Risk Factors for Poor Outcome of Cervical Laminoplasty for Cervical Spondylotic Myelopathy in Patients with Diabetes

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Background: Diabetes is one of the most frequent comorbidities in patients with cervical spondylotic myelopathy. The purpose of this study was to characterize the risk factors for poor treatment outcome following cervical laminoplasty for cervical spondylotic myelopathy in patients with diabetes.

Methods: A total of 105 consecutive patients with diabetes and cervical spondylotic myelopathy who underwent double-door laminoplasty were included in this study; there were sixty-five male patients and forty female patients with a mean age of 68.2 years (range, forty-three to eighty-three years). All patients were followed for twelve months or more after surgery, with a mean follow-up time (and standard deviation) of 25.7 ± 14.2 months. All patients had palliative controlled blood glucose levels in the immediate term during the perioperative period. We evaluated the recovery rate on the basis of the Japanese Orthopaedic Association score. Logistic regression analyses (univariate analysis and multivariate analysis) were performed to identify the risk factors for poor outcome. Poor outcome was defined as a postoperative recovery rate of <50%, and good outcome was defined as a postoperative recovery rate of ≥50%.

Results: Univariate logistic regression analysis showed that a patient age of sixty-five years or older (odds ratio, 3.111; p = 0.0085) and a duration of cervical spondylotic myelopathy symptoms for twelve months or more (odds ratio, 3.940; p = 0.0012) were associated with an increased risk of poor surgical outcome. High glycated hemoglobin levels of ≥6.5% (odds ratio, 2.591; p = 0.0193) and a duration of diabetes for ten years or more (odds ratio, 2.245; p = 0.0321) were significant risk factors for poor surgical outcome. Multivariate logistic regression analysis determined that glycated hemoglobin levels of ≥6.5% (odds ratio, 2.822; p = 0.0441) and a duration of diabetes for ten years or more (odds ratio, 2.240; p = 0.0410) were significant risk factors for poor treatment outcome. Fasting blood glucose levels did not affect treatment outcomes.

Conclusions: Diabetes with advanced age and long-term cervical spondylotic myelopathy symptoms adversely affected cervical laminoplasty outcomes. High preoperative glycated hemoglobin levels and long-term diabetes are risk factors for poor cervical laminoplasty outcomes in patients with diabetes and cervical spondylotic myelopathy.

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Cervical spondylotic myelopathy is one of the most prevalent and increasingly observed neurological disorders in geriatric populations[1,2]. Decompression surgery, particularly cervical laminoplasty, is the most established treatment modality for cervical spondylotic myelopathy[3]. Cervical laminoplasty has been recommended by many authors because

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of its good results[4-9]. The established prognostic factors for cervical spondylotic myelopathy include age, symptom duration, preoperative neurological condition, and current smoking status[10-16].

Diabetes is one of the most frequent comorbidities in patients with cervical spondylotic myelopathy[17]. Diabetes is a chronic systemic disease that can affect both the microvascular and peripheral nervous systems. Previous authors have reported that diabetic neuropathy and/or angiopathy influences the outcomes of lumbar spine surgery[18-20]. To our knowledge, there have only been a few studies on the outcomes in patients with diabetes and cervical myelopathy, including our previous report[10,17,21-23]. Relatively few studies have assessed the association between diabetes and surgical outcomes[22,23]. Although an understanding of the impact of diabetes on cervical spine surgery is important, to our knowledge, no study has investigated the risk of poor postoperative outcomes of cervical laminoplasty in a large series of patients with diabetes and cervical spondylotic myelopathy. Therefore, we hypothesized that there was a relationship between functional recovery after surgery and severity of diabetes. In addition to examining this relationship, we also designed the current study to identify the prognostic factors in patients with diabetes and cervical spondylotic myelopathy.

Materials and Methods

Study Population

From January 2007 to March 2011, 701 consecutive patients underwent modified double-door laminoplasty for cervical spondylotic myelopathy at the Department of Orthopedic Surgery at Chubu Rosai Hospital in Nagoya, Japan. Exclusion criteria included the following: ossification of the posterior longitudinal ligament; diagnoses of rheumatoid arthritis, cerebral palsy, or cancer; cervical spine injury; destructive spondyloarthritis caused by hemodialysis; previous cervical surgery; spinal fusion with instrumentation; thoracic spondylotic myelopathy; and lumbar spinal stenosis. Of these 701 patients, 528 with cervical spondylotic myelopathy were eligible for participation in this study. Of these, 505 consecutive patients with cervical spondylotic myelopathy who were followed for twelve months or more after surgery were prospectively enrolled in this study, with a follow-up rate of 95.6%. The final sample comprised 311 male patients and 194 female patients with a mean age of 66.6 years (range, forty-one to ninety-one years).

Of these 505 patients, 105 (20.8%) were included in the statistical analysis; there were sixty-five male patients and forty female patients with a mean age of 68.2 years (range, forty-three to eighty-three years) who had diabetes and a mean cervical spondylotic myelopathy symptom duration of 17.8 months (range, one to 120 months). The mean follow-up time (and standard deviation) was 25.7 ± 14.2 months. Patients with diabetes included those with fasting blood glucose levels of ≥126 mg/dL on screening before surgery or those with a previous diagnosis of diabetes. Glycated hemoglobin (HbA1c) levels, as determined by the National Glycohemoglobin Standardization Program (NGSP), also were obtained preoperatively at hospital admission in all patients with diabetes. For these candidates, we consulted diabetes specialists in our hospital, who confirmed that all patients had palliative controlled blood glucose levels in the immediate term during the perioperative period[24,25].

All patients presented with symptoms of myelopathy. Magnetic resonance imaging and myelography findings were consistent with myelopathy secondary to multisegmental cervical spondylotic stenosis. Myelopathy was confirmed in each patient by physical examination, and cord compression was present only between the C2-C3 and C7-T1 disc levels. The institutional review board of Chubu Rosai Hospital approved the study protocol, and written informed consent was obtained from each patient before surgery and before study participation.

Surgical Technique for Modified Double-Door Laminoplasty

In this study, double-door laminoplasty was performed using the Kurokawa method with slight modifications[8,26-28]. The muscles attached to the C2 spinous process were preserved without detachment. Surgical exposure was limited as much as possible. The spinous processes between C3 and C7 were resected at their bases, and the laminae were cut at the center using a high-speed drill. Bilateral gutters were created as hinges at the border between the laminae and facets, which was slightly more medial than that in the original procedure, thus minimizing the invasion of the facets. After the laminar halves were elevated in a manner similar to a French door, the bone graft struts (16 to 18 mm long) created from the C6 or C7 spinous process were sutured to bridge the bilateral laminar edges. Neither somatosensory-evoked potentials nor motor-evoked potentials were monitored in this study.

Postoperative Considerations

Each patient, with rare exceptions, was instructed to sit up and to walk on the first postoperative day wearing a fitted Philadelphia collar, which could be removed by the patient. Cervical range of motion exercises were performed as early as possible during the rehabilitation period. We demonstrated an ideal alignment to all patients after surgery and instructed patients on a good position of the head and neck.

Clinical Outcomes

Surgical duration and intraoperative blood loss were recorded. The severity of myelopathy before and after surgery was evaluated according to a scoring system proposed by the Japanese Orthopaedic Association[12,29]. The Japanese Orthopaedic Association scores were assessed a year after surgery and during the latest follow-up examination. The Japanese Orthopaedic Association score quantifies neurological impairment by the evaluation of motor function in the upper and lower extremities (4 points each), sensory function in the upper and lower extremities and in the trunk sensibility (2 points each, with a total of 6 points), and urinary bladder function (3 points). A perfect Japanese Orthopaedic Association score for cervical myelopathy is 17 points (see Appendix). The recovery rate of the Japanese Orthopaedic Association score was calculated using the following formula originally suggested by Hirabayashi et al.[30]: (postoperative Japanese Orthopaedic Association score − preoperative Japanese Orthopaedic Association score)/(17 − preoperative Japanese Orthopaedic Association score) × 100% (see Appendix). Risk factors for a poor outcome were analyzed as described elsewhere[14,31,32]. A poor outcome was defined as a postoperative recovery rate of <50%, and a good outcome was defined as a recovery rate of ≥50%.

Two patient groups, one with good outcomes and one with poor outcomes, as defined above, were established. Preoperative prognostic factors, including age, sex, body height, body weight, body mass index (BMI), cervical spondylotic myelopathy symptom duration, fasting blood glucose levels, HbA1c levels, duration of diabetes symptoms, insulin use, presence of urinary sugar, presence of hypertension and/or hyperlipidemia, use of anticoagulants and/or antiplatelet agents, and smoking history, were noted. Potential risk factors such as preoperative C2-C7 alignment, presence of mild cervical spine kyphosis, and range of motion of the cervical spine were preoperatively assessed.

The postoperative follow-up period, postoperative Japanese Orthopaedic Association score, surgical duration, intraoperative blood loss, postoperative C2-C7 alignment, preoperative range of motion of the cervical spine, change in alignment, and range of motion preservation were also compared between the two groups after surgery.

Radiographic Outcomes

The preoperative and latest lordotic angles between C2 and C7 were measured in the neutral and maximal flexion-extension lateral radiographic views using the Cobb method[33], with the negative lordotic angle indicating cervical kyphosis and the positive lordotic angle indicating lordosis[33-35]. A change in alignment was assessed using the following formula: alignment change (degrees) = preoperative C2-C7 lordotic angle − postoperative C2-C7 lordotic angle[34]. The range of motion of the cervical spine was assessed by measuring the difference in alignment at flexion and

TABLE I Demographic Data of the Two Patient Groups Before Surgery

Variable*	All (N = 105)	Good Outcome (N = 51)	Poor Outcome (N = 54)	P Value†
Age† *(yr)*	68.2 ± 8.2	66.2 ± 8.7	70.2 ± 7.2	0.0109
Sex§				0.8431
Male	65	31	34	
Female	40	20	20	
Body height† *(cm)*	158.6 ± 8.9	159.6 ± 7.8	157.6 ± 9.8	0.2543
Body weight† *(kg)*	60.5 ± 11.4	62.5 ± 11.7	58.6 ± 10.8	0.0776
BMI† *(kg/m^2)*	23.9 ± 3.4	24.4 ± 3.3	23.5 ± 3.4	0.1726
Symptom duration of cervical spondylotic myelopathy† *(mo)*	17.8 ± 26.0	11.1 ± 23.3	24.2 ± 27.0	0.0092
Preoperative Japanese Orthopaedic Association score† *(points)*	10.1 ± 2.7	10.6 ± 2.9	9.7 ± 2.5	0.0750
Fasting blood glucose† *(mg/dL)*	147 ± 45.8	154 ± 49.7	142 ± 41.3	0.1773
HbA1c level† *(%)*	7.0 ± 0.9	6.8 ± 0.9	7.2 ± 0.9	0.0165
Duration of diabetes symptoms† *(mo)*	123 ± 83.5	110 ± 84.4	135 ± 81.9	0.0470
Use of insulin#	15 (14.3%)	5 (9.8%)	10 (18.5%)	0.2677
Urinary sugar#	27 (25.7%)	13 (25.5%)	14 (25.9%)	0.9593
Prevalence of hypertension#	73 (69.5%)	36 (70.6%)	37 (68.5%)	0.8354
Prevalence of hyperlipidemia#	32 (30.5%)	19 (37.3%)	13 (24.1%)	0.2029
Use of anticoagulant or antiplatelet agents#	55 (52.4%)	25 (49.0%)	30 (55.6%)	0.5602
Smoking history#	33 (31.4%)	16 (31.4%)	17 (31.5%)	0.9904
Preoperative C2-C7 lordotic angle† *(deg)*	11.5 ± 7.5	11.0 ± 7.7	11.9 ± 7.3	0.5716
Kyphosis less than a C2-C7 alignment of 0°#	7 (6.7%)	4 (7.8%)	3 (5.6%)	0.7106
Preoperative range of motion† *(deg)*	38.5 ± 8.9	40.0 ± 9.3	37.1 ± 8.3	0.0916

*The Mann-Whitney U test was used to assess non-normally distributed variables, and the chi-square test was used for categorical variables. †Significance was set at $p < 0.05$. †The values are given as the mean and the standard deviation. §The values are given as the number of patients. #The values are given as the number of patients, with the percentage in parentheses.

extension[36]. Angles created by lines parallel to the inferior aspects of the C2 and C7 vertebral bodies were measured on flexion and extension lateral radiographs and were summed to arrive at a total range of motion value. Range of motion preservation was assessed using the following formula[34]: range of motion preservation (%) = (postoperative range of motion/preoperative range of motion) × 100.

Statistical Analysis

Data were analyzed using SPSS statistical software, version 18.0 (SPSS, Chicago, Illinois). Univariate analyses were performed to identify correlations between outcome at the time of the latest follow-up and prognostic factors. The Mann-Whitney U test was used to assess non-normally distributed variables, and the chi-square test was used to assess categorical variables. A proportional odds model was used to compute odds ratios and 95% confidence intervals (95% CIs) for various categories of diabetes. An improvement in any category was classified using two levels (good or poor) to determine the dependent variables in the model. The following variables were examined: fasting blood glucose of <150 mg/dL or ≥150 mg/dL, HbA1c level of <6.5% or ≥6.5%, and duration of diabetes for less than ten years or ten years or more[37-39]. The potential confounding factors included in the logistic regression analyses were patient age of younger than sixty-five years or sixty-five years or more[40], BMI[41] of <25 kg/m^2 or ≥25 kg/m^2, and duration of cervical spondylotic myelopathy symptoms of less than twelve months or twelve months or more. Variables with a significance of $p < 0.05$, as per univariate analysis, were included in the logistic regression model. The significance of parameters was evaluated by univariate logistic analysis, and those with a significance of $p < 0.05$ were entered into the multivariable logistic model.

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Results

Most patient demographic data showed no significant differences ($p \geq 0.05$) between groups (Table I), with the exception of age, duration of cervical spondylotic myelopathy symptoms, HbA1c levels, and duration of diabetes symptoms. The average HbA1c level was 7.0% (range, 5.8% to 9.5%), and the average duration of diabetes was 123.7 months (range, three to 480 months). When compared with the good-outcome group, the poor-outcome group had a significantly higher mean patient age ($p = 0.0109$) and HbA1c level ($p = 0.0165$) and a significantly longer duration of diabetes ($p = 0.0470$) and cervical spondylotic myelopathy ($p = 0.0092$).

TABLE II Clinical Outcomes of the Two Patient Groups

	All* (N = 105)	Good Outcome* (N = 51)	Poor Outcome* (N = 54)	P Value†
Postoperative follow-up period *(mo)*	27.3 ± 13.6	27.9 ± 10.6	26.8 ± 16.0	0.6806
Postoperative Japanese Orthopaedic Association score *(points)*	13.1 ± 2.9	15.2 ± 1.4	11.2 ± 2.6	<0.0001
Recovery rate of Japanese Orthopaedic Association score *(%)*	47.3 ± 30.7	73.8 ± 18.4	22.3 ± 14.8	<0.0001
Surgical duration *(min)*	75.3 ± 19.7	76.7 ± 21.0	74.1 ± 18.5	0.5026
Intraoperative blood loss *(mL)*	47.3 ± 40.5	46.2 ± 36.7	48.3 ± 44.0	0.7883
Postoperative C2-C7 lordotic angle *(deg)*	14.0 ± 8.4	15.5 ± 8.2	12.6 ± 8.5	0.0852
Postoperative range of motion *(deg)*	33.5 ± 9.0	34.5 ± 9.7	32.5 ± 8.2	0.2450
Alignment change‡ *(deg)*	2.5 ± 6.5§	4.4 ± 6.3§	0.76 ± 6.2§	0.0033
Range of motion preservation# *(%)*	89.1 ± 23.6	88.2 ± 23.8	90.0 ± 23.5	0.7030

*The values are given as the mean and the standard deviation. The Mann-Whitney U test was used to assess non-normally distributed variables. †Significance was set at $p < 0.05$. ‡Alignment change (degrees) = (preoperative C2-C7 lordotic angle) − (postoperative C2-C7 lordotic angle). §There was a lordotic change in these values. #Range of motion preservation (%) = (postoperative range of motion)/(preoperative range of motion) × 100.

All patients underwent modified double-door laminoplasty by a midsagittal splitting of the spinous process at the disc levels of C3-C7 (ninety-one patients), C3-C6 (ten patients), C4-C7 (three patients), and C3-T1 (one patient). The average postoperative follow-up period was 27.3 months (range, twelve to sixty-six months). The average surgical duration for laminoplasty was

TABLE III Logistic Regression Analyses of the Risk Factors for Poor Outcome

	Odds Ratio*	P Value
Univariate		
Patient age of sixty-five years or older	3.111 (1.3365 to 7.2422)	0.0085
Male sex	1.097 (0.4987 to 2.4120)	0.8183
BMI of ≥25 kg/m^2	0.648 (0.2845 to 1.4747)	0.3001
Duration of cervical spondylotic myelopathy symptoms for twelve months or more	3.940 (1.7194 to 9.0277)	0.0012
Fasting blood glucose of ≥150 mg/dL	0.847 (0.2877 to 2.4953)	0.6793
HbA1c level of ≥6.5%	2.591 (1.1266 to 5.9573)	0.0193
Duration of diabetes symptoms for ten years or more	2.245 (1.0278 to 4.9032)	0.0321
Use of insulin	2.091 (0.6618 to 6.6057)	0.2088
Urinary sugar	1.023 (0.4261 to 2.4562)	0.9593
Mild kyphosis†	1.015 (0.9640 to 1.0691)	0.5680
Hypertension	0.818 (0.3946 to 2.0844)	0.9069
Hyperlipidemia	0.534 (0.2297 to 1.2413)	0.1449
Anticoagulant or antiplatelet agent use	1.300 (0.6032 to 2.8015)	0.5030
Smoking	1.250 (0.5188 to 3.0116)	0.6189
Multivariate‡		
Patient age of sixty-five years or older	3.632 (1.3384 to 9.5031)	0.0086
Duration of cervical spondylotic myelopathy symptoms for twelve months or more	5.001 (1.9729 to 12.676)	0.0007
HbA1c level of ≥6.5%	2.822 (1.0279 to 7.7455)	0.0441
Duration of diabetes symptoms for ten years or more	2.240 (1.0310 to 4.9000)	0.0410

*The values are given as the odds ratio, with the 95% CI in parentheses. †Mild kyphosis = −10° < C2-C7 lordotic angle <0°. ‡The multivariate model includes variables with $p < 0.05$ as per univariate analysis.

75.3 minutes (range, forty-seven to 160 minutes), and the average intraoperative blood loss was 47.3 mL (range, 1 to 290 mL). No intraoperative neurological deterioration was observed. The mean Japanese Orthopaedic Association score (and standard deviation) was 10.1 ± 2.7 points preoperatively, 13.0 ± 2.8 points at one year postoperatively, and 13.1 ± 2.9 points at the time of the latest follow-up. The mean recovery rate of the Japanese Orthopaedic Association score (and standard deviation) was 47.3% ± 30.7%. Of the 105 patients, two (1.9%) had superficial wound complications (delayed wound-healing).

There were no significant differences in clinical outcomes between the two groups ($p \geq 0.05$), with the exception of change in postoperative cervical alignment ($p = 0.0033$), the postoperative Japanese Orthopaedic Association score ($p < 0.0001$), and the recovery rate of the Japanese Orthopaedic Association score ($p < 0.0001$) (Table II). The good-outcome group exhibited significant lordotic changes in cervical alignment after laminoplasty ($p = 0.0033$).

Univariate logistic regression analysis showed that patient age of sixty-five years or older (odds ratio, 3.111; $p = 0.0085$) and duration of cervical spondylotic myelopathy symptoms for twelve months or more (odds ratio, 3.940; $p = 0.0012$) were associated with an increased risk of poor surgical outcome. High HbA1c levels of ≥6.5% (odds ratio, 2.591; $p = 0.0193$) and duration of diabetes of ten years or more (odds ratio, 2.245; $p = 0.0321$) were significant risk factors for poor surgical outcome. Sex and BMI were not predictive factors for treatment outcome, and a fasting blood glucose level was not a risk factor for poor outcome in this study. The use of insulin and the presence of urinary sugar were not associated with outcome. Mild kyphosis in the cervical spine did not affect cervical laminoplasty outcomes. Hypertension, hyperlipidemia, anticoagulant and/or antiplatelet agents, and smoking history were not predictive factors for treatment outcome (Table III).

Multivariate logistic regression analysis revealed four significant risk factors for poor outcome, including HbA1c levels of ≥6.5% (odds ratio, 2.822; $p = 0.0441$) and duration of diabetes for ten years or more (odds ratio, 2.240; $p = 0.0410$) (Table III).

Discussion

Cervical spondylotic myelopathy is a common spinal disorder, with the incidence of surgery for cervical spondylotic myelopathy increasing by approximately twofold to sevenfold over the last decade[42,43]. The number of patients with diabetes is increasing worldwide, and the global prevalence of diabetes among adults who are twenty to seventy-nine years of age was estimated to affect 285 million individuals in 2010 and is projected to increase to 439 million individuals by 2030[44]. The treatment of cervical spondylotic myelopathy complicated by diabetes has been a matter of debate; therefore, it remains unclear whether and how diabetes affects the outcomes of cervical laminoplasty for cervical spondylotic myelopathy. To our knowledge, this is the first reported multivariate analysis of surgical outcomes in the largest series of patients with diabetes and cervical spondylotic myelopathy. Our goal was to characterize the risk factors for a poor outcome after the surgical treatment of cervical spondylotic myelopathy in patients with diabetes. The results of this study showed that patient age of sixty-five years or older and duration of cervical spondylotic myelopathy symptoms of twelve months or more were associated with an increased risk of poor surgical outcome. Furthermore, multivariate logistic regression analysis found that relatively high HbA1c levels of ≥6.5% and a duration of diabetes for ten years or more were significant risk factors for poor treatment outcome.

Numerous factors affect postoperative outcomes of patients with cervical spondylotic myelopathy, including age, duration of cervical spondylotic myelopathy symptoms, preoperative neurological condition, smoking history, and sagittal cervical alignment[10-16]. Several previous studies have shown the outcomes of spinal surgery in patients with diabetes[10,17-23,45]. Previous reports on lumbar spinal surgical procedures showed that diabetes is one of several risk factors for poor surgical outcomes[18-20,45]. In patients with cervical myelopathy, current treatment controversies mostly center on the impact of surgical outcomes for the cervical spine[10,17,21-23].

The current study demonstrated that preoperative increased HbA1c levels were associated with an increased risk of a poor surgical outcome. In this study, the fasting blood glucose level was not a predictor of outcome; rather, it was used as a marker of diabetes control. However, this value was easily influenced by physical stress and recent diet. Also, insulin use and the presence of urinary sugar were not associated with treatment outcome, which is considered by diabetes specialists to be a result of strict blood glucose control in the perioperative period. The HbA1c level is reportedly directly proportional to the integrated blood glucose level over the preceding two to three months[22,23]. However, this test is objective and is unaffected by patient diet. Therefore, long-term diabetes control for at least two to three months before surgery is recommended to achieve favorable surgical outcomes. If appropriate blood glucose control is maintained both before and after surgery, patients with diabetes may be more likely to exhibit a reasonable recovery after cervical laminoplasty.

The cumulative risk of diabetic neuropathy increases with disease duration[22,23]. Long-term and severe diabetes usually coexists with diabetic neuropathy; a prolonged duration of diabetes may result in poor neurological recovery after surgery. In the current study, there was a relationship between the recovery rate based on Japanese Orthopaedic Association scores and diabetes duration. It is well known that patients with diabetic neuropathy have sensory disturbances in the extremities, typically showing stocking-and-glove patterns of sensory deficit. In patients with polyneuropathy, the distal portions of the long peripheral nerves are affected first[46].

Previous studies have suggested that the spinal cord is vulnerable to the degeneration of motor neurons and myelinated fibers in elderly patients[47,48]. Our results support findings that the age and duration of symptoms had a negative effect on recovery rate in patients with diabetes. Dokai et al.[22] reported a negative correlation between preoperative HbA1c levels and

recovery rate in patients with diabetes, and Kawaguchi et al.[23] reported that long-term diabetes may result in poor neurological recovery after surgery. These groups speculated that poor recovery of neurological function resulted from diabetic polyneuropathy. Several other studies have described degenerative changes in the spinal cord and peripheral nerves of patients with diabetes, including infarcts, demyelination, atrophy, and softening of the posterior cord columns. To identify correlations between the severity of diabetes and surgical outcomes more clearly, further studies should be conducted with large cohorts of patients with diabetes and cervical spondylotic myelopathy[49,50].

There were several limitations to the present study, including the relatively short follow-up period. However, data at the one-year follow-up visit were used to assess important predictors of outcome in recent well-designed articles[3,16]. In addition, patient-based objective outcomes such as quality-of-life issues, determined with use of a thirty-six-item, short-form survey, and subjective satisfaction were not assessed. We used Japanese Orthopaedic Association scores for the assessment of neurological function. The Japanese Orthopaedic Association score is a simple scoring system that accurately reflects neurological and functional status[51,52]. In comparison with the Nurick disability score[53], the Japanese Orthopaedic Association score more specifically assesses motor function, sensation, and urinary symptoms. It also has high interobserver and intraobserver reliability[52]. The Japanese Orthopaedic Association score is the most comprehensive of the traditional and available measures for quantifying the degree of impairment secondary to myelopathy[52,54]. Many previous investigators have used the Japanese Orthopaedic Association scoring system and its recovery rate for evaluating treatment results[10,17,22,23,54]. There was no electrophysiological study performed to evaluate the existence of diabetic polyneuropathy. Therefore, both preoperative and postoperative neurological status may be ascribed to polyneuropathy and cervical spondylotic myelopathy in patients with diabetes. Postoperative HbA1c levels could not be located in the medical records of all patients. Postoperative neurological recovery may have been affected by not only preoperative diabetic control but also postoperative diabetic control. Nonetheless, we evaluated the largest number of patients who underwent the same single procedure, and this is the first report, to our knowledge, to identify risk factors for a poor outcome using multivariate analysis.

In conclusion, the interaction of diabetes with advanced age and long duration of cervical spondylotic myelopathy symptoms adversely affected the outcomes of cervical laminoplasty. The adverse relationship between recovery rate and preoperative HbA1c levels suggest that long-term diabetes control before surgery is recommended for favorable surgical outcomes. High preoperative HbA1c levels and long duration of diabetes are risk factors for poor outcome of cervical laminoplasty in patients with diabetes.

Appendix

eA A table showing the evaluation of cervical myelopathy using the scoring system proposed by the Japanese Orthopaedic Association and the recovery rate of the Japanese Orthopaedic Association score is available with the online version of this article as a data supplement at jbjs.org. ■

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