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Clinical Study

Perioperative complications of anterior decompression with fusion versus laminoplasty for the treatment of cervical ossification of the posterior longitudinal ligament: propensity score matching analysis using a nation-wide inpatient database

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Abstract

BACKGROUND CONTEXT: Surgical treatment of cervical ossification of the posterior longitudinal ligament (OPLL) has a high risk of various complications. Anterior decompression with fusion (ADF) and laminoplasty (LAMP) are the most representative surgical procedures. However, few studies have compared the two procedures in terms of perioperative surgical complications.

PURPOSE: To compare the perioperative complications post-ADF and LAMP for cervical OPLL using a large national inpatient database.

STUDY DESIGN: A retrospective cohort study with propensity score matching analysis.

PATIENT SAMPLE: Overall, 8,718 (ADF/LAMP:1,333/7,485) patients who underwent surgery for cervical OPLL from April 1, 2010 to March 31, 2016 in hospitals using the diagnosis procedure combination were analyzed.

OUTCOME MEASURES: The occurrence of postoperative complications during hospitalization.

METHODS: We compared the perioperative systemic and local complications, reoperation rates, and costs between ADF and LAMP using propensity score matching analysis.

RESULTS: One-to-one matching resulted in 1,192 pairs of patients who underwent ADF and LAMP. The postoperative cardiovascular event rate was significantly higher (ADF/LAMP=1.9/0.8%, p=.013) in the ADF group. The incidence rates of dysphagia (similarly, 2.4/0.2%, p<.001), pneumonia (1.0/0.3%, p=.045), and spinal fluid leakage (2.4/0.4%, p<.001) were also higher in the ADF group, even after matching. The costs were also higher in the ADF group. However, surgical site infection (2.0/3.4%, p=.033) was significantly lower in the ADF group. No significant difference in the reoperation rates was found between the groups.

CONCLUSION: The present study, using a large nationwide database, demonstrated that perioperative complications were more common in the ADF group, but that surgical site infection (SSI) was more frequently observed in the LAMP group.

Keywords: Anterior decompression with fusion; Inpatient database; Laminoplasty; OPLL; Perioperative complications; Propensity score matching.

FDA device/drug status: Not applicable.

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Introduction

Cervical ossification of the posterior longitudinal ligament (OPLL) is a disease that causes various symptoms due to compression of the spinal cord. The incidence of OPLL ranges from 1.9% to 4.3% in East Asian populations, whereas it ranges from 0.1% to 1.7% in Caucasian populations [1]. This ossified lesion often compresses the spinal cord as it develops leading to severe myelopathy or predisposing to spinal cord injury. Minimally, symptomatic OPLL patients can be managed nonoperatively, though patients with progressive myelopathy often require surgical treatment [2,3].

The optimal approach for the surgical treatment of OPLL remains controversial. Both anterior and posterior approaches have their merits and demerits. Anterior decompression and fusion (ADF) can directly relieve compression, but the procedure is more complex [4,5]. Posterior approaches, including laminoplasty (LAMP), are less technically demanding, but rely on indirect decompression which is occasionally insufficient in patients with massive OPLL and/or kyphotic alignment [2,4,6]. To date, a number of studies have documented the neurologic outcomes after ADF and LAMP, which are representative surgical methods for cervical OPLL. Generally, surgical treatment of cervical OPLL carries a high risk of complications. Previous studies have reported surgical complications for each method [7–10]. However, few studies have compared the two procedures in terms of their perioperative surgical complications. Furthermore, most published studies are single-institution small case series. There have been no studies investigating the surgical complications of these methods with large sample sizes.

Information regarding the surgical risks of these treatment options is critically important for surgical decision-making. Thus, in this study, we investigated the perioperative complications after ADF and LAMP to treat cervical OPLL, using a large national inpatient database in Japan called the diagnosis procedure combination (DPC) database [11–15]. Furthermore, we conducted a propensity score matching analysis to minimize the bias of surgical method when comparing the surgical risks of ADF and LAMP.

Material and methods

Data source

We obtained data from the Japanese DPC database as described previously [11–15]. The DPC was launched in 2002 by the Ministry of Health, Labor, and Welfare of Japan as a case-mix patient classification system linked to a lump-sum payment system [12,16]. In our study, the data included the following information: patient sex, age, body mass index (BMI), smoking index, operation, diagnoses, costs, admission type, emergency transport, past history of spine surgery within study period, hospital type, comorbidities at admission and complications after admission recorded according to the International Classification of Diseases, Tenth Revision (ICD-10) codes, activities of daily living (ADL) score for admission and discharge by the Ministry of Health, Labor, and Welfare, blood transfusions, and in-hospital deaths. These data distinguished between the comorbidities that were present at admission and complications that occurred after admission [17]. Use of the DPC database was approved by ethics committee at Tokyo Medical and Dental University.

We included patients who were admitted to participating hospitals with a primary diagnosis of cervical OPLL (ICD-10 code, M4882). The selected patients had undergone surgery, either anterior decompression with fusion (ADF, K142-1 by Japanese original operation code, or K-code) or laminoplasty (LAMP, K142-6) from April 1, 2010 to March 31, to 2016. Those who required anterior and posterior surgery at one admission and laminectomy were excluded from the analysis. The details on comorbidities present at admission were as follows: diabetes mellitus (DM, E10–14), cardiovascular disease (ICD-10 codes: I200,201,208–214, 219–221, 228, 229, 238), cardiac failure (I110, I500, 501, 509), atrial fibrillation (I48), cerebrovascular disease (ICD-10 codes: I614, 619, I630–639), chronic obstructive pulmonary disease (J441, 448, 449), pneumonia (J13, 14, 150–159, J180–182, 188, 189), renal failure (N17-19, N289, I120), hepatic failure (K704, 711, 719, 720, 729, 769), gastric ulcer and hemorrhage (K250–270, K279, K922), malignancy (C00-97), rheumatoid arthritis (M69), osteoporosis (M800–805, 808–816, 818, 819), systemic complications; cardiovascular disease, cardiac failure, atrial fibrillation, cerebrovascular disease, respiratory failure (J959–961, 969), pneumonia, hoarseness (R490), dysphagia (K918, R13), recurrent nerve palsy (G522, 978), renal failure, hepatic failure, gastric ulcer and hemorrhage, deep venous thrombosis (I801, 802, 828), pulmonary embolism (I269), sepsis (A394, 400–403, 409–415, 418, 419) and delirium (F050, 051, 059), blood transfusion, reoperation for systemic complication; cardiac (K-code: K538–605), gastric (similar, K646–668), vena cava filter (K620), tracheoplasty (K403) or tracheotomy (K386) and shunt form (K608, 610), local complications; infection (T793, 814), paralysis (G823–825, 831, 832), meningitis (G001–003, 008–009, 039, A390, 392), spinal fluid leakage (G960, 961) and hematoma (S064, 141, 241, 341, T093), reoperation for systemic complication, closure for spinal fluid leakage (K-code: K-179), wound treatment (similar, K000), and debridement (K-002).

Statistical analysis

The analysis using propensity score matching is generally used in retrospective cohort studies to adjust for known confounding biases [12,18–20]. The procedure for this analysis was as follows. First, a propensity score for the operation method (ie, ADF or LAMP) was calculated using patient age and sex, BMI, smoking index, admission type, emergency transport, ADL score for admission, past history of spine surgery within study period, hospital type,

comorbidities present at admission (cerebrovascular disease, diabetes mellitus, rheumatoid arthritis, renal failure, hepatic failure, gastric ulcer and hemorrhage, cardiovascular disease, cardiac failure, atrial fibrillation, chronic obstructive pulmonary disease, osteoporosis, and malignancy), hospital type (teaching or nonteaching), and ADL score for admission with a logistic regression model. The C-statistic was 0.692, which suggested a moderately good fit. Second, ADF and LAMP cases were matched based on propensity score with caliper lower than 0.4. Third, matched cases were analyzed by comparing the association between operation method and systemic complication, local complication, cost, and mortality by a conditional logistic regression model. All statistical analyses were performed using Stata/MP version 14 (StataCorp, College Station, TX), with p values <.05 considered statistically significant.

Results

The demographic data for the 8,818 patients included in this study are shown in Table 1. There were 1,333 patients who underwent ADF and 7,485 patients who underwent LAMP. Before propensity score matching, the LAMP-treated group included older patients (ADF/LAMP=60.3±11.3/65.1±10.9 years old, p<.001) and more patients who were taken by an ambulance compared with the ADF-treated group (ADF/LAMP=1.4/2.4%, p=.037). The patients in the LAMP group had more comorbidities, including cardiovascular disease (ADF/LAMP=2.3/3.7%, p=.013), DM (similarly, 22.2/27.7%, p<.001), malignancy (0.6/1.3%, p=.036), renal failure (1.0/2.0%, p=.011), and cardiac failure (ADF/LAMP=1.1/2.0%, p=.015). In terms of the other types of comorbidity, there were no significant differences between the groups. Meanwhile, the ADF group

Table 1
Patient characteristics in ADF and LAMP before and after the matching

	Before propensity score matching			After propensity score matching		
	ADF (N=1,333)	LAMP (N=7,485)	p Value	ADF (N=1,192)	LAMP (N=1,192)	p Value
Age (mean±SD) (years)	60.3±11.3	65.1±10.9	<.001*	60.9±11.3	60.8±11.7	.70
Sex			.32			.59
Male	948 (71.1%)	5,221 (69.8%)		847 (71.1%)	859 (72.1%)	
Female	385 (28.9%)	2,264 (30.2%)		385 (28.9%)	333 (27.9%)	
BMI (mean±SD) (kg/m^2)	25.3±4.2	25.3±4.4	.93	25.3±4.2	25.2±4.8	.84
Smoking index (median [IQR])	50 (0–760)	30 (0–800)	.92	100 (0–800)	57.5 (0–745)	.30
Admission type			.91			.93
Scheduled	1,217 (91.3%)	6,834 (91.3%)		1,090 (91.4%)	1,093 (91.7%)	
Unscheduled	105 (7.9%)	597 (8.0%)		93 (7.8%)	89 (7.5%)	
Unknown	11 (0.8%)	54 (0.7%)		9 (0.8%)	10 (0.84%)	
Emergency transport			.037†			.20
Yes	19 (1.43%)	178 (2.38%)		18 (1.51%)	28 (2.35%)	
No	1,313 (98.54%)	7,306 (97.61%)		1,173 (98.41%)	1,164 (97.65%)	
Unknown	1 (0.01%)	1 (0.01%)		1 (0.08%)	0 (0%)	
Past history of spine surgery within study period			<.001*			.55
Yes	37 (2.8%)	14 (0.2%)		11 (0.9%)	14 (1.2%)	
No	1,296 (97.2%)	7,471 (99.8%)		1,181 (99.1%)	1,178 (98.8%)	
Hospital type			.87			.83
Teaching	243 (18.2%)	1,350 (18.0%)		224 (18.8%)	220 (18.5%)	
Nonteaching	1,090 (81.8%)	6,135 (82.0%)		968 (81.2%)	972 (81.5%)	
Preoperative comorbidities						
Diabetes mellitus	296 (22.2%)	2,070 (27.7%)	<.001*	274 (23.0%)	277 (23.2%)	.88
Cardiovascular disease	60 (4.5%)	413 (5.5%)	.13	57 (4.8%)	56 (4.7%)	.92
Cardiac failure	14 (1.1%)	152 (2.0%)	.015†	14 (1.2%)	12 (1.0%)	.69
Atrial fibrillation	15 (1.1%)	133 (1.8%)	.09	15 (1.3%)	15 (1.3%)	>.99
Cerebrovascular disease	31 (2.3%)	275 (3.7%)	.013†	29 (2.4%)	26 (2.2%)	.68
Chronic obstructive pulmonary disease	7 (0.5%)	48 (0.6%)	.62	7 (0.6%)	10 (0.8%)	.47
Pneumonia	0 (0%)	6 (0.1%)	.30	0 (0%)	2 (0.2%)	.16
Renal failure	13 (1.0%)	149 (2.0%)	.011†	12 (1.0%)	15 (1.3%)	.56
Hepatic failure	39 (2.9%)	235 (3.1%)	.68	38 (3.2%)	35 (2.9%)	.72
Gastric ulcer	45 (3.4%)	228 (3.1%)	.52	42 (3.5%)	40 (3.4%)	.88
Gastric hemorrhage	3 (0.2%)	9 (0.1%)	.34	2 (0.2%)	3 (0.3%)	.65
Malignancy	8 (0.6%)	95 (1.3%)	.036†	8 (0.67%)	8 (0.67%)	>.99
Rheumatoid arthritis	3 (0.2%)	41 (0.6%)	.12	3 (0.25%)	3 (0.25%)	>.99
Osteoporosis	21 (1.6%)	102 (1.4%)	.54	19 (1.59%)	11 (0.92%)	.14
ADL score for admission (points)	17.3±5.0	17.2±5.3	.53	17.3±5.0	17.4±5.1	.73

SD, standard deviation; IQR, interquartile range; ADL, activities of daily living.
*: p < .01, †: p < .05

Table 2
Systemic complications before and after the matching

	Before propensity score matching			After propensity score matching		
	ADF (N=1,333)	LAMP (N=7,485)	p Value	ADF (N=1,192)	LAMP (N=1,192)	p Value
Systemic complications						
Cardiovascular events	24 (1.8%)	95 (1.3%)	.12	23 (1.9%)	9 (0.8%)	.013†
Cardiac failure	6 (0.5%)	58 (0.8%)	.20	6 (0.5%)	7 (0.6%)	.78
Atrial fibrillation	1 (0.1%)	24 (0.3%)	.12	1 (0.1%)	4 (0.3%)	.18
Cerebral hemorrhage	2 (0.2%)	5 (0.1%)	.32	2 (0.2%)	1 (0.1%)	.56
Cerebral infarction	7 (0.5%)	29 (0.4%)	.47	7 (0.6%)	2 (0.2%)	.10
Respiratory failure	13 (1.0%)	33 (0.4%)	.013†	13 (1.1%)	5 (0.4%)	.06
Pneumonia	12 (0.9%)	38 (0.5%)	.08	12 (1.0%)	4 (0.3%)	.045†
Hoarseness	3 (0.2%)	0 (0%)	<.001*	3 (0.3%)	0 (0%)	.08
Dysphagia	30 (2.3%)	36 (0.5%)	<.001*	29 (2.4%)	2 (0.2%)	<.001*
Renal failure	3 (0.2%)	22 (0.3%)	.66	3 (0.3%)	2 (0.2%)	.65
Hepatic failure	3 (0.2%)	19 (0.3%)	.85	3 (0.3%)	7 (0.6%)	.21
Gastric ulcer	53 (4.0%)	245 (3.3%)	.19	46 (3.9%)	44 (3.7%)	.83
Gastric hemorrhage	14 (1.1%)	35 (0.5%)	.008*	13 (1.1%)	5 (0.4%)	.06
Deep venous thrombosis	5 (0.4%)	56 (0.8%)	.13	5 (0.4%)	7 (0.6%)	.56
Pulmonary embolism	1 (0.1%)	11 (0.2%)	.51	1 (0.1%)	1 (0.1%)	>.99
Sepsis	2 (0.2%)	7 (0.1%)	.55	2 (0.2%)	0 (0%)	.16
Delirium	4 (0.3%)	32 (0.4%)	.50	4 (0.3%)	2 (0.2%)	.41
At least one systemic complication	168 (12.6%)	686 (9.2%)	<.001*	159 (13.3%)	94 (7.9%)	<.001*
Blood transfusion	98 (7.4%)	238 (3.2%)	<.001*	85 (7.1%)	41 (3.4%)	<.001*
Reoperation for systemic complication						
Cardiac	1 (0.1%)	18 (0.2%)	.23	1 (0.1%)	4 (0.3%)	.18
Gastric (including endoscope)	7 (0.5%)	6 (0.1%)	<.001*	7 (0.6%)	1 (0.1%)	.034†
Vena cava filter	0 (0%)	5 (0.1%)	.35	0 (0%)	0 (0%)	NA
Tracheoplasty or tracheotomy	4 (0.3%)	11 (0.2%)	.21	4 (0.3%)	2 (0.2%)	.41
Shunt form	0 (0%)	8 (0.1%)	.23	0 (0%)	0 (0%)	NA
At least one operation for systemic complications	18 (1.4%)	87 (1.2%)	.56	18 (1.5%)	13 (1.1%)	.37

*: $p < .01$, †: $p < .05$
NA, not applicable.

included more patients with a history of spine surgery (ADF/LAMP=2.8/0.2%, p<.001). Propensity score matching resulted in 1,192 pairs of patients undergoing ADF and LAMP. After propensity score matching, the large biases between the treatment groups diminished. All patients' backgrounds were almost completely adjusted (Table 1).

Table 2 shows the perioperative systemic complications in ADF and LAMP before and after the patient matching as well as interventions that were needed for systemic complications. There were more perioperative systemic complications observed in the ADF group than in the LAMP group, especially for respiratory complications, dysphagia, and hoarseness. Further, ADF was associated with a greater chance of transfusion than LAMP was. Even after patient matching based on the propensity score, significantly more systemic complications were observed in the ADF group. At least one systemic complication was seen in 13.3% of the ADF-treated patients, as opposed to 7.9% in the LAMP-treated patients (p<.001). The incidence of cardiovascular complications (ADF/LAMP=1.9/0.8%, p=.013), dysphagia (2.4/0.2%, p<.001), and pneumonia (1.0/0.3%, p=.045) was significantly higher in the ADF group. The rate of intervention for gastric complication, including endoscopy (ADF/LAMP=0.6/0.1%, p=.034), was higher in the ADF group. However, there were no significant differences in other measures between the groups (Table 2).

Local complications and reoperation rates for local complications were also analyzed before and after patient matching (Table 3). Cerebrospinal fluid leakage (ADF/LAMP=2.4/0.4%, p<.001) was significantly higher in the ADF group both before and after matching. On the other hand, the incidence of surgical site infection was greater in the LAMP group than in the ADF group (ADF/LAMP=2.0/3.4% p=.033). The reoperation rates that were required for local complications were similar between the groups (ADF/LAMP=2.6/2.8%, p=.80; Table 3).

We further investigated the cost of health care for the ADF- and LAMP-treated patients. The health care cost was $3,899 higher, on average ($22,242±10,980/18,343±7,878; p<.001), in the ADF group (Table 4). However, there were no differences in mortality rates between the groups.

Discussion

ADF and LAMP are the representative treatment options for cervical myelopathy caused by OPLL. The frequency of perioperative complications following each surgery has been previously investigated [5,21,22], but most such

Table 3
Local complications before and after the matching

	Before propensity score matching			After propensity score matching		
	ADF (N=1,333)	LAMP (N=7,485)	p Value	ADF (N=1,192)	LAMP (N=1,192)	p Value
Local complications						
Infection	29 (2.2%)	170 (2.3%)	.83	24 (2.0%)	41 (3.4%)	.033†
Paralysis	19 (1.4%)	80 (1.1%)	.26	15 (1.3%)	11 (0.9%)	.43
Meningitis	4 (0.3%)	9 (0.1%)	.12	4 (0.3%)	1 (0.1%)	.18
Spinal fluid leakage	36 (2.7%)	30 (0.4%)	<.001*	29 (2.4%)	5 (0.4%)	<.001*
Hematoma	8 (0.6%)	64 (0.9%)	.34	7 (0.59%)	10 (0.8%)	.47
At least one local complications	87 (6.5%)	344 (4.6%)	.003*	72 (6.0%)	67 (5.6%)	.66
Reoperation for local complications						
Closure for fluid leakage	6 (0.5%)	6 (0.1%)	.001*	6 (0.5%)	1 (0.1%)	.06
Wound treatment	23 (1.7%)	145 (1.9%)	.60	21 (1.8%)	29 (2.4%)	.25
Debridement	0 (0%)	7 (0.1%)	.26	0 (0%)	1 (0.1%)	.32
At least reoperation for local complications	34 (2.6%)	169 (2.3%)	.51	31 (2.6%)	33 (2.8%)	.80

*: $p < .01$, †: $p < .05$

Table 4
The cost, mortality, and ADL score for discharge before and after the matching

	Before propensity score matching			After propensity score matching		
	ADF (N=1,333)	LAMP (N=7,485)	p Value	ADF (N=1,192)	LAMP (N=1,192)	p Value
Cost (mean±SD) ($)	22,039±10,820	17,759±7,346	<.001*	22,242±10,980	18,343±7,878	<.001*
Mortality	2 (0.2%)	6 (0.1%)	.44	2 (0.2%)	0 (0%)	.16
ADL score for discharge (points)	17.7±4.4	17.7±4.5	.82	17.7±4.4	17.9±4.2	.31

SD, standard deviation; ADL, activities of daily living.
*: $p < .01$, †: $p < .05$

studies were single-institution, small case series primarily because the prevalence of OPLL is relatively low, especially in Western countries [5,21]. Therefore, there has been insufficient information regarding the risk of surgical complications to make appropriate decisions regarding treatment choice. Furthermore, there is little information on systemic complications, including cardiac, respiratory, and peripheral vascular complications. In this study, we used a large national inpatient database that included more than 8,800 surgically treated patients and investigated the perioperative complications, including systemic complications, for each surgical method. We applied the propensity matching method to compare the perioperative complications between ADF- and LAMP-treated patients. The propensity score is a balancing score that is calculated by logistic regression analysis, which enabled us to make the distribution of the measured baseline covariates similar between the treatment groups [23]. In fact, the covariates were successfully adjusted by one-to-one propensity score matching (Table 1), and the results indicated that the bias was minimized after matching the baseline characteristics between the treatment groups.

Our results after adjustment by propensity score showed that ADF was associated with a high risk of perioperative systemic complications. Having at least one systemic complication was 1.7 times more frequent in patients after ADF than in patients after LAMP. Notably, respiratory complications (eg, pneumonia) were more frequently seen in the ADF group. Anterior surgery is commonly performed under general anesthesia in the supine position, which decreases the functional residual capacity and predisposes to atelectasis [24]. Furthermore, the esophagus is retracted during the surgery. Dysphagia can occur due to esophageal irritation, laryngeal nerve impairment, or edema of the postpharyngeal wall. Indeed, according to our data, the incidence of postoperative dysphagia was more than 10 times higher in the ADF group than it was in the LAMP group. This may also be a trigger for aspiration pneumonia.

Our study revealed that the incidence of postoperative cardiac events was also higher in the ADF group. A previous study investigated cardiac complications after cervical surgery and reported that the risk factors for postoperative cardiac events were age, multilevel fusions, and blood loss [25]. ADF for cervical OPLL tends to be multilevel spine fusion surgery, which is associated with greater blood loss and a greater chance of transfusion [26]. Our data also showed that the rate of transfusion was significantly higher in the ADF group, which can cause perioperative cardiovascular stress and lead to various cardiac problems. As previous studies reported [25,27] and as our data indicated, systemic complications, including cardiovascular events and aspiration pneumonia, may be associated with higher health care costs.

In terms of local complications, spinal fluid leakage was more common in the patients undergoing ADF. The incidence of dural tears and cerebrospinal fluid (CSF) fistulas after cervical corpectomy for all pathologies has been reported to be between 0% and 8% [28]. However, the incidence of a CSF leak is much higher (between 6.7% and 31.8%) after anterior cervical OPLL resection [29–32]. In OPLL patients, the dura mater becomes calcified and adheres to the posterior longitudinal ligament, thus increasing the risk for durotomy during anterior decompression [33]. CSF leakage after ADF can be troublesome and can lead to a pseudomeningocele, respiratory obstruction, cutaneous CSF fistula, and meningitis [34]. Therefore, surgeons should be more cautious when decompressing for OPLL through anterior approaches, especially in cases with dural ossification. Anterior decompression with floating OPLL instead of resection may be an effective procedure to reduce the risks of CSF leakage and related complications [35].

Although most perioperative complications were more common in ADF, as discussed above, postoperative SSI was more frequently seen in patients undergoing LAMP. Previous studies have shown that the SSI rate following posterior cervical spine surgery is higher than that observed following anterior approaches, with rates between 6.0% and 18.2% [36–39]. Ghobrial et al. reported that the incidence of postoperative infection in ADF was exceedingly low with a mean rate of 0.07% [40]. It has been reported that the anterior approach has the advantages of minimal soft tissue and muscular dissection compared with the posterior approach [40], resulting in a lower incidence of SSI. OPLL patients are known to frequently have comorbidities such as obesity and DM, both of which are associated with a higher risk for SSI. Therefore, the anterior procedure would be preferable for patients who are susceptible to SSI.

This study had several limitations. First, the DPC database omits some clinically important information, including the cervical levels of operation, discectomy or corpectomy, pre- and postoperative neurologic findings, imaging examination, and the criteria for operative method. Second, the coded diagnoses have not been directly validated against clinical data, and miscoding may have occurred. Additionally, the DPC database does not provide any information after discharge. Therefore, we were unable to identify any complications that occurred after discharge. A longer follow-up of the surgically treated OPLL patients might provide us with additional information regarding clinical importance.

Despite these limitations, this study is the first to compare the surgical risks of ADF and LAMP for OPLL patients by propensity score matching analysis of a large national database. As the incidence of OPLL is much lower in Western countries, information regarding the surgical risks for OPLL obtained from the national database in Japan can be considered useful. The findings in our study will help surgeons select an operative procedure and make appropriate informed decisions for patients with OPLL.

Conclusion

The present study compared the perioperative complications after ADF and LAMP for patients with OPLL by propensity score matching analysis of a large national database. The occurrence of systemic complications, including respiratory and cardiovascular events, was more common in the ADF group, whereas SSI was more frequently seen in the LAMP group. The medical expenses were greater in the ADF group.

References

[1] Yan L, Gao R, Liu Y, He B, Lv S, Hao D. The pathogenesis of ossification of the posterior longitudinal ligament. Aging Dis 2017;8:570–82. doi: 10.14336/AD.2017.0201.

[2] Iwasaki M, Okuda S, Miyauchi A, Sakaura H, Mukai Y, Yonenobu K, et al. Surgical strategy for cervical myelopathy due to ossification of the posterior longitudinal ligament: Part 1: clinical results and limitations of laminoplasty. Spine (Phila Pa 1976) 2007;32:647–53 00007632-200703150-00008 [pii]. doi: 10.1097/01.brs.0000257560.91147.86.

[3] Iwasaki M, Okuda S, Miyauchi A, Sakaura H, Mukai Y, Yonenobu K, et al. Surgical strategy for cervical myelopathy due to ossification of the posterior longitudinal ligament: Part 2: advantages of anterior decompression and fusion over laminoplasty. Spine (Phila Pa 1976) 2007;32:654–60. doi: 10.1097/01.brs.0000257566.91177.cb.

[4] Liu T, Xu W, Cheng T, Yang HL. Anterior versus posterior surgery for multilevel cervical myelopathy, which one is better? A systematic review. Eur Spine J 2011;20:224–35. doi: 10.1007/s00586-010-1486-7.

[5] Kimura A, Seichi A, Hoshino Y, Yamazaki M, Mochizuki M, Aiba A, et al. Perioperative complications of anterior cervical decompression with fusion in patients with ossification of the posterior longitudinal ligament: a retrospective, multi-institutional study. J Orthop Sci 2012;17:667–72. doi: 10.1007/s00776-012-0271-3.

[6] Tani T, Ushida T, Ishida K, Iai H, Noguchi T, Yamamoto H. Relative safety of anterior microsurgical decompression versus laminoplasty for cervical myelopathy with a massive ossified posterior longitudinal ligament. Spine (Phila Pa 1976) 2002;27:2491–8. doi: 10.1097/01.BRS.0000031270.69596.4E.

[7] Sakai K, Okawa A, Takahashi M, Arai Y, Kawabata S, Enomoto M, et al. Five-year follow-up evaluation of surgical treatment for cervical myelopathy caused by ossification of the posterior longitudinal ligament: a prospective comparative study of anterior decompression and fusion with floating method versus laminoplasty. Spine (Phila Pa 1976) 2012;37:367–76. doi: 10.1097/BRS.0b013e31821f4a51.

[8] Hirabayashi K., Toyama Y., Chiba K.. Expansive laminoplasty for myelopathy in ossification of the longitudinal ligament. Clin Orthop Relat Res 1999:35-48.

[9] Ogawa Y, Toyama Y, Chiba K, Matsumoto M, Nakamura M, Takaishi H, et al. Long-term results of expansive open-door laminoplasty for ossification of the posterior longitudinal ligament of the cervical spine. J Neurosurg Spine 2004;1:168–74. doi: 10.3171/spi.2004.1.2.0168.

[10] Hirai T, Okawa A, Arai Y, Takahashi M, Kawabata S, Kato T, et al. Middle-term results of a prospective comparative study of anterior decompression with fusion and posterior decompression with laminoplasty for the treatment of cervical spondylotic myelopathy. Spine (Phila Pa 1976) 2011;36:1940–7. doi: 10.1097/BRS.0b013e3181feeeb2.

[11] Akiyama T, Chikuda H, Yasunaga H, Horiguchi H, Fushimi K, Saita K. Incidence and risk factors for mortality of vertebral osteomyelitis: a retrospective analysis using the Japanese diagnosis procedure combination database. BMJ Open 2013;3. doi: 10.1136/bmjopen-2012-002412.

[12] Chikuda H, Yasunaga H, Takeshita K, Horiguchi H, Kawaguchi H, Ohe K, et al. Mortality and morbidity after high-dose methylprednisolone treatment in patients with acute cervical spinal cord injury: a propensity-matched analysis using a nationwide administrative database. Emerg Med J 2014;31:201–6. doi: 10.1136/emermed-2012-202058.

[13] Masuda K, Chikuda H, Yasunaga H, Hara N, Horiguchi H, Matsuda S, et al. Factors affecting the occurrence of pulmonary embolism after spinal surgery: data from the national administrative database in Japan. Spine J 2012;12:1029–34. doi: 10.1016/j.spinee.2012.10.020.

[14] Chikuda H, Yasunaga H, Horiguchi H, Takeshita K, Kawaguchi H, Matsuda S, et al. Mortality and morbidity in dialysis-dependent patients undergoing spinal surgery: analysis of a national administrative database in Japan. J Bone Joint Surg Am 2012;94:433–8. doi: 10.2106/JBJS.K.00183.

[15] Chikuda H, Ohya J, Horiguchi H, Takeshita K, Fushimi K, Tanaka S, et al. Ischemic stroke after cervical spine injury: analysis of 11,005 patients using the Japanese diagnosis procedure combination database. Spine J 2014;14:2275–80. doi: 10.1016/j.spinee.2014.01.024.

[16] Matsuda S., Ishikawa K., Kuwabara K., Fujimori K., Fushimi K., Hashimoto HNV-3. Development and use of the Japanese case-mix system 2008;14:27-30.

[17] Oichi T, Chikuda H, Ohya J, Ohtomo R, Morita K, Matsui H, et al. Mortality and morbidity after spinal surgery in patients with Parkinson's disease: a retrospective matched-pair cohort study. Spine J 2017;17:531–7. doi: 10.1016/j.spinee.2016.10.024.

[18] Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. Biometrika 1983;70:41–55.

[19] Okuzono S, Fujiwara T, Kato T, Kawachi I. Spanking and subsequent behavioral problems in toddlers: a propensity score-matched, prospective study in Japan. Child Abus Negl 2017;69:62–71. doi: 10.1016/j.chiabu.2017.04.002.

[20] Kato S, Chikuda H, Ohya J, Oichi T, Matsui H, Fushimi K, et al. Risk of infectious complications associated with blood transfusion in elective spinal surgery—a propensity score matched analysis. Spine J 2016;16:55–60. doi: 10.1016/j.spinee.2015.10.014.

[21] McAfee PC, Regan JJ, Bohlman HH. Cervical cord compression from ossification of the posterior longitudinal ligament in non-orientals. J Bone Joint Surg Br 1987;69:569–75.

[22] Liu W, Hu L, Chou PH, Liu M, Kan W, Wang J. Comparison of anterior decompression and fusion versus laminoplasty in the treatment of multilevel cervical ossification of the posterior longitudinal ligament: a systematic review and meta-analysis. Ther Clin Risk Manag 2016;12:675–85. doi: 10.2147/TCRM.S100046.

[23] Kato S, Nouri A, Wu D, Nori S, Tetreault L, Fehlings MG. Comparison of anterior and posterior surgery for degenerative cervical myelopathy: an MRI-based propensity-score-matched analysis using data from the prospective multicenter AOSpine CSM North America and international studies. J Bone Joint Surg Am 2017;99:1013–21. doi: 10.2106/JBJS.16.00882.

[24] Bohl DD, Ahn J, Rossi VJ, Tabaraee E, Grauer JN, Singh K. Incidence and risk factors for pneumonia following anterior cervical decompression and fusion procedures: an ACS-NSQIP study. Spine J 2016;16:335–42. doi: 10.1016/j.spinee.2015.11.021.

[25] Fineberg SJ, Oglesby M, Patel AA, Singh K. Incidence and mortality of perioperative cardiac events in cervical spine surgery. Spine (Phila Pa 1976) 2013;38:1268–74. doi: 10.1097/BRS.0b013e318290fdac.

[26] Carabini LM, Zeeni C, Moreland NC, Gould RW, Hemmer LB, Bebawy JF, et al. Predicting major adverse cardiac events in spine fusion patients: is the revised cardiac risk index sufficient? Spine (Phila Pa 1976) 2014;39:1441–8. doi: 10.1097/BRS.0000000000000405.

[27] Fineberg SJ, Oglesby M, Patel AA, Singh K. Incidence, risk factors, and mortality associated with aspiration in cervical spine surgery. Spine (Phila Pa 1976) 2013;38:E1189–95. doi: 10.1097/BRS.0b013e31829cc19b.

[28] Cardoso MJ, Koski TR, Ganju A, Liu JC. Approach-related complications after decompression for cervical ossification of the posterior longitudinal ligament. Neurosurg Focus 2011;30:E12. doi: 10.3171/2011.1.FOCUS10278.

[29] Hanai K, Inouye Y, Kawai K, Tago K, Itoh Y. Anterior decompression for myelopathy resulting from ossification of the posterior longitudinal ligament. J Bone Joint Surg Br 1982;64:561–4.

[30] Abe H, Tsuru M, Ito T, Iwasaki Y, Koiwa M. Anterior decompression for ossification of the posterior longitudinal ligament of the cervical spine. J Neurosurg 1981;55:108–16. doi: 10.3171/jns.1981.55.1.0108.

[31] Harsh GR, Sypert GW, Weinstein PR, Ross DA, Wilson CB. Cervical spine stenosis secondary to ossification of the posterior longitudinal ligament. J Neurosurg 1987;67:349–57. doi: 10.3171/jns.1987.67.3.0349.

[32] Smith MD, Bolesta MJ, Leventhal M, Bohlman HH. Postoperative cerebrospinal-fluid fistula associated with erosion of the dura. Findings after anterior resection of ossification of the posterior longitudinal ligament in the cervical spine. J Bone Joint Surg Am 1992;74:270–7.

[33] Mitchell BD, Verla T, Reddy D, Winnegan L, Omeis I. Reliable intraoperative repair nuances of cerebrospinal fluid leak in anterior cervical spine surgery and review of the literature. World Neurosurg 2016;88:252–9. doi: 10.1016/j.wneu.2016.01.014.

[34] Odate S, Shikata J, Soeda T, Yamamura S, Kawaguchi S. Surgical results and complications of anterior decompression and fusion as a revision surgery after initial posterior surgery for cervical myelopathy due to ossification of the posterior longitudinal ligament. J Neurosurg Spine 2017;26:466–73. doi: 10.3171/2016.9.SPINE16430.

[35] Yoshii T, Hirai T, Yamada T, Inose H, Kato T, Sakai K, et al. Intraoperative evaluation using mobile computed tomography in anterior cervical decompression with floating method for massive ossification of the posterior longitudinal ligament. J Orthop Surg Res 2017;12:12. doi: 10.1186/s13018-017-0515-1.

[36] Xu R, Bydon M, Sciubba DM, Witham TF, Wolinsky JP, Gokaslan ZL, et al. Safety and efficacy of rhBMP2 in posterior cervical spinal fusion for subaxial degenerative spine disease: analysis of outcomes in 204 patients. Surg Neurol Int 2011;2:109. doi: 10.4103/2152-7806.83726.

[37] Memtsoudis SG, Hughes A, Ma Y, Chiu YL, Sama AA, Girardi FP. Increased in-hospital complications after primary posterior versus primary anterior cervical fusion. Clin Orthop Relat Res 2011;469:649–57. doi: 10.1007/s11999-010-1549-4.

[38] Kwon BK, Fisher CG, Boyd MC, Cobb J, Jebson H, Noonan V, et al. A prospective randomized controlled trial of anterior compared with posterior stabilization for unilateral facet injuries of the cervical spine. J Neurosurg Spine 2007;7:1–12. doi: 10.3171/SPI-07/07/001.

[39] Sebastian A, Huddleston P, Kakar S, Habermann E, Wagie A, Nassr A. Risk factors for surgical site infection after posterior cervical spine surgery: an analysis of 5,441 patients from the ACS NSQIP 2005-2012. Spine J 2016;16:504–9. doi: 10.1016/j.spinee.2015.12.009.

[40] Ghobrial GM, Harrop JS, Sasso RC, Tannoury CA, Tannoury T, Smith ZA, et al. Anterior cervical infection: presentation and incidence of an uncommon postoperative complication. Glob Spine J 2017;7:12S–6S. doi: 10.1177/2192568216687546.