

Is posterior fusion necessary with laminectomy in the cervical spine?

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Abstract

Background: Cervical decompressive laminectomy is a common procedure for addressing multilevel cervical spine pathology. The most common reasons for performing simultaneous posterior cervical fusion include the prevention of progressive postlaminectomy kyphotic deformity or other types of instability which can contribute to late neurological deterioration.

Methods: The medical literature (Pub Med with MeSH) concerning cervical laminectomy, posterior cervical fusion, and complications of laminectomy/fusion was reviewed. Additionally, references from the articles were queried to find additional literature.

Results: Multiple studies concluded that cervical laminectomy versus laminectomy and fusion produced similar short-term postoperative outcomes. Careful patient selection was warranted to minimize the complications associated with cervical laminectomy alone; these included postoperative kyphosis (6–46%) and late deterioration (10–37%). The addition of a posterior cervical fusion was associated with relatively low complication rates, and avoided the evolution of late deformity or delayed neurological deterioration.

Conclusion: Although the short-term results of cervical laminectomy versus laminectomy and fusion are similar, there appear to be more complications associated with performing laminectomy alone over the long term. Here, we reviewed the pros and cons of posterior cervical decompression alone versus decompression with fusion/instrumentation to treat cervical pathology, highlighting the complications associated with each surgical alternative.

Key Words: Cervical, complications, fusion, indications, laminectomy

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INTRODUCTION

Frequently, the spine surgeon is faced with multilevel compressive cervical pathology that is appropriately treated by a posterior cervical approach. In general, the indications for cervical laminectomy include cervical

stenosis (congenital and acquired), cervical spondylotic myelopathy, multilevel spondylotic radiculopathy, ossification of the posterior longitudinal ligament (OPLL), ossification of the yellow ligament (OYL), neoplasm, and infection.^[3,6,14,16,17,19,23,25] Following cervical laminectomy, several factors may contribute to the

necessity for additionally performing a posterior cervical instrumented fusion.

SUCCESS OF CERVICAL LAMINECTOMY DEPENDS ON AN ADEQUATE LORDOTIC CURVATURE AND PRESERVATION OF THE FACET JOINTS

The natural lordotic curvature of the cervical spine distributes the compressive load differently than in other spinal locations. The cervical spine transmits 36% of compressive loads through the anterior column, while 64% is borne through the posterior column facet joints.^[2,7] In order to preserve stability, the surgeon needs to recognize the potential destabilizing impact of a posterior approach as laminectomy, facetectomy (medial, partial, or full), and muscle denervation may contribute to instability/deformity.^[2,7,9,26,30,34]

The success of cervical laminectomy is determined by several factors. First, the normal lordotic alignment of the cervical spine is 14°–20° from C2–C7.^[2,7,12] For the spinal cord to be adequately decompressed, allowing the cervical spinal cord to drift posteriorly, there should be 10° of lordosis present, without cervical kyphosis.^[9,14] Second, there should be no evidence of instability. Third, and finally, 50% of the facet joints should be preserved during decompression.

INDICATIONS FOR CERVICAL LAMINECTOMY

The indications for cervical laminectomy include cervical stenosis (congenital and acquired), cervical spondylotic myelopathy, multilevel spondylotic radiculopathy, OPLL, OYL, neoplasm, and infection.^[3,6,14,16,17,19,23,25]

CERVICAL LAMINECTOMY OFFERS VENTRAL/DORSAL DECOMPRESSION AND INCREASED PERFUSION

Cervical laminectomy, by removing the posterior bony elements, allows the spinal cord to migrate dorsally away from anteriorly situated compressive pathology, while also affording direct relief from dorsal stenosis/spondyloarthritis. Laminectomy, whether offering ventral or dorsal decompression, improves cervical cord perfusion.

Additional keys to achieving successful outcomes following cervical laminectomy include careful preoperative attention to the location of the compression (anterior/posterior), the preoperative sagittal alignment, and whether the cervical spine is stable.

EARLY SUCCESS OF CERVICAL LAMINECTOMY

The literature is replete with studies documenting the

clinical success and utility of cervical laminectomy. Ryken *et al.* performed a detailed systematic review of the results of cervical laminectomy for cervical myelopathy.^[25] Cervical laminectomy effectively addressed multilevel cervical pathology; success rates ranged from 44.2 to 92% in the early postoperative period.^[25] The results of cervical laminectomy, cervical laminectomy and fusion, and cervical laminoplasty were similar in the early postoperative period.^[23,25] However, although the effectiveness of cervical laminectomy was documented repeatedly, there were still concerns over postoperative kyphotic deformity, cervical instability, and late deterioration.^[3,9,14,16-19,25,28]

INCIDENCE OF POSTOPERATIVE KYPHOTIC DEFORMITY

The potential for the development of postoperative kyphotic deformity is a major concern when choosing to perform cervical laminectomy in adults or children. The incidence of postlaminectomy kyphosis ranges from 6 to 47% in adults, and can reach 100% in children [Table 1].^[6,11,16-18,21,25,31]

PATHOGENESIS OF POSTLAMINECTOMY KYPHOSIS

The pathogenesis of postlaminectomy kyphosis is multifactorial, and varies between adults and children. Yasuko *et al.* found a 46% incidence of postlaminectomy kyphosis for those less than 15 years of age, while the rate was only 6% for those between the ages of 15 and 24. The rate of kyphosis also varied by spinal region, with 100% following cervical laminectomy, 36% following thoracic laminectomy, and 0% following lumbar laminectomy.^[30,31] There was no correlation between the incidence of deformity and sex, number of laminae removed, neurologic condition, or length of time after surgery.^[31]

LOSS OF THE POSTERIOR TENSION BAND IN ADULTS FOLLOWING LAMINECTOMY

Postlaminectomy kyphosis is multifactorial in adults, with the incidence ranging between 6% and 47%.^[2,6,16,17,22] In adults, multiple factors contributed to the development of cervical deformity/sagittal instability following laminectomy.^[7,26] The major factors included: (1) the loss of the posterior tension band with the redistribution of loads through the posterior facets and anterior vertebral body and (2) the loss of the posterior cervical musculature.

POSTOPERATIVE CERVICAL LAMINECTOMY KYPHOSIS IN CHILDREN

In children, there are two types of postoperative

Table 1: Incidence of postlaminectomy kyphosis/instability

Author	# Total patients	# Laminectomy	# Follow-up (years)	Outcome measure	Postlaminectomy kyphosis neurological progression
Kato <i>et al.</i> ^[18]	52	44	Average 14.1	JOA scale	14/30 (46.7%) No progression
Herkowitz ^[16]	45	12	Minimum 2 years	Excellent, good, or poor	3/12 (25%)
Yasouka <i>et al.</i> ^[31]	58	58	Minimum 5 years	None	Age 0–14: 12/26 (46.1%); age 15–24: 2/32 (6.3%)
Mikawa <i>et al.</i> ^[22]	64	64	Average 7.7 years	Radiographs	23/64 (35.9%) Changed alignment, 9/64 (14.1%) kyphosis, no progression
Matsunaga <i>et al.</i> ^[21]	101	37	6.6 years	Radiographs	11/32 (34.3%) Laminectomy 4/58 (6.9%) laminoplasty
Kaptain <i>et al.</i> ^[17]	46	46	Average 4 years	Nurick scale, patient questionnaire radiographs	9/42 (21.4%) Straight/lordotic kyphosis, 6/30 (30%) straight kyphosis 3/22 (13.6%), lordosis kyphosis, no progression

cervical laminectomy kyphosis: wedging of the vertebral bodies and subluxation with excessive motion between vertebrae.^[30] The former wedge deformity was attributed to the resection of the posterior elements, thereby increasing compressive loads on the developing vertebral column. The latter subluxation was correlated with a combination of the loss of the lamina/interspinous ligaments, and increased viscoelasticity of the ligaments in children, contributing to loosening of the posterior facets.^[30] The near 100% rate of postlaminectomy cervical kyphosis found in children, therefore, requires the addition of a fusion following a cervical laminectomy.^[31]

NO IMPACT OF LAMINECTOMY AND POSTOPERATIVE CERVICAL KYPHOSIS ON OUTCOME IN ADULTS

What is the clinical significance of postlaminectomy kyphosis with respect to outcome?^[17,18,22]

Although postoperative cervical kyphosis is a known sequelae of cervical laminectomy, the clinical impact on neurological deterioration is difficult to ascertain. When Kaptain *et al.* evaluated preoperative and postoperative sagittal alignment in 46 patients undergoing cervical laminectomy, the rate of postoperative kyphosis was twofold greater for patients with preoperative “straightened” cervical spinal alignment.^[17] However, no correlation between change in sagittal alignment and neurologic outcome could be determined. Similarly, Kato *et al.* found postoperative progression of kyphotic deformity in 47% of patients, although there was no correlation with neurologic deterioration.^[18] Mikawa *et al.* were also unable to find an association between development of postlaminectomy kyphosis and outcome.^[22]

DELAYED DETERIORATION FROM POSTLAMINECTOMY KYPHOSIS

The incidence of late deterioration following cervical laminectomy alone varies from 10 to 39% [Table 2].^[1,4,8,28,33] The etiology of late deterioration is variously attributed to postoperative deformity and instability, both of which result in draping and compression of the spinal cord over the ventral kyphotic deformity.^[4,5,8,18,25,32] After initially demonstrating neurological recovery following cervical laminectomy, within several postoperative months, multiple studies showed delayed deterioration. Snow and Weiner found a delayed deterioration rate of 10% with long-term follow-up.^[28] Alternatively, Arnold *et al.* reported a 72% incidence of early improvement following cervical laminectomy alone, but only 52% demonstrated sustained improvement after 8 years.^[4]

CERVICAL LAMINECTOMY AND FUSION

Cervical laminectomy and fusion may be performed to avoid the potential complications of instability and kyphosis associated with cervical laminectomy alone. For the latter, dissection and removal of the posterior elements disrupts the normal biomechanics of the cervical spine, leading to postlaminectomy deformity and instability.

POSTERIOR CERVICAL FUSION TECHNIQUES

Posterior cervical fusion techniques have evolved over the years. Currently, the most common method of fixation is lateral mass screw/rod constructs. The fusion rates with these technique are consistently over 90–95%, depending

Table 2: Late deterioration following cervical laminectomy

Authors	# Patients # available	# Laminectomy	Follow-up average range	Outcome measure	Late deterioration
Yonenobu <i>et al.</i> ^[33]	110	22	6 years 2–14 years	JOA scale, other scores	4/22 (18.1%) Early, 3/22 (13.6%) late
Yonenobu <i>et al.</i> ^[32]	95	24	1–13 years	JOA scale, other scores	7/24 (29.1%) Late
Snow and Weiner ^[28]	90	90	4% <4 months, 18% 6–12 months, 33% 1–2 years, 45% 2–4 years	Marked, mild, none, worse	9/90 (10%) Late
Arnold <i>et al.</i> ^[4]	70	44	8 years	Improved, unchanged, worse	33/44 (77.2%) Early laminectomy, 17/33 (51.5%) sustained laminectomy, 13/33 (39.3%) late laminectomy
Ebersold <i>et al.</i> ^[8]	100 (84)	51	7.35 years 3–9.5 years	Nurick, other	35/51 (68.6%) Early laminectomy, 19/51 (37.3%) sustained laminectomy, 19/51 (37.2%) late laminectomy
Kato <i>et al.</i> ^[18]	52 (44)	44	14.1	JOA scale	10/44 (22.7%) Late

on the fusion criteria utilized.^[24,27] When Anderson *et al.* reviewed the treatment of cervical myelopathy, they concluded that posterior cervical decompression with fusion was an acceptable treatment modality.^[3] Furthermore, Kumar *et al.* found no evidence of late deterioration or progression of deformity following cervical laminectomy and fusion.^[20] Nevertheless, others found that posterior cervical fusion techniques were as effective as anterior approaches, cervical laminoplasty, and cervical laminectomy alone, although those undergoing laminectomy without fusion demonstrated increased rates of delayed deterioration.^[3,14,19,23,25]

INCREASED COMPLICATION RATES OF POSTERIOR CERVICAL FUSION

The benefits of posterior cervical stabilization must be weighed against the added potential complications of fusions: increased operative time, blood loss, and instrument-related complications [Table 3]. Heller *et al.* reported an overall 9% complication rate for applying cervical lateral mass screw/plates in 78 consecutive patients.^[15] When complications were reported as a percentage of the number of screws inserted, the incidences of injuries were: nerve root injury 0.6%, facet violation 0.2%, vertebral artery injury 0%, broken screw 0.3%, screw avulsion 0.2%, and screw loosening 1.1%. When complications were reported based on the number of cases performed, they were as follows: spinal cord injury 2.6%, iatrogenic foraminal stenosis 2.6%, broken plate 1.3%, lost reduction 2.6%, adjacent segment degeneration 3.8%, infection 1.3%, and pseudoarthrosis 1.4%.^[15]

DISCUSSION

When to Perform Cervical Laminectomy with Fusion

Cervical laminectomy with or without fusion may be utilized to treat multilevel cervical cord compression. In several studies, the clinical outcomes documented in the immediate postoperative period are similar for laminectomy alone versus laminectomy with fusion. The key question is when to perform the fusion [Table 4].

Factors Affecting the Success of Laminectomy

Factors affecting the success of cervical laminectomy alone were based upon evaluation of several critical preoperative and intraoperative parameters. Where preoperative radiographs documented 10° of cervical lordosis, without instability on flexion/extension views, laminectomy alone sufficed [Figures 1 and 2]. Alternatively, if the patient's preoperative studies demonstrated a loss of the cervical lordotic curvature, the risk of postlaminectomy kyphosis was doubled.^[17]

Extent of Facet Resection Avoids Iatrogenic Instability

When performing cervical laminectomies, close attention to the extent of facetectomy performed over single or multiple levels helps to determine the development of instability. If it is necessary to perform multiple foraminotomies, or resect greater than 30–50% of the facet joint, we recommend the addition of a posterior cervical fusion to avoid iatrogenic instability.^[34]

Posterior Fusion Avoids Postlaminectomy Kyphosis

Cervical laminectomy alone results in a 6–47% incidence

Table 3: Complications associated with lateral mass fusion

Author	# Patients	# Screws	Follow-up duration average range	Complication as % patients	Complications as % screws
Heller <i>et al.</i> ^[15]	78	659	2 years 10–47 months	2.6% Cord, 2.6% foraminal stenosis, 1.3% broken plate, 2.6% lost reduction, 3.8% adjacent degeneration, 1.3% infection, 1.4% pseudoarthrosis	Overall 9%: 0.6% roots, 0.2% facets, 0.3% broken screw, 0.2% screw avulsion, 1.1% screw loosening
Graham <i>et al.</i> ^[13]	21	164	X-rays 6 weeks 3, 6, 12 months	14.2% Root	6.1% Malpositioned 1.8% Root
Wellman <i>et al.</i> ^[29]	43	281	25 months 1–63 months	4.6% Infection 2.3% Hematoma	None
Fehlings <i>et al.</i> ^[10]	44	210	46 months 2–6 years	6.8% Reoperation 4.5% Infection 4.5% Screw pull out	1.0% Screw pull out 3.8% Screw loose

Table 4: Key points

Factors influencing laminectomy success	Cervical lordosis of 10°. No cervical instability. Avoid iatrogenic instability. Remove <50% of facet during laminectomy
Outcome of laminectomy improvement 44–92%	Comparable to other surgery in early postoperative period
Postlaminectomy kyphosis 6–47%	2× increase with straight cervical spine. Definitive clinical significance undetermined
Late deterioration following laminectomy 10–39%	Higher late deterioration vs. anterior surgery vs. laminectomy with posterior fusion
Outcome of laminectomy and fusion	Comparable outcomes with: vs. laminectomy vs. laminoplasty vs. anterior fusion. Laminectomy/fusion avoids progressive deformity, late progression
Complication of laminectomy and fusion	Low complication rates (9%) with lateral mass fixation. High fusion rates upward of 95%

Table 5: Recommendations for cervical laminectomy vs. laminectomy/fusion

Variables	Recommendations for cervical laminectomy alone	Recommendations for cervical laminectomy and fusion
Cervical lordosis	10° of cervical lordosis	<10° of cervical lordosis or straight spine
Instability	None	Yes
Axial neck pain	None	Yes
Age	Elderly (>70)	Younger (<70)
Comorbidities	Cardiac disease, diabetes, coagulopathy, chronic obstructive pulmonary disease	Absence of comorbidities
Postoperative radiation	No	Yes

of postlaminectomy kyphosis that contributes to varying rates of late neurological deterioration (10–39%).^[4,8,18,28,32,33] Such delayed neurological worsening is not observed, however, following laminectomy with fusion.^[4,8,18,28,32,33]

Posterior Cervical Fusion Rates and its Complications

In general, the authors advocate performing cervical laminectomy with fusion, as laminectomy alone can result in postoperative kyphosis and late deterioration [Figures 3 and 4]. Cervical fusions are associated with relatively low complication rates [Table 3]. Posterior cervical fusion rates (with instrumentation) approach 95%.^[24] The morbidity of lateral mass screw/plate fixation is low.^[15]

Indications for Cervical Laminectomy Alone: Geriatric Patients

Those who are considered candidates for a cervical laminectomy alone are typically elderly patients with multiple comorbidities, who demonstrate adequate preservation of the cervical lordotic curvature (10° lordosis), without demonstrable instability.

Indications for Cervical Laminectomy with Posterior Fusion

Posterior cervical fusion is usually appropriate if the patient demonstrates the following factors: significant axial neck pain, minimal lordosis or straightening of the cervical spine, younger age, postoperative radiation, or the

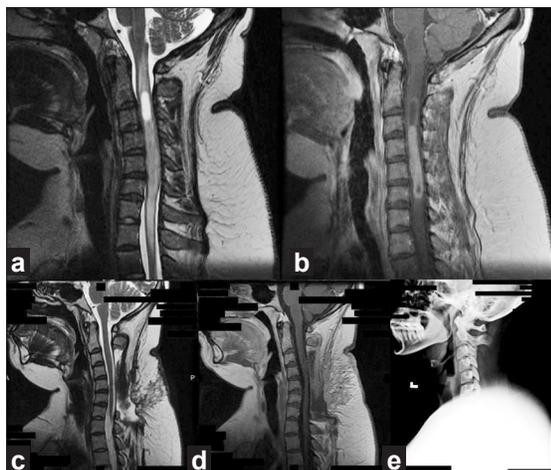


Figure 1: One example of the dilemma on whether to perform a fusion in addition to a cervical laminectomy. A 27-year-old female presented with a several month history of gait imbalance and sensory disturbance attributed to an intradural-intramedullary ependymoma. Despite the patient's young age (27 years old) and loss of lordosis, the patient was very concerned about the ability to monitor for recurrent tumor utilizing MR Scans (with/without Gadolinium-DTPA). After being informed about the risks of postlaminectomy kyphosis and instability, the patient chose a cervical laminectomy alone to resect the tumor. Currently, patient has had improvement in balance and gait with no change in preoperative sensory exam. One year follow up radiographs and MR show no recurrence of tumor or progression of kyphosis. (a) Preoperative T2 Sagittal, (b) preoperative T1 contrast sagittal, (c) postoperative T2 sagittal, (d) postoperative T1 contrast sagittal, (e) postoperative sagittal cervical X-ray, see text recommendations



Figure 3: A 64 year-old male presented with progressive cervical myelopathy characterized by gait imbalance, loss of fine motor skills, and numbness in the fingertips. The patient had previously undergone an anterior cervical discectomy and fusion from C4 to C7 ten years ago. The prior anterior surgery had included discectomy/autograft/plating. New radiographs indicated spinal instability above (C3/4) and below (C7/T1) the previous fusion mass (C4-C7). Concerns for the added complications associated with repeated anterior surgery (esophageal injury, recurrent laryngeal nerve injury, access to T1) and creating further instability, led to a posterior cervical decompression/instrumentation/fusion from C3 to T1 being performed. (a) Sagittal T2 MRI, (b) cervical AP X-ray, (c) cervical lateral X-ray, (d) cervical swimmer's view X-ray

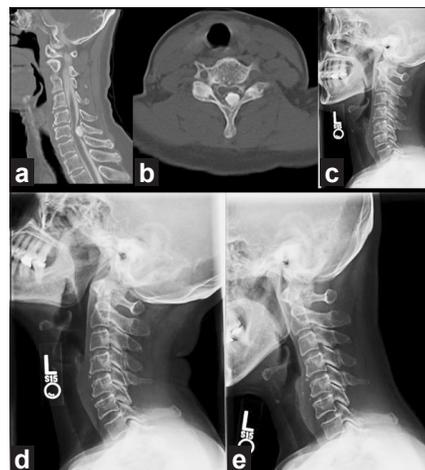


Figure 2: A 67-year-old female presented with myeloradiculopathy from a single level (C6) posterior element mass compressing the spinal cord (a, b). The patient had no evidence of cervical instability on preoperative flexion/extension views, and exhibited normal lordosis. A cervical laminectomy of C6 allowed for direct decompression of the spinal cord and did not lead to instability as it involved minimal resection of the posterior elements (Figure 2c-e). The lesion was found to be calcium pyrophosphate deposition in the yellow ligament at C6. (a) Sagittal CT myelogram, (b) axial CT myelogram, (c) cervical lateral neutral X-ray, (d) cervical lateral extension X-ray, (e) cervical lateral flexion X-ray

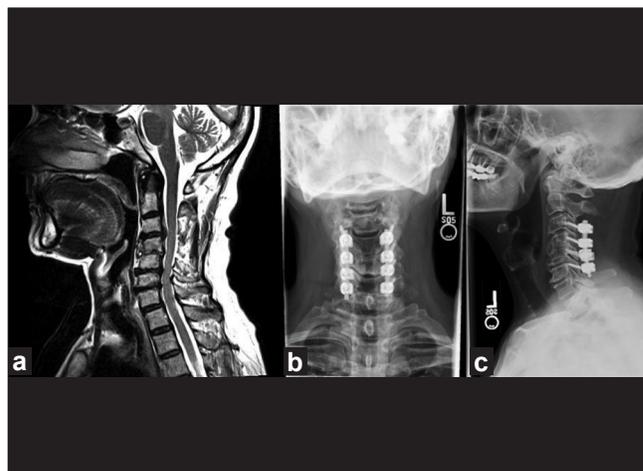


Figure 4: A 64-year-old female presented with symptoms of increased cervical spondylotic myelopathy, accompanied by loss of fine motor skills and gait imbalance, over one year duration. This patient had lost normal cervical lordosis, therefore a posterior C3 to C6 laminectomy and fusion with instrumentation was performed. (a) Sagittal T2 MRI, (b) cervical AP X-ray, (c) cervical lateral X-ray

presence of instability [Table 5]. Ultimately, the decision to perform cervical laminectomy or laminectomy/fusion should be made on an individualized basis with the patient understanding the risks and clinical benefits of each.

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