meanwhile, in the present study, about 75% of patients with DCM were diagnosed with stage 3 locomotive syndrome preoperatively, which decreased to 60% after surgery, less than that for other degenerative musculoskeletal diseases. The discrepancy in the extent of postoperative improvement in the locomotive syndrome stage possibly results from the pathology of

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Table 4. Poisson Regression Model of Improvements of Locomotive Syndrome Stage Following Cervical Spine Surgery.

			Number of patients	Number of improved patients	Prevalence of improved patients (%)	p-value by chi-square test	Univariable model				Age & sex-adjusted model			
							Relative risk (RR)	95% confidence interval (CI)		p-value	Relative risk (RR)	95% confidence interval (CI)		p-value
Age		<65	42	18	42.9		Reference				Reference			
		65–74	28	5	17.9		0.4	0.2	1.0	0.05	0.4	0.2	1.0	0.05
		≥75	45	5	11.1	<0.01	0.3	0.1	0.6	<0.01	0.3	0.1	0.6	<0.01
Sex		Women	37	8	21.6		Reference				Reference			
		Men	78	20	25.6	0.64	1.2	0.6	2.4	0.64	1.1	0.5	2.2	0.80
Body mass index		<25 kg/m^3	81	20	24.7		Reference				Reference			
		≥25	34	8	23.5	0.90	1.0	0.5	2.0	0.90	0.8	0.4	1.5	0.43
Ossification of posterior longitudinal ligament		No	90	23	25.6		Reference				Reference			
		Yes	25	5	20.0	0.57	0.8	0.3	1.9	0.58	0.6	0.2	1.3	0.17
Surgical procedure		Posterior decopmpression alone	72	14	19.4		Reference				Reference			
		Posteror decompression+posterior fusion	16	5	31.3		1.6	0.7	3.8	0.29	1.2	0.6	2.4	0.62
		Anterior cervical discectomy and fusion	25	8	32.0		1.6	0.8	3.5	0.19	0.9	0.4	2.0	0.86
		Anterior cervical discectomy and fusion+posterior fusion	2	1	50.0	0.41	2.6	0.6	11.2	0.21	3.3	0.6	18.0	0.17
ASA		1	13	6	46.2		Reference				Reference			
		2	92	19	20.7		0.7	0.3	1.5	0.37	0.9	0.4	1.9	0.78
		3	10	3	30.0	0.62	1.0	0.3	3.0	0.93	1.1	0.4	3.1	0.89
JOACMEQ	Cervical spine function	Tertile1 (score<51)	38	4	10.5		Reference				Reference			
		Tertile2	27	8	29.6		2.8	0.9	8.4	0.07	2.2	0.7	6.6	0.16
		Tertile3 (score>75)	50	16	32.0	0.05	3.0	1.1	8.4	0.03	2.1	0.7	6.2	0.17
	Upper extremity function	Tertile1 (score<58)	38	6	15.8		Reference				Reference			
		Tertile2	33	7	21.2		1.3	0.5	3.6	0.56	0.9	0.3	2.4	0.86
		Tertile3 (score>80)	44	15	34.1	0.14	2.2	0.9	5.0	0.07	1.3	0.5	3.1	0.58
	Lower extremity function	Tertile1 (score<40)	38	4	10.5		Reference				Reference			
		Tertile2	35	9	25.0		2.4	0.8	7.1	0.12	2.0	0.7	6.2	0.21
		Tertile3 (score>65)	41	15	36.6	0.03	3.5	1.3	9.6	0.02	3.0	1.01	8.8	0.047
	Bladder function	Tertile1 (score<55)	29	3	10.3		Reference				Reference			
		Tertile2	42	9	21.4		2.1	0.6	7.0	0.24	1.4	0.4	5.3	0.58
		Tertile3 (score>81)	44	16	36.4	0.04	3.5	1.1	11.1	0.03	2.4	0.7	7.8	0.15
	Quality of life	Tertile1 (score<36)	38	8	21.1		Reference				Reference			
		Tertile2	33	6	18.2		0.9	0.3	2.2	0.76	0.7	0.3	1.8	0.47
		Tertile3 (score>50)	44	25	56.8	0.33	1.5	0.7	3.2	0.28	1.3	0.6	2.7	0.49

JOACMEQ, JOA Cervical Myelopathy Assessment Questionnaire; ASA, American society of anesthesiologists physical status

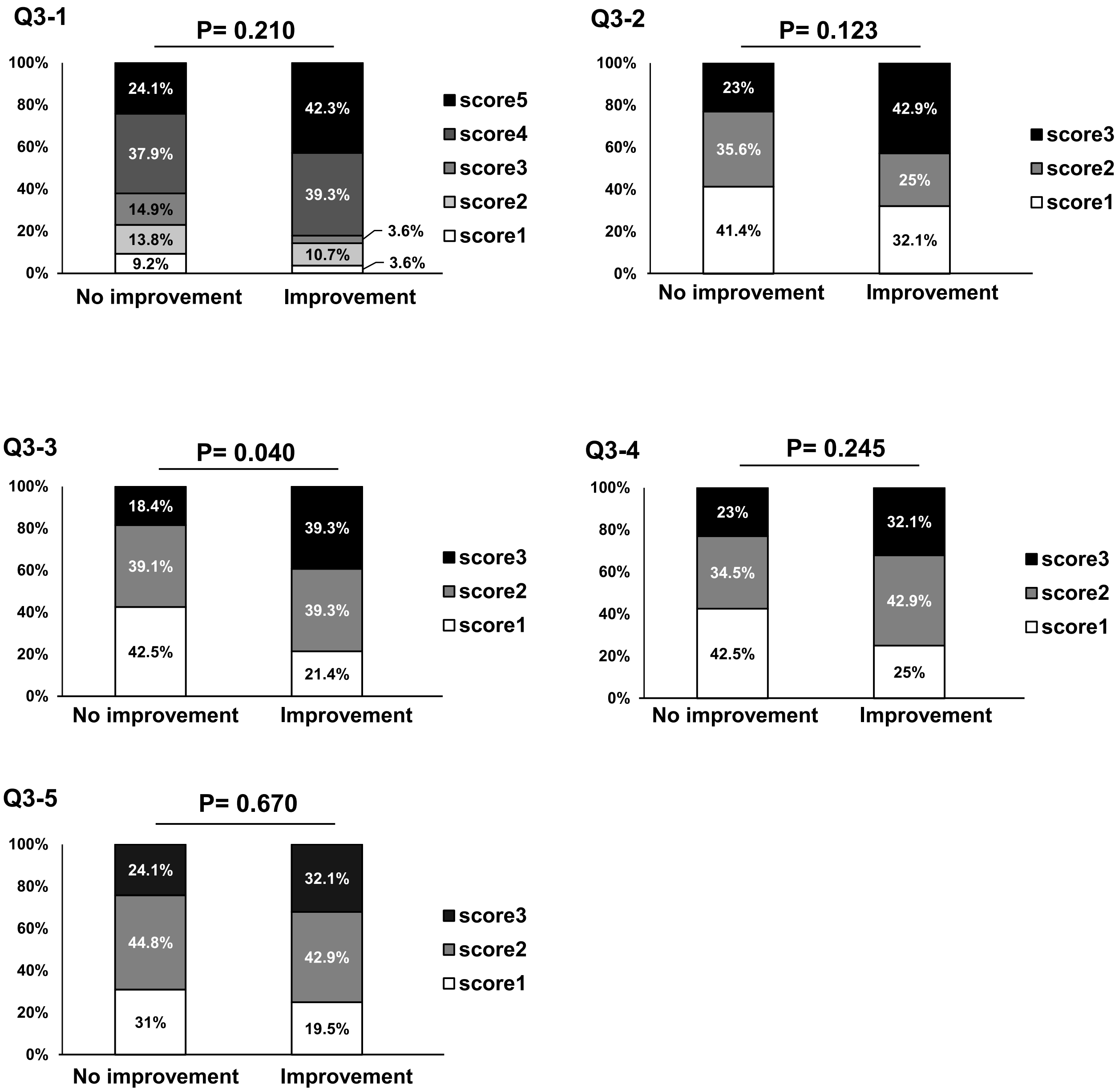

Figure 2. The comparison of scores of five-questioned items of the lower extremity function domain of JOACMEQ between the groups with and without improvement in locomotive syndrome after cervical spine surgery. The chi-square test was used for statistical analysis.

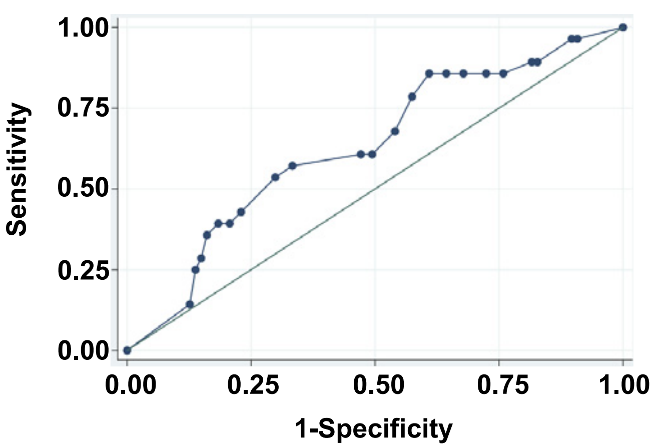

Figure 3. The calculation of the area under the curve based on the receiver operating characteristic curve.

DCM, which mainly involves a disorder of the spinal cord[24]. These findings partially concur with previously reported findings that cervical spine patients will be less satisfied with surgery than those with lumbar spine disease[25].

Although the 25 items in GLFS-25 include some questions indirectly related to clinical symptoms of DCM, our results showed that cervical spine surgery improved the score in most of the 25 items. Since spastic gait is an important clinical feature of DCM and can lead to future falls, its prevention and treatment are crucial for the locomotive syndrome. Notably, the 24th question regarding fall-related anxiety on the GLFS-25 showed a significant improvement with surgery (Table 3), suggesting that cervical spine surgery for patients with DCM also effectively prevents falling. Meanwhile, Kimura et al. reported that the GLFS-25 effec-

Table 5. Cutoff Value for Locomotive Syndrome Improvement 1 Year after Surgery.

	AUC	Cutoff value	Sensitivity (%)	Specificity (%)
Lower extremity function	0.63 (95% CI=0.51–0.75)	41	85.7	39.1

AUC, area under the curve; CI, confidence interval

tively predicts the risk of recurrent falls in patients with CSM[26]. Altogether, GLFS-25 can be a useful assessment tool for fall risk in patients with DCM.

Another important finding of this study was that a significant improvement in the locomotive syndrome stage following cervical spine surgery is likely when lower extremity function was preserved before surgery. Conversely, these results indicate that the locomotive function of patients with DCM with a severe loss of lower extremity function preoperatively will hardly improve even after surgery. A previous report showed that poor lower extremity function in patients with CSM was specifically associated with stage 3 locomotive syndrome[18], suggesting that the stage of the locomotive syndrome in patients with DCM may largely depend on lower extremity function. Several previous studies have consistently reported that a chief factor associated with poor surgical outcomes for DCM is a severe clinical presentation[27-31]. Therefore, surgical intervention in patients with DCM must be conducted before lower extremity function becomes severe. Although the predictive ability of the sensitivity and specificity of preoperative lower extremity function in JOACMEQ in locomotive syndrome after cervical spine surgery was assessed in this study, our ROC analysis showed the low predictive ability of the cutoff value. Therefore, future research should aim to determine the clinically reliable cutoff values for the severity of the lower extremity function using several data.

This study had several limitations. First, it is based on a retrospective data analysis from a limited number of patients. Prospective studies with large sample sizes are needed to corroborate our results. Second, the present study included patients with CSM and those with OPLL. Recently, the diseases causing compressive myelopathy in the cervical spine have been comprehensively defined as DCM[1]. However, since the two diseases have different pathologies, they should have been analyzed separately. Third, the follow-up duration was only 1 year. An extended follow-up period would be beneficial because the symptoms of a patient with DCM may change even after 1 year postoperatively. Fourth, although patients with DCM commonly have other degenerative musculoskeletal diseases, the participants were not evaluated for these diseases using radiography, magnetic resonance imaging, or medical examination. In this study, we identified the patients with diseases affecting lower extremity function from the medical history and compared the prevalence of these diseases between the groups with and without improvement in locomotive syndrome after cervical spine surgery. However, these diseases should have been diagnosed definitively by imaging and examination, and patients with these diseases should have been excluded from the study cohort. Lastly, postoperative treatment was not considered in the present analysis, although postoperative rehabilitation was involved in the surgical outcome[32]. Despite these limitations, this study pioneers the longitudinal assessment of the locomotive syndrome stage in patients with DCM using GLFS-25.

In conclusion, our results showed that patients with DCM experienced a significant improvement in the stage of the locomotive syndrome following cervical spine surgery. Particularly, the preoperative lower extremity function was significantly associated with this postoperative improvement. We believe these findings shall provide useful insight into surgical treatment for patients with DCM.

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Author Contributions: Conception and design: Nobuyuki Fujita.

Acquisition of data: Hiroki Takeda, Sota Nagai, Soya Kawabata.

Interpretation of data: Kei Ito, Takehiro Michikawa, Daiki Ikeda, Shinjiro Kaneko.

Drafting of the manuscript: Hiroki Takeda, Takehiro Michikawa, Nobuyuki Fujita.

Critical manuscript revisions: Sota Nagai, Kei Ito, Soya Kawabata, Daiki Ikeda, Shinjiro Kaneko.

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