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Relationship between changes in physical function parameters and Roland-Morris disability questionnaire score after decompression surgery for lumbar spinal canal stenosis

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ABSTRACT

Although decompression surgery for lumbar spinal canal stenosis (LSS) improves leg symptoms, low back pain (LBP), and disability, the factors related to the improvement of subjective disability have not been studied sufficiently. The purpose of the study was to clarify the relationship between subjective disability and objective physical function parameters. A total of 51 patients who underwent decompression were included and evaluated preoperatively and 6 and 12 months postoperatively. Patient-reported outcomes related to activity limitation due to LBP were evaluated using Roland–Morris disability questionnaire (RDQ) and VAS (Visual Analog Scale). Physical function was assessed using 6-min walk distance (6MWD) and trunk muscle strength. Univariate analysis and multivariable linear regression analysis were performed to identify significant factors for RDQ score change. The 6- and 12-month postoperative RDQ scores, VAS scores, and trunk extensor strength significantly improved relative to the preoperative values. In the univariate analysis, age, changes in VAS (LBP, leg pain, and numbness) scores, and change in 6MWD were associated with the RDQ score change ($p < 0.05$). Multivariable linear regression showed that 6MWD changes were significantly associated with RDQ score changes, explaining 41% of the variance in the RDQ score change. This study showed the change in 6MWD was significantly associated with the RDQ score change. Our results suggest that improving 6MWD may reduce disability in activities of daily living.

Keywords: lumbar spinal canal stenosis, decompression surgery, Roland-Morris disability questionnaire, physical function, 6-min walk distance

Abbreviations:
LSS: lumbar spinal canal stenosis
RDQ: Roland-Morris Disability Questionnaire
ODI: Oswestry Disability Index
6MWT: 6-min walk test
6MWD: 6-min walk distance
VAS: Visual Analog Scale
CT: computed tomography

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FFD: finger-floor distance
SLR: straight leg raise
VIF: variance inflation factor

INTRODUCTION

Lumbar spinal canal stenosis (LSS) is a disorder associated with symptoms such as low back pain (LBP), lower limb pain and numbness, intermittent claudication, and difficulties in activities of daily living.[1] LSS affects nearly 3.6 million people aged > 40 years in Japan and has a prevalence rate of approximately 10% in Japanese people in their 70s.[2] Surgery is the treatment of choice, whereas conservative therapy is ineffective, for severe LSS.[3] Decompression surgery is common surgical intervention for LSS, and is performed to alleviate neural compression in patients without instability.[1]

Although decompression surgery improves symptoms (ie, LBP, leg symptoms, and disability), the factors related to the improvement of subjective disability have not been studied sufficiently.[4] Since LSS is caused by degenerative changes resulting from aging, not only nerve compression but also discogenic and myofascial back pain may occur. Thus, the Roland-Morris Disability Questionnaires (RDQ) score or Oswestry Disability Index (ODI), which are LBP-related disability indices, have been used to evaluate the postoperative outcomes of decompression surgery.[4] The RDQ is composed of 24 items that assess whether commonly performed daily activities, such as standing, walking, dressing, and working, are disturbed by low back pain.[5] The RDQ score is a clinical outcome that has been adopted as a nationwide standard on the basis of data from the general Japanese population (n = 2966).[6,7]

Trunk muscles play an important role in functional performance,[8] and exercises for improving walking capacity and trunk muscle strength have been used in the physical therapy of patients after lumbar spinal surgery.[9] The self-paced walking test (SPWT), treadmill walking test, and 6-minute walk distance (6MWD) have been used for the objective evaluation of walking distance in patients with LSS.[10-12] Moreover, only a few reports have examined the recovery of trunk muscle strength after surgery in patients with LSS.[13,14]

It remains unclear how changes in objective physical function parameters are related to changes in subjective disability after decompression surgery. It is important to have an understanding of this to set postoperative goals.

In this study, we investigated the subjective disability and physical functions such as walking ability and trunk muscle strength, as well as VAS (Visual Analog Scale) (LBP, leg pain, and leg numbness) of patients who underwent decompression surgery. The purpose of the study was to clarify the relationship between changes in subjective disability and changes in objective physical function parameters.

MATERIALS AND METHODS

The research ethics committee of our institute approved this study (Asahi Hospital No. A-27, Nagoya University No. 16-519). All patients provided written or oral informed consent, and the study was conducted according to the principles of the Declaration of Helsinki. We conducted this retrospective, observational, cohort study at a single hospital. We excluded patients with severe osteoarthritis of the knees and hips, history of central nervous system disorder, vertebral fracture, fusion surgery, nerve paralysis (≤ 2 in the manual muscle test), history of spinal surgery, and insufficient understanding of the questionnaire. The inclusion criteria were as follows: 1) severe neurogenic claudication characterized by leg pain and/or numbness; 2) available magnetic resonance imaging, computed tomography (CT) myelography, and radiologic findings; 3) ineffective nonoperative therapy; and 4) decompression surgery performed to alleviate neural compression in patients without instability[1]. A total of 91 patients who underwent surgery for LSS between June 2013 and January 2019 were included in this study. Fifty-one of the 91 patients who met our criteria completed our evaluation. Forty patients were excluded from for the following reasons: appointment cancellation (n=19), missing data at the 6-month follow-up (n=21). Table 1 shows the patients' characteristics. The mean age at surgery of all patients was 68.7 (standard deviation, 7.5) years. Comorbidity was defined as the presence of treatment with medication in nine patients (17.6%), as follows: seven patients (13.7%) with diabetes, one (2.0%) patient with cardiac disease, and one (2.0%) patient with depression. Nine patients (17.6%) had a smoking habit. Preoperative pain medication was provided to 40 patients (78.4%). The medications included pregabalin in 33 patients (64.7%) and nonsteroidal anti-inflammatory drugs in 23 patients (45.1%). The minimum area of the dural sac was measured using CT myelography (Alexion; Toshiba Medical Systems Corporation, Tochigi, Japan). The cross-sectional area of the dural sac was measured at each disc level from L1-2 to L5-S1.

Table 1 Patients' characteristics (n = 51)

Sex, n (%)	
Male	38 (74.5)
Age (years)	68.7 (7.5)
Height (cm)	163.8 (9.2)
Body weight (kg)	64.8 (10.6)
BMI (kg/m^2)	24.1 (2.7)
Duration of symptoms (years)	1.6 (2.2)
Surgery-related factors	
Blood loss (mL)	45.4 (59.1)
Operation time (min)	74.9 (27.1)
Operation segments, n (%)	
1	29 (56.9)
≥ 2	22 (43.1)
Minimum area of the dural sac (mm^2)	41.8 (27.1)

Data are expressed as mean (standard deviation) or number of patients (%).
BMI: body mass index

Surgical procedure and rehabilitation management

Decompression surgery was performed using the open method. Decompression surgery was selected for patients without lumbar spine instability. In this surgery, the spinous process was split and the stenotic part of the lumbar spine was decompressed through a partial medial facetectomy.[15] Patients who underwent decompression surgery began rehabilitation on postoperative day 3 and were discharged on postoperative day 5. The mean hospitalization duration in patients who underwent decompression surgery was 7 days. Patient started walking using a walker. Physical therapy of approximately 40 minutes per day was continued until discharge. The patients were encouraged to walk daily, avoid extreme bending of the trunk and lifting heavy items, perform light exercises (heel up, toe up, one-leg standing, half squat in the standing position, abdominal draw-in maneuver and pelvic lift in the supine position, and sit-ups in the supine position), and perform stretching (hip flexion and abduction, hamstring stretching, and calf stretching). The patients were encouraged to continue rehabilitation after discharge. A corset was not used in patients who underwent decompression surgery.

Patient-reported outcome to assess disability and Pain

Patients were asked to answer the RDQ (Table 2). The RDQ score ranges from 0–24 (24 indicating the worst disability). The VAS (scores from 0 to 100, with 100 indicating the worst pain or numbness) was used to assess LBP, lower-extremity pain, and numbness.

Table 2 Twenty-four questions in Roland Morris Disability Questionnaire (RDQ)

1.	I stay at home most of the time because of my back.
2.	I change position frequently to try and get my back comfortable.
3.	I walk more slowly than usual because of my back.
4.	Because of my back I am not doing any of the jobs that I usually do around the house.
5.	Because of my back, I use a handrail to get upstairs.
6.	Because of my back, I lie down to rest more often.
7.	Because of my back, I have to hold on to something to get out of an easy chair.
8.	Because of my back, I try to get other people to do things for me.
9.	I get dressed more slowly then usual because of my back.
10.	I only stand for short periods of time because of my back.
11.	Because of my back, I try not to bend or kneel down.
12.	I find it difficult to get out of a chair because of my back.
13.	My back is painful almost all the time.
14.	I find it difficult to turn over in bed because of my back.
15.	My appetite is not very good because of my back pain.
16.	I have trouble putting on my socks (or stockings) because of the pain in my back.
17.	I only walk short distances because of my back.
18.	I sleep less well because of my back.
19.	Because of my back pain, I get dressed with help from someone else.
20.	I sit down for most of the day because of my back.
21.	I avoid heavy jobs around the house because of my back.
22.	Because of my back pain, I am more irritable and bad tempered with people than usual.
23.	Because of my back, I go upstairs more slowly than usual.
24.	I stay in bed most of the time because of my back.

Evaluation of physical function

The 6-minute walk test (6MWT) was performed according to established guidelines.[16] The 6MWD has been shown to be useful for the evaluation for LSS.[17,18] The strength of the trunk muscles was measured using a strain-gauge dynamometer (Mobie®; SAKAI Medical, Japan). The isometric extension strength and isometric flexion strength of the trunk muscles were measured in the sitting position, and two maximal effort attempts were performed. The higher performance between the two attempts was selected for analysis. The flexibility of the trunk for LSS surgery was assessed using the finger-floor distance (FFD).[19] By using a ruler, the FFD was measured as the distance from the fingertips to the table, with the patients standing at the edge of the table. In this test, the patients were asked to bend forward and reach toward the table. The results were categorized as "positive" when the fingertips passed the table and "negative" when the fingertips did not reach the table. The flexibility of hamstring was assessed using a straight leg raise (SLR) test. The test was passively performed, with the patients positioned supine with the hips and knees extended and the pelvis in a neutral position. The examiner passively raised the patients' leg, kept the knee straight, and evaluated the angle.

Statistical analysis

For the recovery of the RDQ score and physical function parameters after surgery, one-way repeated-measure analysis of variance and post hoc Bonferroni test were used to compare each variable examined preoperatively and 6 and 12 months postoperatively. Univariate associations among patient characteristics, changes in VAS scores, physical function parameters, and RDQ score at 12 months postoperatively were evaluated using bivariate regression analyses. Multivariable linear regression analyses were performed for variables in univariate association analysis that showed a $p < 0.05$ correlation coefficient with the RDQ score change at 12 months postoperatively. Statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University), a graphical user interface for R (The R Foundation for Statistical Computing, version 2.13.0).[20] Differences were considered statistically significant at $p < 0.05$. Multicollinearity was evaluated using the variance inflation factor (VIF). If the value of the VIF was < 10, multicollinearity was considered to be present.

RESULTS

Patient-reported outcome to assess disability

The 6- and 12-month postoperative RDQ significantly improved relative to the preoperative scores (Table 3). However, the 12-month postoperative scores did not significantly differ from those at 6 months.

Pain

The 6- and 12-month postoperative VAS (LBP, lower-extremity pain, and numbness) scores significantly improved relative to the preoperative scores (Table 3). However, the 12-month postoperative scores did not significantly differ from those at 6 months.

Physical function

The 6- and 12-month postoperative 6MWD significantly improved compared with the preoperative values (Table 3). However, the 12-month postoperative value did not significantly differ from that at 6 months.

The trunk extensor strength and SLR range significantly improved at 6 and 12 months postoperatively compared with the preoperative levels (Table 3). In contrast, the trunk flexor strength did not significantly improve at 6 and 12 months postoperatively compared with the preoperative strength (Table 3).

Table 3 Recovery of patient-reported outcomes and physical function parameters

	Preoperative	Postoperative 6M	Postoperative 12M	p Value	Post hock analysis Pre vs 6M	Pre vs 12M	6M vs 12M
Patient-reported outcomes							
RDQ score (points)	8.1 (5.0)	1.7 (2.4)	1.4 (2.2)	< 0.001	< 0.001	< 0.001	0.8
VAS scores (mm)							
LBP	54.4 (26.2)	22.6 (20.7)	18.5 (19.0)	< 0.001	< 0.001	< 0.001	0.2
Leg pain	60.8 (26.2)	16.6 (20.8)	15.9 (22.1)	< 0.001	< 0.001	< 0.001	1.0
Leg numbness	59.4 (30.2)	12.2 (17.3)	17.8 (24.5)	< 0.001	< 0.001	< 0.001	0.2
Physical function							
6MWD (m)	313.4 (151.8)	484.2 (83.0)	490.6 (77.9)	< 0.001	< 0.001	< 0.001	0.5
Trunk extensor strength (kg)	21.2 (7.8)	24.9 (8.1)	24.8 (7.4)	< 0.001	0.001	< 0.001	1.0
Trunk flexor strength (kg)	16.5 (4.9)	17.8 (4.6)	17.9 (4.7)	0.11	NA	NA	NA
FFD (mm)	–49.9 (143.2)	–43.1 (133.1)	–39.1 (129.5)	0.65	NA	NA	NA
SLR (°)	70.1 (12.4)	73.2 (10.3)	73.8 (10.2)	0.04	0.01	0.003	0.2

Values are presented as mean (standard deviation).
6M: 6 months
12M: 12 months
RDQ: Roland-Morris Disability Questionnaire
LBP: low back pain
6MWD: 6-min walk distance
FFD: finger-floor distance
SLR: straight leg raise
NA: not applicable
Differences between groups were tested using analysis of variance, followed by Bonferroni post hoc test for continuous variables.

Table 4 Related factors of RDQ score change at 12 months

	Crude estimates β	95% CI	p Value	Adjusted estimates β	95% CI	p Value	VIF
Sex (0: female, 1: male)	1.2	–2.3 to 4.7	0.5				
Age (years)	0.2	0.004 to 0.4	0.045	0.08	–0.1 to 0.3	0.4	1.2
BMI (kg/m^2)	–0.3	–0.8 to 0.3	0.2				
Minimum area of the dural sac (mm^2)	0.04	–0.02 to 0.09	0.2				
Duration of symptoms (years)	–1.6	–3.2 to 0.08	0.06				
Change in LBP VAS score (0–100) (mm)	0.08	0.03 to 0.13	< 0.001	0.05	–0.002 to 0.1	0.06	1.3
Change in leg numbness VAS score (0–100) (mm)	0.07	0.04 to 0.12	< 0.001	0.02	–0.03 to 0.07	0.4	2.0
Change in leg pain VAS score (0–100) (mm)	0.07	0.03 to 0.12	0.002	0.02	–0.03 to 0.07	0.4	2.0
Change in 6MWD (m)	0.02	0.01 to 0.03	< 0.001	0.01	0.002 to 0.02	0.01	1.2
Change in trunk extensor strength (kg)	–0.007	–0.3 to 0.3	0.9				
Change in trunk flexor strength (kg)	0.18	–0.1 to 0.5	0.3				
Change in FFD (mm)	0.08	–0.01 to 0.02	0.6				
Change in SLR (°)	0.09	–0.09 to 0.16	0.6				

Standardized partial regression coefficient beta (β), CI, and p value for crude and adjusted estimates in the multiple regression analyses are shown. The total model explained 42% of the variance in 6MWD at the 12-month follow-up (adjusted $R^2 = 0.42$, $p < 0.01$).
CI: confidence interval
VIF: variance inflation factor
VAS: Visual Analog Scale
LBP: low back pain
FFD: finger-floor distance
SLR: straight leg raise

Univariate and multivariate analyses

Table 4 shows the results of univariate and multivariate analyses of the association between changes in VAS scores and physical function parameters and the RDQ score change at 12 months. In the univariate analysis, age, changes in VAS (LBP, leg pain, and numbness) scores, and change in 6MWD were associated with the RDQ score change ($p < 0.05$). In the multivariate analysis, only the change in 6MWD was significantly associated with the RDQ score change (standardized partial regression coefficient beta [β], 0.01; 95% confidence interval, 0.002–0.02), explaining 42% of the variance in the RDQ score change ($p < 0.01$).

DISCUSSION

We examined the improvements in the RDQ score, VAS scores, and physical function parameters, and the association between the RDQ score change and physical function parameters in patients undergoing decompression surgery. The RDQ score, VAS (LBP, lower-extremity pain, and numbness) scores, 6MWD, and trunk extensor strength were improved at 6 months postoperatively; however, no further significant improvement was found at the 12-month follow-up. Multivariate analysis showed that 6MWD change was associated with RDQ score change.

LSS is caused by age-related degeneration, which results in nerve compression along with discogenic and myofascial back pain. LBP may limit activities of daily living. Therefore, LBP and subjective disability scores (LBP related disability of daily living) are used to study postoperative outcomes of decompression surgery.[4] A systematic review and meta-analysis of cohort studies reported that patients with LSS experienced substantial reductions in pain (LBP with or without leg pain) and disability (RDQ score or ODI) in the first 3 months after surgery.[4] In this study, the mean changes at 6 months were 6.5 points for RDQ score, 32.4 points for LBP VAS score, 44.6 points for leg pain VAS score and 47.2 points for leg numbness VAS score. An RDQ score change of 4–5 points is considered to have clinical value.[21] The minimal clinically detectable change in the VAS score (0–10 rating scale) is considered to be 1.2 points for LBP and 1.6 points for leg pain.[22] Ono et al showed that out of 841 patients reporting LBP for one month, the prevalence of RDQ categories 1-5 and RDQ category 0 was 42.5% and 30.8%, respectively.[6] We found the prevalence of RDQ categories 1-5 and RDQ category 0 to be 37.3% and 51.0%, respectively, at 6 months after surgery. Therefore, our results suggest that decompression surgery adequately improves the RDQ and VAS scores during the first 6 months.

In the evaluation of physical function, 6MWD improved at 6 and 12 months postoperatively. Försth et al reported that the 6MWD in patients with LSS improved (from 309–331 m preoperatively) by 70–80 m at 2 years postoperatively.[17] Additionally, Loske et al reported that the 6MWD in patients with LSS improved (from 357 ± 107 m preoperatively) by 26 m between 10 weeks and 12 months.[23] The 6MWD in the present study has a mean of 484.2 m at 6 months and 490.6 m at 12 months, suggesting that decompression surgery adequately improves the 6MWD during the first 6 months. However, the postoperative 6MWD did not improve to the level of healthy elderly patients: the 6MWD for 70-74-year-old individuals in Japan is reported to be 616.6 m for men and 575 m for women.[24] The locomotive syndrome that is seen in elderly patients contributes to the reduced mobility in patients with LSS who commonly belong to this demographic.[25] 6MWT is helpful in clinical practice because it provides a quicker assessment of walking than the SPWT and treadmill walking test, which take up to 30 minutes.

In the present study, the postoperative trunk extensor strength significantly improved compared with the preoperative strength. Structural changes in the back muscles, such as multifidus muscle atrophy and fatty infiltration, were previously reported to occur in patients who underwent spine fusion and decompression surgery.[26] Hence, the recovery of strength in the trunk extensors, such as the multifidus muscle, is essential. Our findings are consistent with the result of the reported trunk extensor strength after fusion surgery.[13,14,27] The results of the present study showed that decompression surgery, similarly to fusion surgery, improved the postoperative trunk extension strength. In addition, the trunk extension strength using the same measuring device was reported to be 22.5 kg on average for men and 17.5 kg on average for women in their 70s.[28] The postoperative 6-month data in the present study showed an average of 26 kg for men and 18.2 kg for women. Therefore, the data in this study can be described as recovering to the same level as healthy adults. In contrast, we found no improvements in postoperative trunk flexor strength in either group when compared to preoperative strength. One possible reason is that it is not difficult for LSS patients to use trunk flexors due to low local epidural pressure in forwarding flexion, and LSS symptoms are relieved by lumbar flexion (sitting).[29] Moreover, trunk flexors are not damaged during surgery, which may explain the lack of change in trunk flexor strength in LSS patients.

Multivariate analysis showed that the factor associated with the RDQ score change was the change in 6MWD. Improvement in walking and activities of daily living disability occurs in the first few months after surgery is a result of pain relief from nerve decompression and improvement in neurogenic intermittent claudication.[30] The RDQ score is a patient-reported outcome that evaluates whether commonly performed activities of daily living, such as standing, walking, dressing, and working, are impaired due to low back pain. Physical activity level has been reported to be an important factor for 6MWD.[31] Therefore, it is thought that the improvement in walking from the early postoperative period improved the physical activities of daily living, and as a result, the subjective disability (RDQ) score also improved at 12 months after surgery. The results show that improvement in objective parameters of functional disability (6MWD) explain the improvement in the subjective disability (RDQ score). Therefore, 6MWD can be used as an objective goal to assess the postoperative outcomes of decompression surgery for LSS.

This study had several limitations. First, the present study had a short-term follow-up of approximately 12 months. Previous studies in cohorts similar to ours have examined outcomes at 2 years after LSS surgery.[32] However, several studies in Japan have reported that significant recovery in patient-reported outcomes was expected to occur between 6 and 12 months postoperatively.[15,33] Second, no gold standard exists for assessing trunk muscle strength, although a previous study reported assessing postoperative trunk muscle strength using an isometric method with the patients in the standing position.[13] However, because the standing position increases leg pain in patients with LSS,[29] we used the isometric method with the patients in the sitting position to minimize pain. Third, because there are questions about walking (No. 3, 5, 17, 23) among the 24 questions in the RDQ, it is a potential confounder for the 6MWD. Therefore, it is necessary to clarify the percentage of improvement in questions No. 3, 5, 17, and 23. Then, we need to examine the relationship between the percentage improvement in the questions about walking and the change in 6MWD. However, we have no records of the responses to each question item, only the total scores. Therefore, further research is needed. Furthermore, the quantitative amount of postoperative rehabilitation is unclear. Finally, since this is not an interventional study with a comparison group, we cannot comment on causality. Future research is needed to determine the impact of these factors on the postoperative course.

CONCLUSION

This study showed the change in 6MWD was significantly associated with the RDQ score change. Our results suggest that improving 6MWD may lead to reduced disability in activities of daily living.

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A CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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