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Cervical laminectomy for the treatment of cervical degenerative myelopathy

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Object. The objective of this systematic review was to use evidence-based medicine to examine the efficacy of cervical laminectomy for the treatment of cervical spondylotic myelopathy (CSM).

Methods. The National Library of Medicine and Cochrane Database were queried using MeSH headings and keywords relevant to cervical laminectomy and CSM. Abstracts were reviewed after which studies meeting inclusion criteria were selected. The guidelines group assembled an evidentiary table summarizing the quality of evidence (Classes I–III). Disagreements regarding the level of evidence were resolved through an expert consensus conference. The group formulated recommendations that contained the degree of strength based on the Scottish Intercollegiate Guidelines network. Validation was done through peer review by the Joint Guidelines Committee of the American Association of Neurological Surgeons/Congress of Neurological Surgeons.

Results. Laminectomy has improved functional outcome for symptomatic cervical myelopathy (Class III). The limitations of the technique are an increased risk of postoperative kyphosis compared to anterior techniques or laminoplasty or laminectomy with fusion (Class III). However, the development of kyphosis may not necessarily to diminish the clinical outcome (Class III).

Conclusions. Laminectomy is an acceptable therapy for near-term functional improvement of CSM (Class III). It is associated with development of kyphosis, however. *(DOI: 10.3171/2009.1.SPINE08725)*

Key Words • **cervical spine** • **cervical spondylosis** • **laminectomy** • **myelopathy** • **practice guidelines** • **treatment outcome**

Recommendations

Indications. Laminectomy is recommended as a surgical treatment option for symptomatic CSM in selected patients in whom the risk of postoperative kyphosis is felt to be minimal (quality of evidence, Class III; strength of recommendation, D).

Technique. Laminectomy is recommended as a surgical treatment option for symptomatic cervical myelopathy. The limitations of the technique are an increased risk of postoperative kyphosis compared to anterior techniques, laminoplasty, or laminectomy with fusion. However, the development of kyphosis does not appear to diminish clinical outcome (quality of evidence, Class III; strength of recommendation, D).

Timing. There is insufficient evidence to make a recommendation regarding timing.

Rationale. The purpose of this evidence-based review is to specifically examine the data on the use of laminectomy in the treatment of CSM and the information available on the development of postlaminectomy spinal instability. Cervical spondylotic myelopathy is an often progressive condition affecting the adult popula-

Abbreviations used in this paper: ACD = anterior cervical discectomy; CSM = cervical spondylotic myelopathy; ROM = range of motion.

tion. Moderate and severe cases are frequently considered for operative intervention. Both anterior and posterior approaches have been developed in an attempt to halt or reverse the symptoms. Posterior approaches have traditionally been considered less complicated; laminectomy in particular has been commonly undertaken with this concept in mind. The theoretical effects of the decompression are to permit dorsal migration of the spinal cord away from anterior compressive osteophytes, to decrease compression of the spinal cord itself, and to improve vascular perfusion. Potentially significant complications of multilevel laminectomy performed for CSM are the development of postoperative spinal instability, kyphosis, and/or spondylolisthesis.

Search Criteria

Our search of the National Library of Medicine and the Cochrane Database for the period from 1966 through 2007 using the MeSH subject headings of "cervical" and "surgery" and limited to humans generated a broad base of studies (9589 references). We reviewed the titles and abstracts with attention to those titles addressing clinical management. We followed the initial search with a secondary search crossing "myelopathy" with "surgery" and "cervical" and" myelopathy," and then reviewed the bibliographies of selected papers for additional relevant references.

We selected articles if they addressed issues related to surgical management of cervical myelopathy. We included articles with data on anterior approaches if they contained comparative data for posterior surgical approaches; articles were excluded if they addressed anterior approaches only because this topic is addressed in a separate section of these Guidelines. Finally, we also excluded articles that did not contain clinical information relevant to laminectomy outcomes. Only papers providing data in a minimum of 15 patients undergoing cervical laminectomy for CSM with a minimum of 1-year follow-up data were included in the evidentiary table (Table 1).

Scientific Foundation

The review process identified no papers providing Class I or II data specifically addressing decompressive laminectomy for CSM. Twenty-four articles provided Class III information.

Historical Review

A number of large series have been reported that did not meet our inclusion criteria based on lack of full follow-up information or for methodological concerns. Nurick's classic report[26] in 1972 compared 36 conservatively treated patients with 43 patients who underwent surgical treatment, with the majority undergoing laminectomy. The author found basically no difference between the 2 groups, but the follow-up period was not described and the reason for assignment to either group was not clear. This clearly illustrated the need for higher quality studies to address the issue.

Gonzalez-Feria and Peraita-Peraita[12] described a large cooperative multicenter survey of 521 patients with cervical myelopathy, 242 of whom underwent laminectomy. They reported a mean improvement for this group as 0.92 on the Nurick scale. Little additional data specific to the laminectomy group were available; in particular, the authors did not report the follow-up period and there was no indication of the selection criteria. Gorter[13] reviewed data in 567 patients who underwent laminectomy, and 164 patients who received conservative treatment (adding 75 new patients). This author did not report any statistics nor did they give any indication of the method of patient selection or assignment. The study did not use any validated outcomes measures. The report included a historical summary of 22 studies in patients with CSM who underwent laminectomy, resulting in an overall reported cure in 10%, improvement in 47%, and symptom arrest in an additional 23%. Conservative measures described in a summary of 5 studies resulted in a reported cure rate of 0%, improvement in 50%, and an arrest of symptoms in 36%.

Guidetti and Fortuna's retrospective report[15] in 105 patients who underwent laminectomy or anterior decompression demonstrated rather modest improvements (reported as percentage of "very good"), with posterior decompression ranging from 16 to 43% very good compared to 51% for the anterior procedures. The lack of valid outcome measures, selection criteria, adequate follow-up, and statistical analysis limit the applicability of this and other similar contemporary studies. Jeffreys[19] reported a prospective single-surgeon experience in 137 patients who underwent either cervical laminectomy (in 29 patients) or anterior decompression (in 108) according to predefined criteria. He used a nonvalidated functional outcome scale, and the follow-up period was short (6–9 months). The results were not reported according to treatment group, which complicated data interpretation.

The results of these studies suggest that the expectation of success in treating CSM with decompressive laminectomies ranges from approximately 15 to 60%. These studies all were generally lacking in follow-up, but most were published in the 1970s and were representative of the publication style at that time.

Class III Studies: Retrospective Single-Arm Studies of Laminectomy for CSM

The studies detailed in this section comprised retrospectively reviewed experiences with laminectomy for CSM. Most of these studies were published in the 1970s but formed the basis for subsequent comparative studies. They described success rates ranging from 42 to 92%. A brief summary of the relevant studies follows.

Adams and Logue[1] reported on a series of 24 patients who underwent laminectomy for CSM. They focused on a comparison of 2 groups: a good outcome and a poor outcome group. These authors were looking for indicators of improved outcome and found that both a decreased ROM postoperatively and a lesser degree of change of the spinal curvature were significantly correlated with the good outcome group. Bishara[6] reported long-term results in 59 patients who underwent laminectomy, reporting a 56% improvement rate at 5 years, and 51% improvement at the

10-year follow-up with no reported instability in any of the patients.

Casotto and Buoncristiani[8] described 46% good or excellent results in 44 patients who underwent laminectomy for myelopathy. They evaluated risk factors for a poor outcome and found a significant relationship with preoperative duration of symptoms and severity of the preoperative motor deficit. Epstein et al.[10] found a 92% good or excellent rate of improvement in 24 patients who underwent laminectomy. The outcome measures used were not validated, and no statistics were provided; however, the authors felt strongly that the procedure beneficial in these patients. Fager's report[11] summarized 35 patients who underwent laminectomy with 1–7 years of follow-up. In this series 68% of patients improved, and an additional 26% had an arrest of symptom progression.

Although the majority of their report was a review of previously published cases, Gorter and associates[13] did include data and follow-up in 75 new patients who underwent laminectomy. In the new patient groups (standard laminectomy versus wide laminectomy), the authors reported 60 to 68% as cured or improved with mean follow-up of 5.9 and 2.5 years, respectively. Kato et al.[22] described the outcome in 44 patients who underwent laminectomy with a 44.2% 1-year recovery rate that decreased slightly to 43 and 33% at 5 and 10 years, respectively. These authors found a 23% incidence of late deterioration (mean 9.5 years), and a 47% rate of postoperative kyphosis. The development of kyphosis did not appear to correlate with neurological deterioration. Miyazaki and Kirita[25] reported an 82% overall improvement rate in a study of 155 patients who underwent multilevel laminectomies; 11% of patients worsened, however. Follow-up was relatively short at only 1 year.

Postoperative Kyphosis and Effect on Clinical Outcome

Although excluded from grading because of methodological concerns, Batzdorf and Batzdorff[4] presented a series of 28 patients who underwent decompressive laminectomies with a rather in-depth and complex system of postoperative radiographic analysis. Despite the absence of validated outcome measures and the lack of reported statistics, the authors raised the issue of evaluation of pre- and postoperative spinal alignment, and suggested that changes in alignment could account for some of the variability in both short- and long-term outcomes seen after decompressive laminectomy. Their historical report highlighted the concern about destabilizing the cervical spine with laminectomy alone. As a result, we reviewed a number of studies which provided information regarding the development of postoperative kyphosis and instability. These studies suggested that the incidence of postlaminectomy kyphosis ranged from 14 to 47%. However, none of these studies could correlate outcome in any fashion with the development of radiographic postoperative kyphosis. Not surprisingly, when compared to laminoplasty, the rate of kyphosis appeared significantly higher (34 vs 7%).[18,23]

Guigui et al.[16] described 58 patients who underwent multilevel laminectomy. They reported the development of postoperative kyphosis in 31% with 15 patients (25%) believed to be unstable, and 3 (5%) requiring surgical stabilization. The authors proposed the careful study of preoperative dynamic radiographs in assisting with selection of patients at risk for postlaminectomy kyphosis and instability. Ishida et al.[18] compared 55 patients undergoing laminectomy with 55 patients undergoing laminoplasty. Although the 2 groups were comparable demographically, assignment to treatment groups was not randomized, and the criteria used was not clear from the methods described. In the laminectomy group, a kyphotic deformity developed in 13 patients (24%) with a 71% overall recovery rate, compared to the laminoplasty group with 3 patients (5%) with kyphotic deformities and an 80% overall recovery rate. The extent of decompression was assessed, and those judged to have had full decompression had an approximately 90% recovery rate in both groups. The ROM was decreased from 30 to 21° after laminectomy, and 31 to 17° in the laminoplasty group. Statistical analysis did not indicate significant differences in overall recovery or ROM between the 2 groups.

Kaptain et al.[21] reported on 46 patients undergoing laminectomy who underwent pre- and postoperative radiography. The development of a postoperative deformity (kyphosis) was more than twice as likely in patients with a "straight" preoperative spine (loss of lordosis) than in those with a normal preoperative lordosis. However, the preoperative spinal alignment was not shown to be predictive of outcome. Kato et al.[22] described the outcome in 44 patients undergoing laminectomy with a 44.2% 1-year recovery rate that decreased slightly to 43 and 33% at 5 and 10 years, respectively. These authors found an incidence of 23% late deterioration (mean 9.5 years) and a 47% rate of postoperative kyphosis. The development of kyphosis did not appear to correlate with neurological deterioration.

Matsunaga and colleagues[23] compared postoperative kyphosis rates in 37 patients who underwent laminectomy to those in 64 patients who underwent laminoplasty with mean follow-up periods of 79 and 66 months, respectively. Postoperative kyphosis was noted in 11 patients (34%) in the laminectomy group and 4 patients (7%) in the laminoplasty group. This report did not address functional outcome. Mikawa et al.[24] described 64 patients undergoing laminectomy and found that 36% had a change in postoperative alignment, and kyphosis developed in 14% with no effect noted on outcome.

Comparison Studies

Many authors have attempted to compare various procedures for the surgical management of cervical myelopathy. The studies identified that specifically include data regarding laminectomy are included. The comparative studies summarized below are all Class III studies and are subject to bias. Overall it appears that laminectomy in selected patients compares favorably to alternative strategies. Arnasson et al.[2] described 29 patients undergoing laminectomy for myelopathy with a 69% overall rate of improvement, compared to only 20% improvement with ACD and fusion, or 0% with conservative measures only. Age or preoperative duration of symptoms did not appear to impact results.

TABLE 1: Evidentiary summary of posterior laminectomy for cervical degenerative disease*

Authors & Year	Study Description	Data Class	Conclusions
Adams & Logue, 1971	24 patients treated w/ laminectomy reviewed retrospectively. Focus on comparison of good outcome group (n = 7, FU 45 mos) & poor outcome group (n = 7, FU 28 mos). No validated outcome measures.	III	Postop ROM was 28° in the good outcome group compared to 43° in the poor outcome group. Significant difference between the 2 groups comparing both the range of motion & the contour of the postop spine ($p < 0.001$). Limited detail of the analysis provided.
Arnasson et al., 1987	39 patients w/ myelopathy (laminectomy 29, ACDF 5, conservative 5). Assignment to Tx group not randomized. FU 2–14 yrs w/ nonvalidated outcome measure. Results expressed as improved, unchanged or worse.	III	Improvement in patients w/ myelopathy: laminectomy 20/29 (69%), ACDF 1/5 (20%), conservative 0/4 (0%). Results were not influenced by age or the duration of symptoms.
Arnold et al., 1993	70 patients w/ myelopathy (laminectomy [44] anterior fusion [19] laminectomy & fusion [7]). Assignment to Tx group not randomized. Mean FU 8 yrs; nonvalidated outcome measure. Results expressed as improved, unchanged, or worsened.	III	Early improvement (0–6 mos): laminectomy 34/44 (77%), ventral fusion 17/19 (90%), laminectomy & fusion 5/7 (72%). Late improvement (mean 8 yrs): laminectomy 17/33 (52%), ventral fusion 14/19 (74%), laminectomy & fusion 5/6 (83%). Most cases of later deterioration were in the laminectomy group.
Benzel et al., 1991	75 patients w/ myelopathy: laminectomy (18), laminectomy w/ DLS (40), anterior fusion (17). Assignment to Tx group not randomized. FU reported as 1–2 mos w/ mJOA.	III	Functional improvement (mean): laminectomy 3.1 ± 1.5, laminectomy plus dentate ligament section 2.7 ± 2.0, anterior fusion 3.0 ± 2.0. All of the patients who improved substantially (≥6 points) in the laminectomy groups had normal cervical spine contours (lordosis). No instability occurred in either the laminectomy or the laminectomy plus DLS group. No benefit from dentate ligament sectioning was demonstrated.
Bishara, 1971	Laminectomy only: 59 patients w/ myelopathy; mean FU 10 yrs. Outcome nonvalidated (reported as improved or unimproved).	III	5-yr FU: 33 of 59 (56%) improved. 10 yr FU: 30 of 59 (51%) improved. No instability developed.
Carol & Ducker, 1988	206 patients w/ myelopathy: laminectomy (125), ACDF (81), & both (10). FU 10 yrs. Assignment to Tx group not randomized. Outcome nonvalidated (reported as percentage improved).	III	Improvement: posterior 68%, anterior 73%. Combined approach not reported. No statistics presented.
Casotto & Buoncristiani, 1981	Retrospective, laminectomy w/ or w/o foraminotomy. 44 patients w/ myelopathy (7% described w/ a radicular component). FU 6 mos to 8 yrs.	III	Results: excellent or good 46%, fair in 34%, unchanged 9%, worse 11%. Statistically significant relationship of poor outcome w/ increased preop duration of symptoms & w/ severity of preop motor deficit.
Ebersold et al., 1995	Long-term FU in 84 of 100 patients w/ myelopathy (33 ACDF, 51 laminectomy). Mean FU 7.35 yrs (range 3–9.5 yrs). Nurick Scale used; anterior approach used for kyphosis & 1–3 levels.	III	Immediate outcomes: laminectomy: 35/51 (69%) improved; 11/51 (22%) unchanged; 5/51 (9%) worse. ACDF: 24/33 (73%) improved; 9/33 (27%) unchanged. Long-term outcomes: laminectomy 19/51 (37%) improved; 13/51 (26%) unchanged; 19/51 (37%) worse. ACDF: 18/33 (55%) improved; 9/33 (27%) unchanged; 6/33 (18%) worse. Duration of symptoms preoperatively related to potential deterioration. Age, severity of disease, no. of levels operated, & preop grade were not predictive of outcome.
Epstein et al., 1982	24 patients w/ myelopathy treated w/ laminectomy. No validated outcome measure (reported as excellent, good, same, poor). FU min of 1 yr (1–7 yrs).	III	Results: excellent 6/24 (25%); good 16/24 (67%); same 0/24 (0%); poor 2/24 (8%).
Fager, 1973	35 patients w/ myelopathy treated w/ laminectomy; FU 1–7 yrs. No validated outcome measure (reported as improved, arrested, worse).	III	Results: improved 24/35 (68%), arrested 9/35 (26%), worse 2/35 (6%).

(continued)

TABLE 1: Evidentiary summary of posterior laminectomy for cervical degenerative disease* *(continued)*

Authors & Year	Study Description	Data Class	Conclusions
Gorter, 1976	Review article adding 75 new cases. Table that summarized data for laminectomy (567 patients) & conservative management (164 patients). No statistics & no validated outcome measures.	III	New patients: Group A: limited laminectomy group (n = 20, mean FU 5.9 yrs), 60% cured or improved. Group B: wide laminectomy group (n = 35, mean FU 2.4 yrs), 67.7% cured or improved. Historical review laminectomy in 22 studies: cured 10.4%, improved 47.4%, unchanged 22.7%, worse 14.8%, & died 4.7%. Conservative (5 studies): cured 0%, improved 49.3%, unchanged 35.9%, worse 14.8%, & died 0%.
Gregorius et al., 1976	Retrospective analysis of 55 patients w/ cervical myelopathy: laminectomy (29), ACDF (26). Mean FU 85 mos. Nonvalidated outcome measure (used a 5-step disability scale). Tx choice not randomized.	III	Results not reported specifically for laminectomy patients. Statistical analysis compared those patients changing in disability score by ≥1 grade based on surgical approach. There was a significant deterioration in patients treated w/ laminectomy alone vs anterior procedure ($p = 0.035$). The described trend of long-term deterioration in patients treated w/ laminectomy alone was concerning.
Guigui et al., 1998	Retrospective study in 58 patients w/ multilevel laminectomy. Mean FU 3.6 yrs. JOA scale used. Postop radiographic evaluation.	III	Postop kyphosis in 18 patients (31%). Postop instability in 15 patients (25%) w/ reop in 3. Neither associated w/ worsened outcome. Destabilization required reop in 3 patients. All the levels appearing to be destabilized on the postop films were hypermobile on the preop dynamic radiographs.
Hamanishi & Tanaka, 1996	69 patients, 34 judged unstable combined w/ fusion. JOA scale used, mean FU 3.5 yrs.	III	Results: No fusion: 50.8% improvement. Fusion: 51.2% improvement (p = NS). Authors concluded that wide laminectomy w/ or w/o posterolateral fusion is a simple operation that can be recommended.
Ishida et al., 1989	Retrospective comparison: laminectomy (55); laminoplasty (55). Evaluation of postop radiographs JOA assessment. Mean FU 61 mos.	III	Laminectomy: 13 of 55 (24%) developed kyphotic deformity. Overall JOA improvement 71% recovery rate (preop 7.1 to postop 13.6); w/ full decompression 90% recovery rate (preop 9.2 to postop 16.2). Preop ROM 30°; postop ROM 21°.
Kaminsky et al., 2004	Laminectomy in 22 patients & laminoplasty in 20 patients. Mean FU 5 yrs. Nurick classification used. Matched on age, sex, operative levels, length of FU.	III	Myelopathy (Nurick score) improved in both groups: Laminectomy preop 3.09 to postop 2.50; pain improved 8%. Laminoplasty preop 2.44 to postop 1.48; pain improved 57%. The only variable that predicted the postop degree of myelopathy in either group was the preop degree of myelopathy. In the laminectomy group better outcomes associated w/ a lesser degree of preop myelopathy ($r = 0.84$, $p < 0.0001$).
Kaptain et al., 2000	46 patients undergoing laminectomy. Assessment of postlaminectomy kyphosis. Comparison of preop and postop dynamic radiographs w/ outcome. Nurick scale; outcome assessments not blinded. Mean FU 4 yrs.	III	Preop: kyphotic in 4 (9%) of 46, straight in 20 (43%) of 46, lordotic in 22 (48%) of 46. Postop kyphosis: 9 (21%) of 42 patients w/ either straight or lordotic alignment; 6 (30%) of 20 patients w/ straight alignment; 3 (14%) of 22 patients w/ lordotic. Progression of deformity was more than twice as likely if preop radiological studies demonstrated a straight spine. Outcome: 13 (29%) of 45 patients improved. 19 (42%) of 45 remained unchanged. Preop spinal alignment was not predictive of outcome. Cervical mobility correlated w/ improved functional performance ($p = 0.005$).

(continued)

TABLE 1: Evidentiary summary of posterior laminectomy for cervical degenerative disease* *(continued)*

Authors & Year	Study Description	Data Class	Conclusions
Kato et al., 1998	44 of 52 patients underwent laminectomy for OPLL. Follow-up over 10 yrs. JOA outcome scale used.	III	Laminectomy recovery rate: 44.2% after 1 yr, 42.9% after 5 yrs, 32.8% after 10 yrs. Multivariate stepwise analysis: age, severity, history of trauma. Late neurological deterioration was observed in 10 (23%) of 44 patients (mean 9.5 yrs, range 1–17 yrs). Postop kyphosis: 47% of patients (but not associated w/ neurological deterioration).
Matsunaga et al., 1999	Laminoplasty (64), laminectomy (37). Plain radiographs evaluated; mean FU: 79 mos (laminectomy), 66 mos (laminoplasty).	III	Overall postop kyphosis ("buckling-type" alignment): 34% after laminectomy, 7% after laminoplasty. Chi-square calculation for laminectomy vs laminoplasty is 43.2 ($p < 0.01$), indicating a significantly higher rate of postop kyphosis in the laminectomy group.
Mikawa et al., 1987	Postop radiographic evaluation of 64 patients undergoing laminectomy; mean FU 2 yrs.	III	23 of 64 (36%) postop change in alignment. 9 of 64 (14%) developed postop kyphosis. None were related to a worse outcome or neurological deficit.
Miyazaki & Kirita, 1986	Retrospective study of 155 patients w/ cervical myelopathy treated w/ multilevel laminectomy. Mean FU 1 yr, JOA score for outcome.	III	Overall 82% improvement, 7% unchanged, & 11% worse.
Perez-Lopez et al., 2001	Retrospective study: laminectomy (19), laminectomy & fusion (17). Nurick scale used. Mean FU 40 mos.	III	Laminectomy: 0.84 Nurick score improvement, 24% postop kyphosis. Laminectomy & fusion: 1.24 Nurick score improvement, 7% postop kyphosis. The observed improvement in myelopathy scores following laminectomy w/ or w/o fusion was similar. Postop kyphosis more common w/ laminectomy alone.
Phillips, 1973	102 patients: cervical immobilization (24), laminectomy (24), ACDF (65). FU 2–10 yrs. No validated outcome measure.	III	Improved: cervical immobilization (37%), laminectomy (50%), ACDF (74%). Better results if symptoms < 1 yr in all groups.
Yonenobu et al., 1985	95 patients: laminectomy (24), ACDF (50), corpectomy & fusion (21). FU 12–157 mos, JOA outcome.	III	Laminectomy 3.3, ACDF 3.3, corpectomy 6.0. Laminectomy resulted in late deterioration (>30 mos) in 29%. Corpectomy for 3 levels or less had best results ($p < 0.01$). The authors recommended laminectomy for 4 or more levels.

* The criteria for scoring each manuscript into a class were described in the *Methodology* chapter. Abbreviations: ACDF = anterior cervical discectomy w/ fusion; DLS = dentate ligament section; FU = follow-up; JOA = Japanese Orthopaedic Association; OPLL = ossification of the posterior longitudinal ligament.

Arnold et al.[3] reported on 44 patients who underwent laminectomy in a nonrandomized series of 70 patients treated for CSM. They observed early improvement (within 6 months) in 77% of patients who underwent laminectomy, and this improvement was maintained at late follow-up (mean 8 years) in 52%. This rate of improvement was slightly less than that reported in patients who underwent anterior decompression, the majority of which were done using ACD (90% with early improvement, and 74% with late improvement). Most cases of late deterioration were in the laminectomy group. The authors hypothesized that late deterioration was related to postoperative instability.

Benzel and associates[5] reported on 18 patients who underwent laminectomy, 40 patients who underwent laminectomy and dentate ligament section, and 17 who had anterior fusion. In this nonrandomized study there was no difference between any of the groups, with modified Japanese Orthopaedic Association score improvements of 3.1, 2.7, and 3.0, respectively. There was no impact of dentate ligament sectioning and no increase in instability noted with posterior decompression. All patients who underwent laminectomy and had substantial improvement (≥ 6 points) had normal radiographic alignment preoperatively.

Carol and Ducker[7] reported on a total of 206 patients with CSM including 125 treated with laminectomy, 81 with anterior decompression and fusion, and 10 with a combination. The authors reported long-term follow-up (mean of 10 years) in the nonrandomized groups. The study did not use standard outcome measures and did not provide any statistical analysis. The improvement rate of 68% for the laminectomy group was comparable with the 73% improvement rate in the anterior surgical group.

Ebersold et al.[9] reported outcomes in 84 patients who underwent surgical treatment for myelopathy, 51 with laminectomy and 33 with anterior decompression and fusion. Six-month outcomes showed improvements of 69 and 73% in these groups, with long-term improvements of 37 and 55%, respectively. Despite the trend toward later deterioration in the laminectomy group, this outcome was noted in both groups, and the authors provided no statistical comparison. Only the preoperative duration of symptoms was shown to be associated with a worsened outcome. Age, severity of disease, extent of decompression, and preoperative grade were all not predictive in this study.

Gorter[13] published a review of the literature with a detailed report of 55 new cases comparing limited laminectomy with wide laminectomy. The results between the 2 groups were comparable. In patients who underwent limited laminectomy, 60% were cured or improved versus wide laminectomy in whom 67% were cured or improved (follow-up periods of 5.9 and 2.4 years, respectively). Gorter did not use validated outcome measures. Gregorius et al.[14] retrospectively reviewed 55 patients with cervical myelopathy including 29 who underwent laminectomy, and 26 who underwent ACD and fusion. The study did not use a validated outcome measure and treatment assignments were not randomized. There was a concerning trend of long-term late deterioration in the laminectomy alone group.

Hamanishi and Tanaka[17] reported on their experience with 69 patients with CSM. Thirty-four were judged as "unstable" on preoperative radiographs and underwent laminectomy and fusion. The authors compared this group to the remaining 35 patients who underwent laminectomy alone. The authors did not observe any significant differences between them, noting 51% improvement in both groups (51.2 vs 50.8%) after a mean follow-up period of 3.35 years. Ishida et al.[18] compared 55 patients undergoing laminectomy with 55 patients undergoing laminoplasty. This study was analyzed above in the kyphosis subsection. The authors assessed the extent of decompression. Those judged with "full" decompression had approximately a 90% recovery rate in both groups.

The report by Kaminsky et al.[20] had a case-control study design, and could possibly have qualified as Class II data. However, the authors did not perform their analysis in this fashion, and the study group was relatively small; some interesting data were provided, however. The design matched 22 laminectomy patients with 20 laminoplasty patients. Both groups showed improvement in their myelopathy scores (Nurick scale), and an increase in motor recovery was demonstrated in the laminoplasty group. In the laminectomy group, a better outcome was associated with a smaller degree of preoperative deficit ($r = 0.84$; $p < 0.0001$). This result was consistent with the observations of Nurick in the historic 1972 paper mentioned previously.

Matsunaga et al.[23] compared postoperative kyphosis rates in 37 patients who underwent laminectomy with 64 patients who underwent laminoplasty with mean follow-up periods of 79 and 66 months, respectively. The authors reported postoperative kyphosis in 11 (34%) of 37 patients in the laminectomy group compared to 4 (7%) of 64 in the laminoplasty group; functional outcome was not addressed. Perez-Lopez et al.[27] compared a cohort of 19 patients with laminectomies to 17 patients who underwent laminectomy and fusion. They found a similar improvement in Nurick score (0.84 vs 1.24) and an increase in postoperative kyphosis with laminectomy alone (7 vs 24%). Phillips[28] reported a study of 102 patients among whom 24 were treated with a cervical collar, 24 with laminectomy, and 65 with anterior decompression; overall improvement rates were 37, 50, and 74%, respectively. In all groups, better results were seen in patients who had experienced preoperative symptoms for less than a year.

Yonenobu et al.[29] reported the outcomes of 3 treatment groups: laminectomy in 24 patients, anterior segmental discectomy in 50, and anterior corpectomy in 21. The laminectomy group had a similar overall improvement to the anterior segmental decompression (both 3.3 points improvement on the Japanese Orthopaedic Association scale). The best results were observed when 3 segments were treated with corpectomy. The authors recommended laminectomies for 4-segment disease or more. Patients who underwent laminectomy had a 29% rate of late deterioration.

Summary

Historically, cervical laminectomies have been a safe and direct method for decompressing cervical spinal cord compression causing myelopathy. Large case series from the 1960s and 1970s and earlier have supported the use of this technique. At present laminectomy remains a viable consideration for the surgical management of cervical myelopathy. Concern has been raised over the development of postlaminectomy spinal instability, which may occur in 14–47% of patients who have had surgery for CSM. Whether this is related to reports of delayed deterioration in selected patients is not clear. Although postlaminectomy kyphosis may be frequently observed radiographically, it is less clear how it relates to the development of clinical symptoms. A straight or kyphotic alignment of the spine may predict a greater chance of late instability and kyphosis. Thus far, however, no study has clearly demonstrated a relationship between postlaminectomy kyphosis and deterioration in the quality of life of the patient.

Key Issues for Future Investigation

Despite many years of experience reported with cervical laminectomies, controversy remains over optimal patient selection. Many authors advocate always using fusion in decompressed individuals, while others do not agree with this strategy, and others have focused on laminoplasty. None of these techniques may be considered the best in all situations. Additional data collection would still be of benefit for this patient population, and randomization appears to be a feasible option.

The development of specific predictors of successful clinical outcome, such as radiographic data, remains promising. Specifically, the study of any early radio-

graphic evaluation that assists in predicting the development of postoperative kyphosis and instability would be beneficial.

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