■ SPINE

Clinical outcomes after surgery for cervical radiculopathy performed in public and private hospitals

A NATIONWIDE RELATIVE EFFECTIVENESS STUDY

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Aims

The number of patients undergoing surgery for degenerative cervical radiculopathy has increased. In many countries, public hospitals have limited capacity. This has resulted in long waiting times for elective treatment and a need for supplementary private healthcare. It is uncertain whether the management of patients and the outcome of treatment are equivalent in public and private hospitals. The aim of this study was to compare the management and patient-reported outcomes among patients who underwent surgery for degenerative cervical radiculopathy in public and private hospitals in Norway, and to assess whether the effectiveness of the treatment was equivalent.

Methods

This was a comparative study using prospectively collected data from the Norwegian Registry for Spine Surgery. A total of 4,750 consecutive patients who underwent surgery for degenerative cervical radiculopathy and were followed for 12 months were included. Case-mix adjustment between those managed in public and private hospitals was performed using propensity score matching. The primary outcome measure was the change in the Neck Disability Index (NDI) between baseline and 12 months postoperatively. A mean difference in improvement of the NDI score between public and private hospitals of ≤ 15 points was considered equivalent. Secondary outcome measures were a numerical rating scale for neck and arm pain and the EuroQol five-dimension three-level health questionnaire. The duration of surgery, length of hospital stay, and complications were also recorded.

Results

The mean improvement from baseline to 12 months postoperatively of patients who underwent surgery in public and private hospitals was equivalent, both in the unmatched cohort (mean NDI difference between groups 3.9 points (95% confidence interval (CI) 2.2 to 5.6); p < 0.001) and in the matched cohort (4.0 points (95% CI 2.3 to 5.7); p < 0.001). Secondary outcomes showed similar results. The duration of surgery and length of hospital stay were significantly longer in public hospitals. Those treated in private hospitals reported significantly fewer complications in the unmatched cohort, but not in the matched cohort.

Conclusion

The clinical effectiveness of surgery for degenerative cervical radiculopathy performed in public and private hospitals was equivalent 12 months after surgery.

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Introduction

Degenerative disorders of the spine are among the most common causes of lost disability-adjusted life years throughout the world,[1] and the health-related costs associated with these conditions have been increasing over the past few decades.[2,3] Degenerative changes in the cervical spine (spondylosis) increase with age and may be associated with disc herniation, hypertrophy of ligaments and facet joints, and may give rise to symptoms of nerve root compression, termed degenerative cervical radiculopathy. Patients with

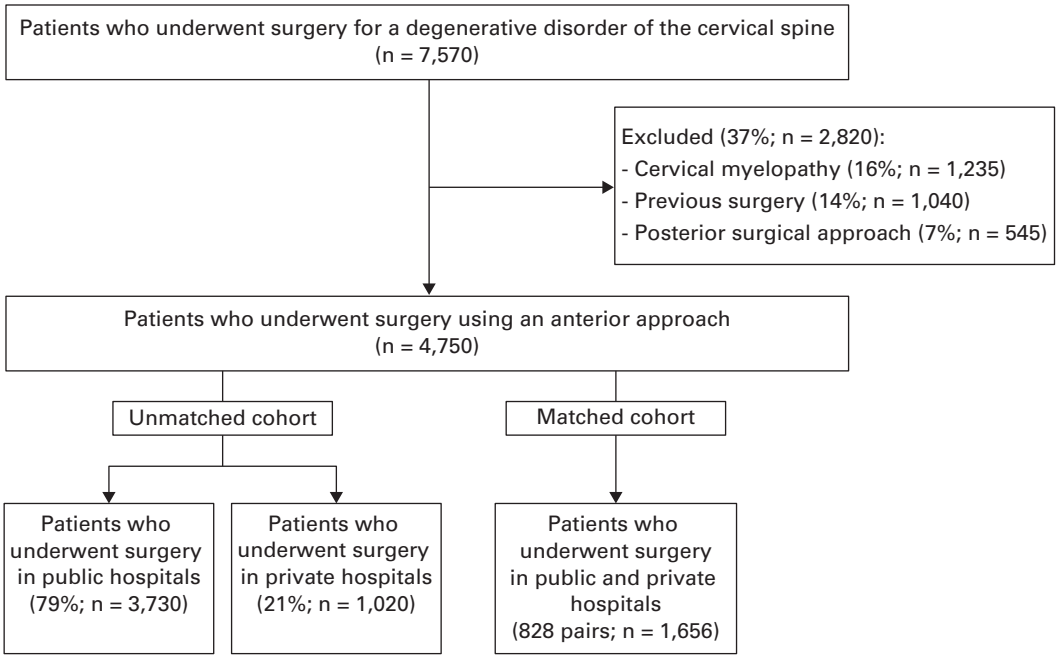

Fig. 1

Flow diagram of the patients.

this condition often present with radicular neck and arm pain, numbness, or muscle weakness.[4,5] Surgery may be indicated in selected patients.[5,6]

Norway has a government-funded healthcare system with universal cover.[7] Most specialized health services are provided in the public sector. Many public hospitals, however, have limited capacity and long waiting times,[8,9] and this has paved the way for supplementary private providers of cervical spinal surgery.[10] Most patients operated in private hospitals have health insurance paid for either by employers or by themselves.[7]

How to balance the provision of healthcare in this area between the public and the private sectors has been debated, due to the rising costs and increased use of spinal surgery. An argument for an increase in private providers is that this would allow a general increase in the capacity and efficiency of treatment in the health services.[11] There are, however, concerns that inequalities in access to health services and overuse could occur as a consequence of privatization.[10,11] Information about the efficiency and clinical effectiveness of the treatment in these two settings can help policy-makers make judgements about performance and allow appropriate prioritization and allocation of resources. Such information is limited in the field of cervical spinal surgery. The aim of this study was to investigate whether clinical outcomes were equivalent among patients who underwent surgery for degenerative cervical radiculopathy in public and private hospitals in Norway.

Methods

This was a comparative effectiveness study of consecutive patients who underwent surgery for degenerative cervical radiculopathy in six public (n = 3,730) and six private (n = 1,020) hospitals in Norway between January 2012 and August 2020. Data were retrieved from the government-funded Norwegian Registry for Spine Surgery (NORspine), intended for research and quality improvement. This registry includes data from all hospitals performing cervical spinal surgery with 100% inclusion in 2020.[12,13] Approximately 82% of those who undergo surgery for degenerative cervical radiculopathy in Norway are included in the registry. Most of the patients who are not recorded in the registry have undergone emergency surgery, particularly during weekends and holidays.[13]

The study is presented in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[14] It was approved by the Regional Committee for Medical and Health Research Ethics (REK-Midt; 2016/840) and the scientific committee of the NORspine. Consent to participate in the NORspine is voluntary and not required for access to the treatment.

All patients who underwent surgery for degenerative cervical radiculopathy with an anterior cervical discectomy and fusion were eligible for inclusion. In order to make the groups of patients as comparable as possible, patients with myelopathy, those who underwent surgery using a posterior approach, and those who had previously undergone cervical spinal surgery were excluded. The NORspine does not include patients aged < 16 years, those unable to respond due to cognitive or language barriers, and those undergoing surgery for neoplasm, infection, or fracture.

Data were collected prospectively and analyzed retrospectively. At the time of admission for surgery (baseline), the patients completed a self-administered questionnaire which included demographic details, lifestyle issues, the duration of symptoms, and patient-reported outcome measures (PROMs).

Table I. Baseline characteristics of patients who underwent surgery in public and private hospitals for the unmatched and matched cohorts.

Variable	Unmatched cohort			Propensity matched cohort		
	Public hospital	Private hospital	p-value	Public hospital	Private hospital	p-value
Total, n	3,730	1,020		828 pairs	828 pairs	
Mean age, yrs (95% CI)	50 (49.7 to 50.4)	49 (48.1 to 49.1)	< 0.001*	49 (48.1 to 49.2)	49 (48.0 to 49.1)	0.856†
Female, n (%)	1,893 (50.8)	347 (34.0)	< 0.001‡	307 (37.1)	303 (36.6)	0.870§
Native Norwegian speaker, n (%)	3,379 (90.6)	943 (92.5)	0.140‡	760 (91.8)	765 (92.4)	0.704§
BMI ≥ 30.0 kg/m², n (%)	906 (25.0)	235 (23.2)	0.240‡	196 (23.7)	200 (24.2)	0.863§
Missing	102 (2.7)	6 (0.6)		0 (0.0)	0 (0.0)	
Smoker, n (%)			< 0.001‡			0.518§
Yes	1133 (30.9)	222 (22.1)		208 (25.1)	196 (23.7)	
Missing	67 (1.8)	13 (1.3)		0 (0.0)	0 (0.0)	
ASA grade, n (%)			< 0.001‡			0.962¶
I	1,075 (29.6)	520 (51.1)		394 (47.6)	397 (47.9)	
II	2,299 (63.3)	471 (46.3)		415 (50.1)	408 (49.3)	
III	257 (7.1)	27 (2.7)		19 (2.3)	23 (2.8)	
IV	1 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
V	1 (0.0)	2 (0.2)		0 (0.0)	0 (0.0)	
Missing	97 (2.6)	2 (0.2)		0 (0.0)	0 (0.0)	
Level of education, n (%)			< 0.001‡			0.498¶
Primary and secondary school	562 (15.4)	81 (8.1)		85 (10.4)	69 (8.5)	
Vocational school	1,253 (34.4)	366 (36.4)		273 (33.5)	291 (35.7)	
High school	480 (13.2)	132 (13.1)		110 (13.5)	114 (14.0)	
University/college education < 4 yrs	738 (20.3)	282 (28.1)		185 (22.7)	228 (27.9)	
University/college education ≥ 4 yrs	606 (16.7)	144 (14.3)		163 (20.0)	144 (14.0)	
Missing	89 (2.4)	14 (1.4)		12 (1.4)	12 (1.4)	
Higher education, n (%)**	1,344 (36.9)	426 (42.4)	0.002‡	348 (42.6)	342 (41.9)	0.921§
Work status, n (%)			< 0.001‡			0.913¶
Working full-time	1,105 (30.0)	503 (49.5)		384 (46.4)	384 (46.4)	
Homemaker	25 (0.7)	3 (0.3)		4 (0.5)	3 (0.4)	
Student	16 (0.4)	0 (0.0)		0 (0.0)	0 (0.0)	
Retired pensioner	192 (5.2)	12 (1.2)		8 (1.0)	10 (1.2)	
Unemployed	68 (1.8)	5 (0.5)		2 (0.2)	4 (0.5)	
Sick leave	1,464 (39.7)	455 (44.8)		391 (47.2)	393 (47.5)	
Active sick leave	107 (2.9)	21 (2.1)		21 (2.5)	18 (2.2)	
Rehabilitation	257 (7.0)	9 (0.9)		9 (1.1)	9 (1.1)	
Disability pension	393 (10.7)	6 (0.6)		8 (1.0)	6 (0.7)	
Disability pension and sick leave	57 (1.5)	2 (0.2)		1 (0.1)	1 (0.1)	
Missing	43 (1.2)	2 (0.2)		0 (0.0)	0 (0.0)	
Duration of arm pain > 12 mths, n (%)	1,864 (51.4)	274 (27.9)	< 0.001‡	250 (30.2)	257 (31.0)	0.568§
Missing	101 (2.7)	37 (3.6)		0 (0.0)	0 (0.0)	
EQ-5D-3L anxiety and/or depression, n (%)††	1,585 (43.3)	363 (35.9)	< 0.001‡	321 (38.8)	298 (36.0)	0.252§
Missing	72 (1.9)	10 (1.0)		0 (0.0)	0 (0.0)	

*Independent-samples *t*-test.
†Paired *t*-test.
‡Chi-squared test.
§McNemar's test.
¶Marginal homogeneity test.
**University or college education (yes/no).
††EuroQol-5D-3L moderate-to-severe problems (yes/no).
ASA, American Society of Anesthesiologists; CI, confidence interval; EQ-5D-3L, EuroQol five-dimension three-level questionnaire.

They were sent follow-up questionnaires and prestamped envelopes three and 12 months after surgery by the central NORspine unit without involving the treating hospitals. Complications were reported by patients at three months' follow-up according to a standardized set of questions.[15] A reminder with a new copy of the forms was sent to those who did not respond within two weeks.

The surgeon who performed the operation recorded information about the diagnosis, the radiological findings, surgical approach, instrumentation, the American Society of Anesthesiologists (ASA) grade,[16] the number of levels involved in the operation, perioperative complications, duration of surgery (minutes), and length of hospital stay (days).

The primary outcome measure was improvement of the Neck Disability Index (NDI) score 12 months postoperatively.[17] The NDI measures disability related to neck pain in ten activities of daily living. Each item has six different responses, from 0 (highest level of function) to 5 (lowest level of function). The

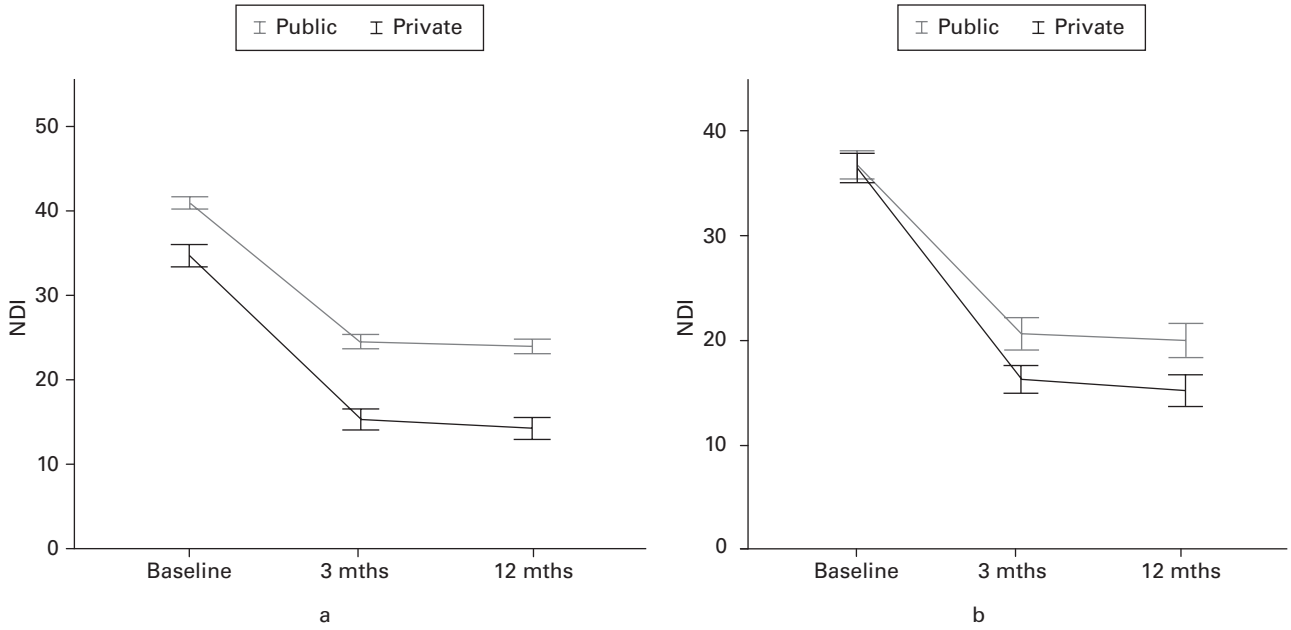

Fig. 2

Mean Neck Disability Index (NDI) scores with 95% confidence intervals for the a) unmatched and b) matched cohort.

sum of the ten items was recalculated into a percentage NDI score from 0 (no disability) to 100 (maximum disability). Secondary outcome measures were changes in a numerical rating scale for neck pain (NRS-NP) and arm pain (NRS-AP) and the health-related quality of life EuroQol five-dimension three-level health questionnaire (EQ-5D-3L).[18]

The minimally clinical important difference (MCID) of the NDI has been reported to range from 7.5 to 10 on a scale from 0 to 50.[19–21] We reported a percentage score from 0 to 100, thus a MCID of 15 was used for the NDI, and a mean difference in improvement of the NDI between public and private hospitals of ≤ 15 was considered equivalent. Conversely, a difference of >15 was considered nonequivalent.

Statistical analysis. Continuous variables are described with means and confidence intervals (CIs). Categorical variables are described with frequencies and percentages. For the unmatched cohort, baseline demographic details and surgical characteristics were compared using independent-samples *t*-tests for continuous data and chi-squared tests for categorical data. For the matched cohort, baseline demographic details and surgical characteristics were compared using paired *t*-tests for continuous variables, McNemar's test for dichotomous variables, and marginal homogeneity tests for categorical variables with > two options.

Since patients were not randomly allocated to a treating hospital, we performed case-mix adjustment by propensity score matching, i.e. post hoc pseudorandomization.[22] A propensity score was calculated using logistic regression, adjusting for the following variables that were chosen based on previous literature: age, sex, native language, university or college education ≥ four years, work status, BMI, smoking status, ASA grade, the number of levels involved in the operation, EQ-5D anxiety and/or depression, baseline NDI, and duration of arm pain.[23–30] Patients who were treated in public hospitals were matched with those who were treated in private hospitals using a caliper width of 0.01.

We performed mixed linear model analyses of the primary and secondary outcome measures both in the unmatched and matched cohorts, using all available baseline and follow-up PROM data. In both cohorts, the combination of time (baseline, three months, and 12 months) and surgical treatment were used as fixed effects. The random effects were patient identification and pair identification for the matched cohort, and patient identification for the unmatched cohort. Since missing data were handled in the mixed linear model analyses, no imputation was performed.[31]

We also performed complete case analyses of the outcome measures in the unmatched and matched cohorts. We used paired *t*-tests to compare baseline and 12-month postoperative scores for public and private hospitals separately. Independent-samples *t*-tests were used to compare the change in the scores between public and private hospitals. The patterns of missing data were assessed by comparing baseline characteristics of respondents and non-respondents at 12 months' follow-up.

A two one-sided test was used to evaluate whether surgical treatment between public and private hospitals was equivalent. The p-value for equivalence was calculated as 1 minus the maximum confidence level for which the confidence interval was contained within the interval (-15 to 15), divided by 2. This was performed both in the unmatched and matched cohorts for complete case analyses and mixed linear model analyses. A p-value < 0.05 was considered significant.

All analyses were performed using SPSS v. 28.0 (IBM, USA) and software R v. 4.1.2 (R Foundation for Statistical Computing, Austria).

Table II. Mixed linear model analyses of the primary and secondary outcomes of patients who underwent surgery in public and private hospitals for the unmatched and matched cohorts.

Variable	Public hospital			Private hospital			Difference	p-value*
	Baseline	12-mth follow-up	Mean improvement	Baseline	12-mth follow-up	Mean improvement		
Unmatched cohort mean (95% CI)								
NDI	37.0 (36.0 to 38.0)	19.9 (18.7 to 21.4)	17.2 (16.0 to 18.3)	36.8 (35.8 to 37.8)	15.8 (14.5 to 17.0)	21.1 (19.9 to 22.3)	3.9 (2.2 to 5.6)	< 0.001
EQ-5D-3L	0.50 (0.48 to 0.52)	0.75 (0.73 to 0.77)	0.25 (0.22 to 0.27)	0.50 (0.48 to 0.52)	0.80 (0.78 to 0.82)	0.30 (0.28 to 0.33)	0.05 (0.02 to 0.09)	
NRS-NP	5.5 (5.4 to 5.7)	3.0 (2.8 to 3.2)	2.3 (2.4 to 2.8)	5.6 (5.4 to 5.7)	2.2 (2.0 to 2.5)	3.3 (3.1 to 3.5)	0.7 (0.4 to 1.1)	
NRS-AP	6.0 (5.8 to 6.2)	2.4 (2.2 to 2.6)	3.6 (3.4 to 3.8)	5.9 (5.8 to 6.1)	1.8 (1.6 to 2.0)	4.1 (3.9 to 4.4)	0.5 (0.2 to 0.9)	
Propensity matched cohort mean (95% CI)								
NDI	37.0 (36.0 to 39.0)	19.9 (18.7 to 21.1)	17.1 (15.9 to 18.3)	36.8 (35.8 to 37.8)	15.8 (14.5 to 17.0)	21.1 (19.9 to 22.3)	4.0 (2.3 to 5.7)	< 0.001
EQ-5D-3L	0.50 (0.48 to 0.52)	0.75 (0.73 to 0.77)	0.25 (0.22 to 0.27)	0.50 (0.48 to 0.52)	0.80 (0.78 to 0.82)	0.30 (0.28 to 0.33)	0.05 (0.02 to 0.09)	
NRS-NP	5.5 (5.4 to 5.7)	3.0 (2.8 to 3.2)	2.6 (2.4 to 2.8)	5.6 (5.4 to 5.7)	2.2 (2.0 to 2.5)	3.3 (3.1 to 3.5)	0.8 (0.5 to 1.1)	
NRS-AP	6.0 (5.8 to 6.2)	2.4 (2.2 to 2.6)	3.6 (3.4 to 3.8)	5.9 (5.8 to 6.1)	1.8 (1.6 to 2.0)	4.1 (3.9 to 4.4)	0.5 (0.2 to 0.9)	

*Two one-sided test.
AP, arm pain; CI, confidence interval; EQ-5D-3L, EuroQol five-dimension three-level questionnaire; NDI, Neck Disability Index; NP, neck pain; NRS, numerical rating scale.

Table III. Complete case analyses of the primary and secondary outcomes of patients who underwent surgery in public and private hospitals for the unmatched and matched cohorts.

Variable	Public hospital			Private hospital			Difference	p-value*
	Baseline	12-mth follow-up	Mean improvement	Baseline	12-mth follow-up	Mean improvement		
Unmatched cohort mean (95% CI)								
NDI	41.8 (41.3 to 42.3)	24.3 (23.5 to 25.0)	17.0 (16.3 to 17.7)	35.7 (34.9 to 36.6)	14.6 (13.4 to 15.9)	20.5 (19.2 to 21.8)	3.5 (1.9 to 5.0)	< 0.001
EQ-5D-3L	0.43 (0.42 to 0.44)	0.68 (0.67 to 0.69)	0.24 (0.23 to 0.26)	0.52 (0.50 to 0.54)	0.81 (0.79 to 0.83)	0.29 (0.26 to 0.31)	0.05 (0.02 to 0.08)	
NRS-NP	6.2 (6.1 to 6.3)	3.4 (3.3 to 3.5)	2.8 (2.7 to 2.9)	5.4 (5.3 to 5.6)	2.2 (2.0 to 2.3)	3.2 (3.0 to 3.5)	0.4 (0.2 to 0.7)	
NRS-AP	6.5 (6.4 to 6.5)	3.0 (2.9 to 3.1)	3.5 (3.4 to 3.6)	5.8 (5.7 to 6.0)	1.7 (1.5 to 1.9)	4.1 (3.9 to 4.4)	0.6 (0.4 to 0.9)	
Propensity matched cohort mean (95% CI)								
NDI	37.0 (36.0 to 38.0)	19.5 (18.0 to 20.9)	16.7 (15.3 to 18.1)	36.8 (35.9 to 37.8)	15.4 (14.0 to 16.8)	21.1 (19.6 to 22.5)	4.4 (2.3 to 6.4)	< 0.001
EQ-5D-3L	0.50 (0.48 to 0.52)	0.75 (0.73 to 0.77)	0.25 (0.22 to 0.28)	0.50 (0.48 to 0.52)	0.80 (0.78 to 0.82)	0.30 (0.27 to 0.33)	0.05 (0.007 to 0.09)	
NRS-NP	5.5 (5.4 to 5.7)	3.0 (2.7 to 3.2)	2.6 (2.3 to 2.8)	5.6 (5.4 to 5.7)	2.2 (2.0 to 2.4)	3.3 (3.0 to 3.6)	0.7 (0.4 to 1.1)	
NRS-AP	6.0 (5.8 to 6.2)	2.4 (2.2 to 2.6)	3.6 (3.3 to 3.9)	5.9 (5.8 to 6.1)	1.8 (1.6 to 2.0)	4.1 (3.9 to 4.4)	0.5 (0.1 to 0.9)	

*Two one-sided test.
AP, arm pain; CI, confidence interval; EQ-5D-3L, EuroQol five-dimension three-level questionnaire; NDI, Neck Disability Index; NP, neck pain; NRS, numerical rating scale.

Results

Of the 7,570 patients who underwent surgery for degenerative disorders of the cervical spine, 4,750 had their operation using an anterior approach: 3,730 (79%) in public hospitals and 1,020 (21%) in private hospitals (Figure 1). The baseline characteristics according to treatment centre are shown in Table I for the unmatched and matched cohorts. Patients in public hospitals were significantly older ($p < 0.001$, independent-samples *t*-test), smoked more, and had more comorbidity and anxiety and/or depression ($p < 0.001$, chi-squared test). There were significantly more women in public hospitals (50.8% (n = 1,893) vs 34.0% (n = 347); $p < 0.001$, chi-squared test). The mean baseline NDI, NRS-NP, and NRS-AP scores were significantly worse in those who underwent surgery in public hospitals compared with private hospitals ($p < 0.001$, independent-samples *t*-test). Significantly more of the patients in private hospitals worked full-time (49.5% (n = 503) vs 30.0% (n = 1,105); $p < 0.001$, chi-squared test). After propensity score matching, there were no significant differences in baseline characteristics between the two cohorts.

Complete case analyses and mixed linear model analyses for outcomes in both the unmatched and matched cohorts at 12 months are shown in Tables II and III. Patients who underwent surgery in both settings reported health improvements after cervical surgery, but those in private hospitals had significantly larger improvements. The difference in mean improvement between patients in the unmatched cohort was 3.9 (95% CI 2.2 to 5.6; $p < 0.001$, mixed linear model analysis) and 4.0 (95%

Table IV. Duration of surgery, length of hospital stay, number of levels involved in the operation, type of surgery, and complications of patients who underwent surgery in public and private hospitals for the unmatched and matched cohorts.

Variable	Unmatched cohort			Propensity matched cohort		
	Public hospital	Private hospital	p-value	Public hospital	Private hospital	p-value
Mean duration of surgery, mins (95% CI)			< 0.001			< 0.001
Operation involved one level	75 (74 to 76)	48 (47 to 49)		72 (70 to 75)	48 (47 to 49)	
Operation involved > one level	113 (111 to 116)	69 (67 to 71)		111 (106 to 115)	69 (67 to 71)	
Mean LOS, (days (95% CI))	2.3 (2.2 to 2.3)	0.03 (0.02 to 0.04)	< 0.001	2.1 (2.0 to 2.2)	0.04 (0.02 to 0.05)	< 0.001
Number of levels in the operation, n (%)			< 0.001			0.831
1	2,723 (73.3)	612 (60.1)		527 (63.6)	531 (64.1)	
2	985 (26.5)	400 (39.3)		299 (36.1)	294 (35.5)	
3	6 (0.2)	6 (0.6)		1 (0.1)	3 (0.4)	
4	2 (0.1)	0 (0.0)		1 (0.1)	0 (0.0)	
Type of surgery, n (%)						
ACDF			< 0.001			0.025
Cervical disc herniation	2,670 (71.4)	810 (79.4)		617 (74.5)	656 (79.2)	
Decompression for spondylosis without disc herniation	1,060 (28.4)	210 (20.6)		211 (25.5)	172 (20.8)	
Additional stabilization with plate	52 (1.4)	8 (0.8)	0.122	10 (1.2)	6 (0.7)	0.454
ACDR	49 (1.3)	1 (0.1)	< 0.001	7 (0.8)	1 (0.1)	0.07
Patient-reported complications at 3 mths, n (%)			< 0.001			0.315
Venous thromboembolism	14 (0.5)	1 (0.1)		3 (0.6)	1 (0.2)	
Wound infection	60 (2.2)	10 (1.5)		11 (2.0)	8 (1.4)	
Pneumonia	22 (0.9)	5 (0.7)		5 (0.9)	4 (0.7)	
Dysphonia	245 (9.6)	35 (5.1)		43 (7.9)	28 (5.1)	
Dysphagia	416 (16.3)	66 (9.7)		70 (12.9)	55 (9.9)	
Urinary tract infection	67 (2.6)	7 (1.0)		10 (1.8)	7 (1.3)	

ACDF, anterior cervical discectomy and fusion; ACDR, anterior cervical disc replacement; CI, confidence interval; LOS, length of stay.

CI 2.3 to 5.7; $p < 0.001$, mixed linear model analysis) in the matched cohort (Figure 2).

Table IV shows the details of the treatment and the complications. The duration of surgery among those who underwent surgery in public hospitals was significantly longer by between 24 and 42 minutes depending on the number of levels involved in the operation ($p < 0.001$, paired *t*-test). The mean length of stay was also significantly longer in those who underwent surgery in public hospitals (2 days (95% CI 2.0 to 2.2) compared with 0 days (95% CI 0.02 to 0.05; $p < 0.001$, paired *t*-test). These results were similar in the unmatched cohort. The most common patient-reported complications three months postoperatively in both public and private hospitals were dysphagia (16.3% (n = 416) vs 9.7% (n = 66)) and dysphonia (9.6% (n = 245) vs 5.1% (n = 35; $p < 0.001$, chi-squared test). These differences were significant, but were not found in the matched cohort.

A total of 3,248 patients (68%) and 3,038 patients (64%) responded at three and 12 months postoperatively, respectively. The non-respondents were younger, more likely to be men, and less educated (Supplementary Table i). They also smoked more, were slightly more obese, had shorter duration of arm pain, and had slightly worse scores for all baseline PROMs.

Discussion

In this nationwide registry-based study, the effectiveness of surgery for degenerative cervical radiculopathy was equivalent in public and private hospitals. This finding was consistent in both the unmatched and matched cohorts, and is in line with a previous study evaluating patients who underwent surgery for degenerative disorders of the lumbar spine.[32] In our complete cohort, patients reported large and clinically relevant improvements.[23,33] The trend towards larger improvements reported by patients who underwent surgery in private hospitals was weak but consistent in all the analyses, including the secondary outcomes. Those who were treated in public hospitals were older, had more comorbidities, a longer duration of symptoms, more disease-specific disability, and characteristics indicating lower socioeconomic status,[34] and these differences were all statistically significant.

Dysphagia was the most common complication, and the frequency was similar to previous reports.[35] Patients treated in private hospitals reported significantly fewer complications in the unmatched cohort, but not in the matched cohort.

The mean duration of surgery was 24 minutes shorter and the mean length of stay was two days shorter in private hospitals. In Norway, cervical spinal surgery is only performed in six university hospitals with high volumes. The volume of surgery in private hospitals can vary, but patients are operated on by experienced specialists from the university hospitals.[15] We therefore did not assess a possible association between the volume of surgery and outcomes. Public hospitals are more complex organizations. They have to handle emergency cases, educate trainees, and manage more complex patients. These factors could explain why patients in private hospitals seem to be managed in a more timely manner.[36] The 'high-volume,

low-complexity' surgery undertaken in private hospitals could reduce the long waiting lists for elective treatments, for instance, by the public reimbursement of surgery performed in private clinics.[37] However, efficiency gains driven by private hospitals could have negative effects, potentially causing an overuse of cervical spinal surgery and increasing inequalities in access to such treatment.[38]

A strength of this population-based study is its pragmatic design, including patients who were treated as part of the workflow of daily clinical practice in all hospitals in which surgery for degenerative cervical radiculopathy is undertaken in Norway. This ensured a high external validity of the results. However, in our large dataset, even minor and clinically irrelevant changes in PROMs can reach clinical significance. We therefore used the MCID for the NDI score to define the margins of equivalence.

A weakness of the study is that there will be some confounding bias related to unknown factors due to the non-randomized design of the study.[22] For instance, the propensity score matching did not account for less measurable differences in the patients related to their expectations of the outcome, financial incentives, and psychosocial factors that might influence recovery. There could also be other unmeasured confounding factors in the total package of care delivered in the two hospital settings. Another weakness is the non-respondent rate of 32% and 36% at three and 12 months postoperatively. However, there were small differences in baseline characteristics between respondents and non-respondents, and the outcomes assessed by complete case analyses and mixed linear model analyses were similar. Moreover, previous research from the Norwegian and Danish spine registries found no significant differences in outcome when comparing respondents and non-respondents.[39,40] Our findings might be less relevant in countries with healthcare systems that differ from those of Nordic countries, and in which access to health services or health insurance policies are different. Lastly, we do not have any data about hospital costs or the patients' income. These factors may be associated both with the access to cervical spinal surgery and the outcome. Further studies are needed to compare the relative cost-effectiveness of spinal surgery in the two hospital settings.

Patients who underwent surgery for degenerative cervical radiculopathy in private hospitals were less complex cases. They had a significantly shorter duration of surgery and hospital stay compared with those who were treated in public hospitals, but after 12 months their clinical outcomes were equal. Much of the small differences in outcomes and management could be attributed to the characteristics of the patients treated in the two hospital settings.

Take home message

- Private supplement of cervical spinal surgery has increased due to capacity shortages in public hospitals.
- We found that patients operated for degenerative cervical radiculopathy in private hospitals had shorter duration of surgery and hospital stay.
- However, clinical outcomes of patients operated in public and private hospitals were equivalent 12 months after surgery.

Supplementary material

Table displaying information about baseline characteristics of respondents and non-respondents at 12-month follow-up.

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