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Outcomes and Complications Following Laminectomy Alone for Thoracic Myelopathy due to Ossified Ligamentum Flavum

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Abstract

Study Design.—Systematic review and meta-analysis.

Objective.—Examine the functional outcomes and complications following laminectomy for thoracic myelopathy due to ossification of the ligamentum flavum (OLF).

Summary of Background Data.—OLF is a rare condition that can cause thoracic myelopathy. Laminectomy is a procedure that can be performed to decompress the spinal cord in patients with thoracic myelopathy due to OLF. Few studies have examined postoperative outcomes and complications following laminectomy for thoracic myelopathy secondary to OLF.

Methods.—A systematic review and meta-analysis was performed. Literature search yielded six studies that met our selection criteria. Study characteristics and baseline patient demographics were extracted from each study. Primary outcomes included pre- and postoperative Japanese Orthopedic Association (JOA) scores and perioperative complications including dural tears, cerebrospinal fluid (CSF) leaks, neurological deficits, surgical site infections, and other complications. We calculated pooled proportion estimates for JOA scores and complications using a random effects model.

Results.—A total of 137 patients were included. The pooled pre-and postoperative JOA scores were 5.08 (95% confidence interval [CI], 2.70–7.47; $I^2 = 98\%$) and 8.29 (95% CI, 7.73–8.85; $I^2 = 18\%$), respectively, with a mean improvement of +3.03 points (95% CI, 1.08–4.98; $I^2 = 88\%$). Pooled proportion estimates for dural tears, CSF leaks, infections, and early neurological deficits were 18.4% (95% CI, 12.6–26.1; $I^2 = 0\%$), 12.1% (95% CI, 6.6–21.2; $I^2 = 0\%$), 5.8% (95% CI, 2.1–15.4; $I^2 = 0\%$), and 5.7% (95% CI, 2.2–14.3; $I^2 = 0\%$), respectively.

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Conclusion.—Thoracic myelopathy secondary to OLF can be treated with laminectomy. However, despite some improvement in JOA score, functional status remains poor postoperatively. Perioperative complications are common, with dural tears and CSF leaks occurring most frequently. OLF is an uncommon condition and more research is needed to better understand how we can improve the outcomes of laminectomy alone for the treatment of thoracic myelopathy due to OLF.

Keywords

complications; decompression; dural ossification; laminectomy; meta-analysis; OLF; ossification of the ligamentum flavum; outcomes; systematic review; thoracic myelopathy.

Ossification of the ligamentum flavum (OLF) is a rare cause of thoracic myelopathy that is not well understood. The underlying pathophysiology involves ossification of hypertrophic fibrous tissue within the ligamentum flavum, which can narrow the spinal canal and lead to spinal cord compression and resultant neurological symptoms.¹ Most of the current literature on thoracic myelopathy caused by OLF is from East Asian countries, particularly Japan, China, and Korea.^{2,3} More recently, there have also been some reports published from Southeast Asia, North America, Middle East, and Caribbean.^{4–6}

Patients presenting with neurological symptoms of thoracic myelopathy due to OLF typically require surgery, as conservative treatment options have been shown to be ineffective by the time of presentation and the disease is progressive in nature.^{7,8} Most commonly, a posterior laminectomy, with or without fusion, is performed to decompress the spinal cord. However, other techniques such as fenestration, laminoplasty, and hemilaminectomy have been reported as well.^{9–14} Even with successful surgical decompression, there can be marked variation in clinical outcomes and the incidence of postoperative complications is not infrequent.^{9,11,14–17}

To date, although several studies have investigated outcomes and complications following laminectomy for OLF, these have mostly been retrospective studies with small patient cohorts.^{1,16–19} Given the low prevalence of thoracic myelopathy caused by OLF and the current paucity of studies in the literature, the safety and effectiveness of different surgical techniques to treat thoracic myelopathy secondary to OLF remains unclear and warrants further attention. We performed a systematic review and meta-analysis to examine the functional outcomes and perioperative complications in patients undergoing laminectomy without fusion for thoracic myelopathy due to OLF.

METHODS

Literature Search Strategy

Recommended guidelines for systematic reviews and meta-analyses were followed for the present study.^{20,21} Electronic searches were performed using Ovid Medline, PubMed, Cochrane Central Register of Controlled Trials (CCTR), Cochrane Database of Systematic Reviews (CDSR), ACP Journal Club, and Database of Abstracts of Review of Effectiveness (DARE) from their dates of inception to December 2016. To achieve the maximum sensitivity of the search strategy, we combined the terms: (ossification ligamentum flavum

OR ossification yellow ligament) AND (laminectomy OR decompression OR fusion) as either key words or MeSH terms. The reference lists of all retrieved articles were reviewed for identification of other potentially relevant studies and assessed using the inclusion and exclusion criteria as described below.

Selection Criteria

Eligible studies included those in which patients underwent laminectomy for thoracic myelopathy due to OLF. Inclusion criteria were studies of human subjects published in the English language. Studies that did not include either clinical outcomes or perioperative complications as outcome variables were excluded. For duplicate studies with patients from the same initial cohort (*i.e.*, increasing number of patients over time or increased length of follow-up for the same patients), only the study with the most complete set of data was included for quantitative assessment in our meta-analysis. Abstracts, case reports, conference presentations, editorials, reviews, and expert opinions were excluded.

Data Extraction and Critical Appraisal

Data extraction was performed independently by two reviewers (N.O. and A.H.). All data were extracted from each article's text, tables, and figures. The extracted data included the number of patients, baseline patient characteristics, surgical technique, pre- and postoperative Japanese Orthopedic Association (JOA) score, and perioperative complications. Complications reported included dural tears, cerebrospinal fluid (CSF) leaks, neurological deficits, surgical site infections, and other complications.

Both reviewers independently reviewed and assessed the quality of the selected articles. Discrepancies between the two reviewers were resolved by discussion and consensus. Because quality scoring is controversial in meta-analyses of observational studies, the two reviewers independently appraised each article according to the critical review checklist of the Dutch Cochrane Centre that was proposed by the meta-analysis of observational studies in epidemiology (MOOSE) group.²² The key points of this checklist include: (1) clear definition of the study population; (2) clear definition of outcomes and outcome assessment; (3) independent assessment of outcome parameters; (4) sufficient duration of follow-up; (5) no selective loss during follow-up; and (6) important confounders and prognostic factors identified. The final results were reviewed by the senior investigator (S.C.).

Statistical Analysis

A meta-analysis of proportions of functional outcomes and perioperative complications was conducted. First, to establish the variance of raw proportions, a Freeman–Tukey transformation was applied. To incorporate heterogeneity (which was anticipated among the included studies), transformed proportions were combined using DerSimonian–Laird random effects models. Finally, the pooled estimates were back-transformed. Heterogeneity was evaluated using Cochran's Q and I^2 test. Weighted means were calculated by determining the total number of events divided by total sample size. All analyses were performed using the metafor package for R version 3.01. Statistical significance was set at the level $P = 0.05$.

RESULTS

Literature Search and Study Characteristics

The initial literature search yielded 225 references (Figure 1). After removing duplicate and irrelevant studies based on a screen of titles and abstracts, 31 studies were selected for full-text article review. After full-text article review, a total of six articles met our selection criteria and were included. Reasons for exclusion on full-text article review included lack of data about complications, procedures other than laminectomy without fusion, and patient cohorts with other spine pathologies. All of the included studies were retrospective with a minimum of 10 patients. The JOA scoring system was utilized by all studies to assess pre- and postoperative functional status. The characteristics of the six included studies are summarized in Table 1. The quality assessment of each study is outlined in Table 2.

Baseline Patient Characteristics

Baseline patient characteristics are summarized in Table 3. There were a total of 137 adult patients with thoracic myelopathy due to OLF who underwent laminectomy alone. The mean age in each study ranged from 53.0 to 60.5 years. The proportion of male patients in each study ranged from 33.3% to 65.3%.

JOA Scores

JOA scores were reported in three studies, yielding a pooled mean preoperative score of 5.08 (95% CI, 2.70–7.47, $I^2 = 98.0\%$) and a mean postoperative score of 8.29 (95% CI, 7.73–8.85, $I^2 = 18.2\%$). The mean change in JOA score was + 3.03 points (95% CI, 1.08–4.98, $I^2 = 88.2\%$).^{1,17,23}

Perioperative Complications

- i. Dural Tear. The incidence of dural tear was reported in all six studies.^{1,16–19,23} The cumulative incidence of dural tears was 17.5% (24/137), and the pooled proportion estimate was 18.4% (95% CI, 12.6–26.1; $I^2 = 0\%$).
- ii. CSF Leak. CSF leak was reported in five studies.^{1,16–19} The cumulative incidence of CSF leaks was 9.3% (9/97), resulting in a pooled estimate of 12.1% (95% CI 6.6–21.2%, $I^2 = 0\%$).
- iii. Surgical site infection. Infection was reported in three studies with an incidence of 4.8% (3/62).^{16,18,19} The pooled proportion estimate was 5.8% (95% CI, 2.1–15.4%, $I^2 = 0\%$).
- iv. Neurological Deficit. Early neurological deficit that manifested immediately after surgery was reported in three studies.^{17,18,23} The incidence was 5.0% (4/80) and the pooled estimate was 5.7% (95% CI, 2.2–14.3%, $I^2 = 0\%$). Late neurological deterioration that did not occur immediately after surgery was reported in one study in six out of 24 patients.¹⁸
- v. Other Complications. Postoperative hematoma was reported in one study with an incidence of 6.3% (1/16).¹⁷ This epidural hematoma led to an episode of early neurological deterioration which resolved after emergent evacuation of the

hematoma.¹⁷ Hemorrhage was also reported as a complication in one study with an incidence of 3.8% (1/26).¹⁶ However, the study did not include a definition of hemorrhage.

DISCUSSION

OLF is an uncommon condition and there are only a few retrospective studies in the literature examining laminectomy for thoracic myelopathy due to OLF. Additionally, these studies have small patient cohorts, and were likely unable to adequately capture and characterize the breadth of possible complications that occur following surgery. The purpose of this study was to perform a systematic review and meta-analysis to examine the functional outcomes and perioperative complications following laminectomy without fusion for thoracic myelopathy due to OLF.

Functional outcomes in all of the included studies were assessed using pre- and postoperative JOA scores. The mean improvement in JOA score following laminectomy was 3.03 points, resulting in a mean postoperative score of 8.29. A JOA score of less than 9, however, is still considered an indication of severe myelopathy.²⁴ Therefore, despite a mild improvement in JOA score, postoperative functional status after laminectomy still remains low. The pooled rate of improvement in functional status after surgery was 54%, which is consistent with results from previous studies that have reported improvement rates of 40% to 50%.^{7,12,15,17} This moderate rate of improvement may be due to prolonged compression of the spinal cord at either the operated levels or at other spinal levels (e.g., in the cervical or lumbar spine) prior to surgery causing irreversible damage secondary to ischemia.^{14,17}

The overall complication rate in this study was 35%. While there are no prospective studies in the literature examining outcomes or complications following surgical treatment of thoracic myelopathy secondary to OLF for comparison, Li *et al*¹¹ performed one of the larger retrospective studies of laminectomy with and without fusion in 85 patients with thoracic myelopathy due to OLF and found a complication rate of 51%. Another retrospective study performed by Onishi *et al*¹⁰ examining laminectomy with and without fusion for thoracic myelopathy of various etiologies (e.g., OLF, disc herniation, spinal stenosis, ossified posterior longitudinal ligament) demonstrated an overall complication rate of 21% in 73 patients. Although these two studies cannot provide a perfectly equivalent comparison to our study, it appears that the complication rate found in our meta-analysis is consistent with prior literature. This suggests that laminectomy alone for thoracic myelopathy due to OLF is a procedure with a moderately high rate of any perioperative complication.

All six studies included in our meta-analysis reported dural tear as a complication. In all but one study, dural tear was the most frequently seen complication with a pooled incidence of 18.4%. CSF leak, which is associated with dural tears, was the second most common complication with an overall incidence of 12.1%. Our findings are consistent with previous studies that have reported the incidence of dural tears and CSF leaks to be 11% to 32%.^{7,11,12,24,25} One potential explanation for the significant rate of dural tears and CSF leaks is the potential technical challenge encountered by the presence of dural ossification, which

has been described by several authors.^{16,17,19} The pathophysiology of OLF can lead to ossification of the dura mater, resulting in fusion of the ligamentum flavum and dura into a single inseparable layer of bony tissue. This presents a technical challenge when decompressing the spinal cord. Previous studies have indeed established a link between dural ossification and dural tears. The incidence of dural ossification in patients with OLF is as high as 62%, and the incidence of dural tears and CSF leaks has been shown to be disproportionately higher in patients undergoing surgery for OLF that was complicated by dural ossification.⁷ Our findings suggest that despite careful surgical dissection, there remain significant rates of dural tears and CSF leaks in patients undergoing laminectomy for thoracic myelopathy due to OLF.

Dural tears are associated with higher rates of wound infection, wound dehiscence, neurological complications, and longer hospital stay.^{26,27} In addition, total hospital costs increase by \$4,000 to \$10,000 for patients who experience an incidental dural tear.^{26,27} In particular, increased length of stay following a dural tear has been shown to be an independent driver of cost.²⁶ Given the clinical and economic ramifications associated with dural tears, there is great interest in surgical techniques that can minimize this complication. Unfortunately, in the context of spinal decompression in patients with OLF, the current literature is lacking with regards to strong data to support any specific surgical technique to reduce dural tears. However, Wang *et al*²⁸ have described a technique for approaching dural ossification, in which a fragment of ligamentum flavum is left floating at the point of adhesion, and then a high-speed drill is used to abrade this free fragment in order to make it thinner. This technique may allow the surgeon to avoid tearing the dura, while separating a tightly adherent OLF from the dura. The tradeoff, however, is a lesser extent of spinal decompression. Further research is warranted to better elucidate effective and safe surgical techniques to approach dural ossification when decompressing the thoracic spine.

Another complication examined in this meta-analysis was early neurological deficit. The incidence of early neurological deficit had a pooled estimate of 5.7%. Chen *et al*¹⁷ described one case of acute neurological deterioration due to an epidural hematoma. The neurological deficit fully resolved following evacuation of the hematoma.¹⁷ Yoon *et al*²³ reported one transient episode of neurological deficit that resolved without any evidence of long-term sequelae; however, they did not comment on the possible underlying etiology of the neurological deficit. Liao *et al*¹⁸ described two episodes of transient neurological deterioration that occurred following unintended intraoperative spinal cord manipulations. Both cases subsequently resolved with no residual neurological deficit.¹⁸ These reported cases of early neurological deficit are consistent with known etiologies of acute neurological deterioration following spine surgery—that is, direct intraoperative spinal cord injury and postoperative epidural hematoma.^{29–31}

Late neurological deterioration was only reported in one study by Stroup *et al*.²² Six patients were found to have late neurological deterioration. The term “late neurological deterioration” was not specifically defined by the authors. Four of these cases were described as subjective sensorimotor symptoms that were not associated with significant changes in JOA scores. The underlying etiology of these sensorimotor symptoms was unclear. One case was related to comorbid ankylosing spondylitis and the last case was due

to restenosis of the spinal canal from cervical OLF and OPLL. It is difficult to generalize the significance of late neurological deterioration following laminectomy for thoracic myelopathy due to OLF given the low number of cases reported in the literature.

One of the risks of performing a laminectomy to decompress the spinal cord is resection of a significant portion of the facet joints. In the thoracic spine, excessive resection of the facet joints may be a potential cause of instability. Instability can subsequently result in progressive kyphotic deformity and associated neurological deterioration, local recurrence of OLF, or development of OLF at adjacent proximal levels.^{13,14,32} Concurrent posterior instrumentation and fusion has been proposed as a strategy to prevent progression of thoracic kyphosis from surgical decompression, although this remains controversial.^{11,32} However, two studies in this meta-analysis specifically proposed that good clinical results can be achieved with decompression alone without fusion.^{1,23} The late-onset complication of thoracic kyphosis was not reported in these two studies at a follow-up period of 17.3 and 53.2 months, respectively.^{1,23} Li *et al*¹ are proponents of attempting to preserve the facet joints during laminectomy in order to decrease instability. However, the role of different surgical techniques in the risk of developing a late-onset complication of thoracic kyphosis remains unclear. Specifically, the efficacy and safety of decompression alone *versus* decompression with concomitant fusion needs to be further investigated.

Three studies in this meta-analysis reported on the incidence of postoperative infection with a pooled infection rate of 5.8%. Again, because there is a paucity of studies available for comparison. However, Li *et al*'s retrospective study of surgical outcomes after laminectomy with or without fusion for myelopathy due to OLF reported an infection rate of 3.5%, which is fairly consistent with our findings.¹¹ Potential risk factors for infection include failure of intraoperative hemostasis that can be the result of an unknown or occult coagulopathy or failure of a surgical drain.¹¹ The development of a hematoma is a potential sequelae of inadequate intraoperative hemostasis and the hematoma may become a nidus for postoperative infection.¹¹

There are several limitations to this study. First, the diagnostic criteria for OLF varied across studies, and the definitions of perioperative complications varied as well. Second, the surgical technique was not uniform across all studies. There was variability in terms of whether a partial or complete laminectomy was performed. Additionally, there was inherent heterogeneity among the included studies as expected, which may have affected our pooled analysis. Lastly, the studies we included had a low level of evidence (*i.e.*, IV), and as such, were more likely to be subject to bias. Therefore, our pooled analysis of these studies was subjective to the same biases present in the individual studies. This, unfortunately, was unavoidable given the relative paucity of studies on surgical treatment of OLF in the current literature.

In conclusion, thoracic myelopathy due to OLF can be treated with laminectomy alone. However, our results suggest that despite some improvement, postoperative functional outcomes remain fairly low. Complications such as dural tears and CSF leaks are common, particularly in the setting of dural ossification, which can occur in OLF. OLF is an uncommon condition and more research is needed to better understand how we can improve

the outcomes and reduce complications following laminectomy alone for the treatment of thoracic myelopathy due to OLF.

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The manuscript submitted does not contain information about medical device(s)/drug(s).

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➤ Key Points

- ❑ OLF is a rare condition that can cause thoracic myelopathy requiring surgical decompression with laminectomy.
- ❑ Our systematic review and meta-analysis demonstrates that despite some improvement in JOA scores, postoperative functional status remained poor following laminectomy alone.
- ❑ The overall perioperative complication rate was 35%. Dural tears and CSF leaks were the most common complications.
- ❑ More research is needed to better understand how we can improve outcomes and reduce complications following laminectomy alone for the treatment of thoracic myelopathy due to OLF.

Figure 1. Diagram outlining the preferred reporting items for systematic reviews and meta-analyses (PRISMA) search strategy.

TABLE 1.

Characteristics of Studies Included in the Meta-analysis

Study	Location of Study	Number of Patients	Type of Study	Mean Follow-up (mo)	Study Period
Liao <i>et al</i> ¹⁸	Taiwan	24	Retrospective	42.0	1994–2003
Chen <i>et al</i> ¹⁷	China	16	Retrospective	57.3	1996–2003
Hur <i>et al</i> ¹⁶	South Korea	26	Retrospective	27.3	1998–2008
Yoon <i>et al</i> ²³	South Korea	40	Retrospective	17.3	1999–2008
Park <i>et al</i> ¹⁹	South Korea	12	Retrospective	24.2	1999–2005
Li <i>et al</i> ¹	China	19	Retrospective	53.2	2004–2008

TABLE 2.

Baseline Patient Characteristics, Functional Outcome Scores, and Perioperative Complications in Patients Undergoing Laminectomy for Thoracic Myelopathy due to Ossification of the Ligamentum Flavum

Study	Male:Female Ratio	Mean Age (yr)	Mean Preoperative JOA [*] Score	Mean Postoperative JOA [*] Score	Dural Tears (n)	CSF [†] Leaks (n)	Early Neurological Deficits (n)	Late Neurological Deficits (n)	Infection (n)	Hematoma (n)
Liao <i>et al</i> ⁸	7:5	58.2	2.0	2.7	2	2	2	6	1	–
Chen <i>et al</i> ⁷	5:3	57.7	5.0	7.7	3	3	1	–	–	1
Hur <i>et al</i> ⁶	17:9	53.0	6.7	8.2	5	4	–	–	2	1
Yoon <i>et al</i> ²³	13:7	57.1	7.1	8.6	6	–	1	–	–	–
Park <i>et al</i> ⁹	1:2	60.5	4.9	7.9	4	0	–	–	0	–
Li <i>et al</i> ¹	7:12	55.3	3.2	8.3	4	0	–	–	–	–

^{*} JOA, Japanese Orthopedic Association score.

[†] CSF, cerebrospinal fluid.

TABLE 3.

Quality Assessment of the Studies Included in the Meta-analysis

	Liao <i>et al</i>¹⁸	Chen <i>et al</i>¹⁷	Hur <i>et al</i>¹⁶	Yoon <i>et al</i>²³	Park <i>et al</i>¹⁹	Li <i>et al</i>¹
Clear definition of study population	Yes	Yes	Yes	Yes	Yes	Yes
Clear definition of outcomes and outcome assessment	Yes	Yes	Yes	Yes	Yes	Yes
Independent assessment of outcome parameters	No	No	No	No	No	No
Sufficient duration of follow-up	Yes	Yes	Yes	Yes	Yes	Yes
No selective loss during follow-up	Yes	Yes	Yes	Yes	Yes	Yes
Important prognostic factors identified	Yes	No	Yes	Yes	No	No