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Long-Term Results After Surgery for Degenerative Cervical Myelopathy

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BACKGROUND AND OBJECTIVES: Degenerative cervical myelopathy (DCM) is a frequent cause of spinal cord dysfunction, and surgical treatment is considered safe and effective. Long-term results after surgery are limited. This study investigated long-term clinical outcomes through data from the Norwegian registry for spine surgery.

METHODS: Patients operated at the university hospitals serving Central and Northern Norway were approached for long-term follow-up after 3 to 8 years. The primary outcome was change in the Neck Disability Index, and the secondary outcomes were changes in the European Myelopathy Scale score, quality of life (EuroQoL EQ-5D); numeric rating scales (NRS) for headache, neck pain, and arm pain; and perceived benefit of surgery assessed by the Global Perceived Effect scale from 1 year to long-term follow-up.

RESULTS: We included 144 patients operated between January 2013 and June 2018. In total, 123 participants (85.4%) provided patient-reported outcome measures (PROMs) at long-term follow-up. There was no significant change in PROMs from 1 year to long-term follow-up, including Neck Disability Index (mean 1.0, 95% CI −2.1-4.1, $P = .53$), European Myelopathy Scale score (mean −0.3, 95% CI −0.7-0.1, $P = .09$), EQ-5D index score (mean −0.02, 95% CI −0.09-0.05, $P = .51$), NRS neck pain (mean 0.3 95% CI −0.2-0.9, $P = .22$), NRS arm pain (mean −0.1, 95% CI −0.8-0.5, $P = .70$), and NRS headache (mean 0.4, 95% CI −0.1-0.9, $P = .11$). According to Global Perceived Effect assessments, 106/121 patients (87.6%) reported to be stable or improved ("complete recovery," "much better," "slightly better," or "unchanged") at long-term follow-up compared with 88.1% at 1 year. Dichotomizing the outcome data based on severity of DCM did not demonstrate significant changes either.

CONCLUSION: Long-term follow-up of patients undergoing surgery for DCM demonstrates persistence of statistically significant and clinically meaningful improvement across a wide range of PROMs.

KEY WORDS: Cervical spine, Decompressive surgery, Degenerative cervical myelopathy, Cervical spondylotic myelopathy, Observational study, Spine disorder, Spine surgery, Spinal cord dysfunction

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ABBREVIATIONS: DCM, degenerative cervical myelopathy; **EMS,** European Myelopathy Scale; **EQ-5D,** EuroQol 5 dimension; **GPE,** Global Perceived Effect; **mJOA,** modified Japanese Orthopedic Association; **NDI,** Neck Disability Index; **NORspine,** Norwegian registry for spine surgery; **NRS,** numeric rating scales; **PROM,** patient-reported outcome measure.

Cervical spine is prone to degenerative changes in the disks, ligaments, and/or joints, and degenerative cervical myelopathy (DCM) is the most common cause of spinal cord impairment in adults >55 years.[1]

DCM is a progressive spine disorder that may lead to spinal cord compression and dysfunction. The annual incidence during 1966–2011 was 26 per million in Europe[2] and is expected to

increase as the elderly segment of the population is growing[3] The surgical rate in Norway was 6.8/100 000 inhabitants per year in 2014.[4] Awareness of the disease is important to reduce the risk of functional impairment and disability.[5,6] The diagnosis is based on symptoms (numbness in the limbs, fine finger motor disability, neck pain, gait instability, and urinary incontinence) and contiguous signs (hyperreflexia, weakness, pathological reflexes, and alternation of proprioception) with corresponding findings on MRI.[7,8]

Although the evidence for improvement after surgical treatment for DCM is increasing, especially in the short term, evidence for long-term outcomes is limited.[9,10]

Data from the Norwegian registry for spine surgery (NORspine) have shown significant and clinically meaningful improvement after surgery across a wide range of patient-reported outcome measures (PROMs) at a 1-year follow-up.[11] The aim of this study was to investigate whether the outcome after surgery for DCM persists at long-term follow-up.

METHODS

The study was approved by the Regional Committee for Medical Research Ethics (2016/840), and all participants provided written informed consent. The study is reported according to the strengthening the reporting of observational studies in epidemiology statement.[12]

Study Population

NORspine has collected data of patients undergoing surgery for degenerative cervical disorders since 2012. All centers in Norway performing surgery for degenerative disorders in the cervical spine report to the registry. It is a comprehensive registry for quality control and research. Patients fill in questionnaires at baseline and then at 3 and 12 months postoperatively. The surgeons fill in questionnaires directly postoperatively. According to numbers from the Norwegian Directorate of Health, the inclusion rate in the registry for patients who undergo cervical spine surgery in Norway is approximately 82%.[13] Surgery for DCM in Norway is only performed by neurosurgeons. Norway has a public healthcare system, and almost all patients are treated at their regional neurosurgical unit, thus reducing referral bias. Participation in NORspine is voluntary, and the same health care is offered regardless of participation.

In this study, data from the two university hospitals in Central and Northern Norway are evaluated. Patients were operated between January 2013 and June 2018 and approached for additional follow-up in the spring of 2021. At the time of registration in NORspine, patients were ≥18 years, had DCM as the indication for surgery, and a European Myelopathy Scale (EMS) score of <18.

Data Collection

Baseline data were collected on admission for surgery through a self-administered questionnaire, which included demographic data and personal characteristics (marital status, education, body mass index, smoking) in addition to PROMs. Using a standard registration form, the surgeons indicated if the patients were operated for DCM (yes/no) and reported data on comorbidity (including rheumatoid arthritis, hip or knee osteoarthritis, depression or anxiety, musculoskeletal pain, neurological disorders, cerebrovascular disease, cardiovascular disease, vascular claudication, lung disease, osteoporosis, hypertension, endocrine disorders), American Society of Anesthesiologists score, image findings, and surgical procedure. NORspine distributed self-administered questionnaires to the patients by mail 3 and 12 months after surgery. The patients were approached in the spring of 2021, 3 to 8 years after surgery, with an additional questionnaire. Nonresponders received a reminder by telephone and were provided with a new copy of the questionnaire by mail if needed.

Surgical Procedures

The patients were treated with decompression of the cervical spine via an anterior, posterior, or combined approach, with or without instrumented fusion, according to the surgeons' preference. Ventral surgery involved cervical disk removal or corpectomy with subsequent fusion. Posterior surgery involved laminectomy with or without fusion or skip laminectomy.

Outcome Measures

The outcome was defined as the change in outcome measures comparing 1-year results with the long-term follow-up data. The primary outcome was the change in the Neck Disability Index (NDI). Secondary outcome measures were changes in the EMS score, EuroQoL-5D (EQ-5D), and numeric rating scales (NRS) for headache, neck pain, and arm pain. In addition, we report patients' perceived benefit of surgery assessed by the Global Perceived Effect (GPE) scale.

The NDI is a self-administered questionnaire developed for patients with neck pain–related disabilities. It has been translated into Norwegian and tested for reliability, validity, and norming.[14] It includes 10 items: work/daily activities, personal care, lifting driving, reading, recreation and sleep (these 7 are related to activities of daily living), headache and neck pain (these 2 are related to pain), and one item related to concentration. All 10 items are rated from 0 to 5, and the summary score is calculated into a percentage NDI score ranging from 0 to 100 (with higher scores indicating more disability).

The severity of myelopathy was assessed by the EMS score. It has 5 subscores that are obtained by questionnaires filled out by the patients: gait (1-5 points), bladder and bowel function (1-3 points), hand function (1-4 points), proprioception and coordination (1-3 points), and dysesthesia and paresthesia (1-3 points).[15] The total score ranges from 5 to 18, and lower scores indicate more severe deficits. Scores ≥13 were classified as mild DCM, and scores from 5 to 12 points were classified as moderate-to-severe DCM.[16]

Health-related quality of life was measured with EQ-5D.[17] The Norwegian version has shown good psychometric properties and a norm for the general population provided.[18] The EQ-5D evaluates 5 dimensions of life quality: mobility, self-care, activities of daily living, pain, anxiety, and/or depression. An index value for health status is generated for each patient, with scores ranging from −0.6 to 1, where 1 indicates perfect health.[19]

Headache, neck, and arm pain were measured with NRS, a 1-dimensional pain scale ranging from 0 to 10 (no to worst imaginable pain).

Patients' perceived benefit of surgery was evaluated by GPE scale, which has 7 response categories; (1) complete recovery, (2) much better, (3) slightly better, (4) unchanged, (5) slightly worse, (6) much worse, and (7) worse than ever.[20]

Stabilization of myelopathy was considered satisfactory and durable if the outcome measure was unchanged or improved from 1 year to long-term follow-up.[9]

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 and Software R version 3.6.3 (IBM Corp). We defined the significance level for statistical comparison tests as $P \leq .05$. Median range and frequencies were computed for demographic variables at baseline, and changes in PROMs were compared using paired sample *t*-tests and mixed linear models.

Mixed linear model analyses were used for handling missing data. This was in line with previous studies showing that additional imputations are unnecessary when mixed model analysis on longitudinal data is performed.[21,22] In the mixed model, patients could still be included in the analysis if a variable was present at a minimum of one of the follow-up time points. All the mixed linear models had time as a fixed factor and unstructured covariance for repeated measurements on each individual.

We used linear regression to check if time from surgery to follow-up affected the results.

RESULTS

Of the 144 consecutive patients operated from January 2012 through June 2018, 123 participants (85.4%) provided PROMs at long-term follow-up with a mean follow-up time of 5 years and 10 months. At baseline, the median age was 59 years (range 29–85), 59 (41.0%) were female, and 31 patients (25.5%) had moderate-to-severe DCM. Baseline characteristics are presented in Table 1. Data on the surgical approach were available for 119/123 patients (96.7%). Among these, 53 (44.5%) were operated via and anterior approach and 66 (55.5%) via a posterior approach (Table 2).

Primary Outcome Measure

There was no significant difference in NDI from 1 year (mean 22.5, 95% CI 18.6-26.3) to long-term follow-up (23.5, 95% CI 19.2-27.7) (mean change 1.0, 95% CI: −2.1-4.1, $P = .53$), and the results were consistent with mixed linear models analyses (mean change −0.1, 95% CI: −3.0-2.8, $P = .95$). See Table 3.

Secondary Outcomes

There were no significant changes in secondary outcomes from 1 year to long-term follow-up, including EMS (mean change −0.3, 95% CI −0.7-0.1 to, $P = .09$), EQ-5D index score (mean change −0.02, 95% CI −0.09-0.05, $P = .51$), NRS neck pain (mean change 0.3, 95% CI −0.2-0.9, $P = .22$), NRS arm pain (mean difference −0.1, 95% CI −0.8-0.5, $P = .70$), and NRS headache (mean difference 0.4, 95% CI −0.1-0.9, $P = .11$).

Mixed linear model analyses showed similar results for all PROMs (Table 2).

Patients' perceived benefit of surgery assessed by the GPE at 1 year and long-term follow-up is presented in Figure. In 106 of 121 patients (87.6%), the myelopathy was stabilized according to the GPE; 13.2% "complete recovery," 37.2% "much better," 18.2% "slightly better," or 19.0% "unchanged" at long-term follow-up. In total, 15 of 121 patients (12.4%) reported feeling "slightly worse," "much worse," or "worse than ever" at long-term follow-up.

TABLE 1. Baseline Characteristics of the Patient Population

Variable	
Age—y (median, range)	59 (29-85)
Female sex—No. (%)	59 (41%)
Married or partner—No. (%)	87 (60.4%)
College education—No. (%)	43 (33.6%)
Mean body mass index	27.4 (95% CI 26.6-28.3)
Current smoker—No. (%)	47 (34.1%)
Comorbidity—No. (%)	87 (62.6%)
Previous cervical spine surgery	8 (5.8%)
Symptoms >1 year	23 (17.4%)
ASA grade >2	41 (30.1%)
Preoperative NDI	33.1 (CI 95% 29.7-35.7)
Preoperative EMS score	13.9 (CI 95% 13.4-14.3)
EMS moderate-to-severe (5-12)—No. (%)	31 (25.5%)
Preoperative EQ-5D	0.43 (CI 95% 0.36-0.49)
Preoperative NRS neck pain	4.5 (CI 95% 4.0-5.0)
Preoperative NRS arm pain	4.9 (CI 95% 4.4-5.5)
Preoperative NRS headache	3.1 (CI 95% 2.6-3.8)

ASA, American society of anesthesiologists; EMS, European myelopathy scale; EQ-5D, EuroQol 5 dimension; NDI, Neck disability index; NRS, numeric rating scale.

Linear regression showed no association between the time of follow-up from surgery and the PROMs at long-term follow-up.

No difference in the PROMs at long-term follow-up was found between the anterior and posterior approaches in this unmatched nonrandomized cohort (Table 3).

DISCUSSION

The present population-based study on patients operated for DCM in the central and northern parts of Norway shows that patient-reported outcomes after surgery remained stable from 1 year to long-term follow-up.

Our results are in concordance with a recent prospective study on 42 patients undergoing surgery for DCM in the Netherlands. This study demonstrated satisfactory results with a significant increase in mean modified Japanese Orthopedic Association (mJOA) score from baseline to a 2-year follow-up, and the results were unchanged at a 10-year follow-up.[9]

A recent retrospective study with 195 patients with a mean follow-up of 6.3 years demonstrated neurological improvement in 89% at 5 years and 76% at 10 years. No PROMs were reported in the long-term follow-up in this study.[23]

TABLE 2. Anterior vs Posterior Approach

Variable	Anterior approach, n = 62		Posterior approach, n = 73		Anterior vs posterior	
	Baseline	Long term	Baseline	Long term	Mean change difference (95% CI) at long term	*P* value
NDI	27.6	23.4 (18.0-28.7)	34.3	26.2 (21.5-30.9)	−2.7 (−9.6-4.2)	.43
EMS score	14.9	15.4 (14.8-16.0)	13.4	14.3 (13.7-15.0)	0.3 (−0.6-1.3)	.84
EQ5D	0.50	0.64 (0.54-0.73)	0.46	0.56 (0.48-0.64)	−0.01 (−0.14-0.12)	.83
NRS neck pain	4.3	3.3 (2.4-4.2)	4.0	3.1 (2.3-3.9)	0.1 (−1.1-1.4)	.84
NRS arm pain	4.5	3.1 (2.3-4.0)	4.8	3.6 (2.8-4.4)	0.2 (−1.2-1.5)	.79
NRS headache	3.1	2.2 (1.6-3.1)	2.8	2.5 (1.6-3.2)	0.6 (−0.6-1.7)	.34
No. of levels decompressed		Mean 1.3 Median 1 Range 1–2		Mean 2.1 Median 2 Range 1–5		
Reoperations		7 (11.3%)		6 (8.2%)		
Operation method	ACDF with stand-alone cage 60 ACDF with anterior plating 1 Arthroplasty 0 Corpectomy with autograft 1		Laminectomy 56 Laminoplasty 0 Skip laminectomy 14[a] Foraminotomy 7 Laminectomy with fusion 4[b]			

ACDF, anterior cervical discectomy and fusion; EMS, European myelopathy scale; EQ-5D, EuroQol 5 dimension; NDI, Neck disability index; NRS, numeric rating scale.
[a]Some surgeons reported both laminectomy and skip laminectomy.
[b]The four fused patients are probably carefully selected because of some inherent features and are therefore excluded from the analysis of the PROMs in this table, but included in the analysis in Table 2.

The Scandinavian countries have a tradition for the use of laminectomy without fusion in the surgical treatment of DCM.[24]

A Swedish study from 2022 using data from the Swedish Spine Registry compared the results after laminectomy vs laminectomy with fusion in 717 patients.[25] They found no difference in clinical results, complications, or reoperation rates between the groups, indicating that fusion does not give better results but generates higher costs. They found durable results in both groups after 5 years. The comparative study design using propensity score matching to compare the two surgical methods does, however, make the study less generalizable.

Only four of our patients operated with laminectomy were fused. These patients probably had some inherent special features, but the number of patients is too low to make any statistical comparison. The good long-term results and the low number of reoperations in our patients operated with a posterior approach may indicate that laminectomy without fusion does not cause symptomatic postlaminectomy kyphosis with the need for reoperations. Furthermore, the regression analysis showed no association between time from surgery (3-8 years) and clinical outcomes.

Different age-related degenerative changes in the cervical spine may result in DCM.[26] The surgical strategy for decompression is based on patient-specific factors and surgeons' preferences. In a recent randomized trial, the outcomes were similar between patients operated with anterior and posterior approaches.[27] Our unmatched cohort study was not designed to study the relative effect of these two surgical techniques.

Our study has a relatively low proportion of patients with moderate-to-severe myelopathy (25.5%), and most of the patients are operated within 1 year. We found the same durability of the results in patients with both mild and moderate-to-severe myelopathy. In a previous study, we have shown that moderate-to-severe patients have the most to gain from surgery, but the mild patients with myelopathy still end up with better function after surgery (ie, ceiling effect). There is still a paucity in the literature regarding whether to operate patients with mild myelopathy. Future high-quality trials should focus on the indications for surgery in these patients.

GPE measures the patients' perceived benefit of surgery and is susceptible for recall bias at long-term follow-up. Still, the GPE ratings lend support to the findings in the PROMs with a high rate

TABLE 3. PROMs

Variable	Complete case, N = 121			Mean difference 1 year to long-term follow-up (95% CI)	*P* value
	Baseline	One year	Long term		
NDI	31.1	22.5	23.5	1.0 (−2.1-4.1)	.53
EQ-5D	0.51	0.65	0.63	−0.02 (−0.09-0.05)	.51
EMS score	14.1	15.2	14.9	−0.3 (−0.7-0.1)	.09
Neck pain NRS	4.1	2.8	3.1	0.3 (−0.2-0.9)	.22
Arm pain NRS	4.7	3.5	3.4	−0.1 (−0.8-0.5)	.70
Headache NRS	2.8	2.1	2.5	0.4 (−0.1-0.9)	.11
Variable	**Mixed models analysis, N = 144**			**Mean difference 1 year to long (95% CI)**	***P* value**
	Baseline	**One year**	**Long term**		
NDI	33.1	26.2	26.1	−0.1 (−3.0-2.8)	.95
EQ-5D	0.43	0.61	0.57	−0.03 (−0.10-0.03)	.30
EMS score	13.9	15.0	14.7	−0.3 (−0.7-0.1)	.10
Neck pain NRS	4.5	3.1	3.3	0.3 (−0.2-0.8)	.28
Arm pain NRS	4.9	3.7	3.5	−0.3 (−0.8-0.3)	.33
Headache NRS	3.1	2.2	2.5	0.3 (−0.1-0.7)	.20

EMS, European myelopathy scale; EQ-5D, EuroQol 5 dimension; NDI, Neck disability index; NRS, numeric rating scale; PROM, patient-reported outcome measure.

of stabilized patients at long-term follow-up. These findings must be interpreted from the perspective that the traditional goal of surgery for DCM has been to prevent worsening of the condition.

Strengths and Limitations

This registry study is based on data from everyday practice in two health regions in Norway and thus has a high level of external validity.

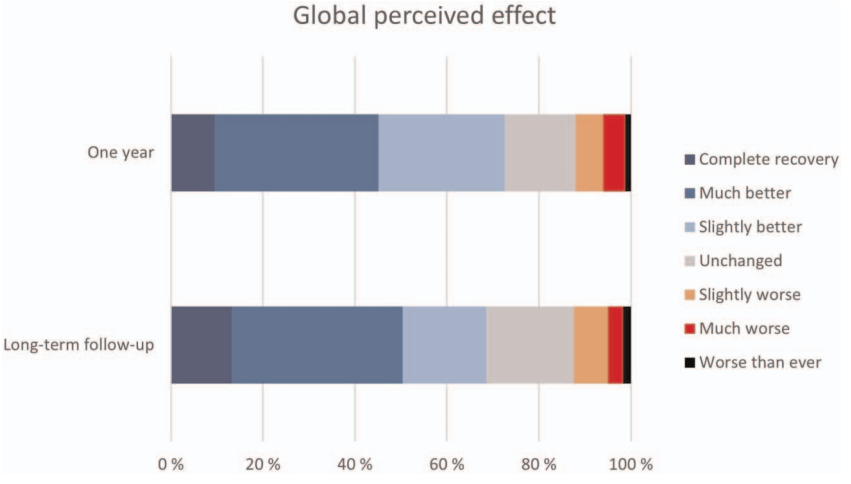

FIGURE. *Global perceived effect.*

A long-term follow-up rate of 85% is probably higher than expected.

Loss to follow-up is a concern, but previous NORspine studies on degenerative lumbar and cervical spine surgery have shown no differences in outcomes between responders and nonresponders.[28,29]

Because of the high proportion of patients with mild myelopathy and short duration of symptoms in our study, the generalizability of the results across other patient populations with more severe and chronic long-term preoperative symptoms is a concern. Our study is, however, a cohort from a national registry and represents consecutive patients from everyday practice.

The lack of postoperative imaging to evaluate the postlaminectomy kyphosis is a limitation of our study. We report multiple PROMs that demonstrate good long-term results after surgery for DCM. Thus, we believe that very few of our patients have symptomatic postlaminectomy kyphosis.

NORspine uses the EMS score as the disease-specific PROM for patients with DCM. The modified mJOA (Japanese Orthopedic Association) scale is currently the most used outcome measure in the field of DCM research. Using the EMS score can make comparison of results with the latest research in the DCM field more demanding. The use of the NDI and EMS score, which are included in most recent papers on DCM, reduces this problem. The EMS score was chosen as one of the PROMs in NORspine before there was a consensus on using the mJOA, and the EMS score is therefore the PROM chosen in our study.[30] The EMS score and mJOA are, however, very similar, and ongoing validation studies will demonstrate whether they can be used interchangeably. An earlier study comparing different scales, including mJOA and EMS score, found that both detected significant improvement after surgery.

In a recent study on improvement after surgery for DCM with a comparison of different PROMs, the NDI and the NRS neck pain percentage change score were the most accurate to measure clinical improvement.[32] Both these PROMs were used in our study.

CONCLUSION

Surgery for DCM is associated with statistically significant and clinically meaningful improvement across a wide range of PROMs, and the results remain stable at long-term follow-up.[31]

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