**J Neurosurg Spine 11:**150–156, 2009

# Laminectomy and fusion for the treatment of cervical degenerative myelopathy

**Paul A. Anderson, M.D.,[1] Paul G. Matz, M.D.,[2] Michael W. Groff, M.D.,[3] Robert F. Heary, M.D.,[4] Langston T. Holly, M.D.,[5] Michael G. Kaiser, M.D.,[6] Praveen V. Mummaneni, M.D.,[7] Timothy C. Ryken, M.D.,[8] Tanvir F. Choudhri, M.D.,[9] Edward J. Vresilovic, M.D., Ph.D.,[10] and Daniel K. Resnick, M.D.[11]**

*Departments of [1]Orthopaedic Surgery and [11]Neurological Surgery, University of Wisconsin, Madison, Wisconsin; [2]Division of Neurological Surgery, University of Alabama, Birmingham, Alabama; [3]Department of Neurosurgery, Harvard Medical School and Beth Israel Deaconess Medical Center, Boston, Massachusetts; [4]Department of Neurosurgery, University of Medicine and Dentistry of New Jersey—New Jersey Medical School, Newark, New Jersey; [5]Division of Neurosurgery, David Geffen School of Medicine, University of California at Los Angeles, California; [6]Department of Neurological Surgery, Neurological Institute, Columbia University, New York, New York; [7]Department of Neurosurgery, University of California at San Francisco, California; [8]Department of Neurosurgery, University of Iowa Hospitals and Clinics, Iowa City, Iowa; [9]Department of Neurosurgery, Mount Sinai School of Medicine, New York, New York; and [10]Department of Orthopaedic Surgery, Milton S. Hershey Medical Center, Pennsylvania State College of Medicine, Hershey, Pennsylvania*

*Object*. The objective of this systematic review was to use evidence-based medicine to examine the efficacy of cervical laminectomy and fusion 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, fusion, and CSM. Abstracts were reviewed, after which studies that met the inclusion criteria were selected. The guidelines group assembled an evidentiary table summarizing the quality of evidence (Class I–III). Disagreements regarding the level of evidence were resolved through an expert consensus conference. The group formulated recommendations which 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*. Cervical laminectomy with fusion (arthrodesis) improves functional outcome in patients with CSM and ossification of the posterior longitudinal ligament (OPLL). Functional improvement is similar to laminectomy or laminoplasty for patients with CSM and OPLL. In contrast to laminectomy, cervical laminectomy with fusion it is not associated with late deformity (Class III).

*Conclusions*. Laminectomy with fusion (arthrodesis) is an effective strategy to improve functional outcome in CSM and OPLL. *(DOI: 10.3171/2009.2.SPINE08727)*

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

## Recommendations

*Indications*. Cervical laminectomy with arthrodesis is recommended in the treatment of patients with CSM and OPLL (quality of evidence, Class III; strength of recommendation, D).

*Technique*. Cervical laminectomy with arthrodesis is recommended as an equivalent strategy to laminectomy or laminoplasty for functional improvement in the treatment of patients with CSM and OPLL. There is conflicting data as to whether fusion improves functional outcome relative to laminectomy with one study showing arthrodesis superior and one showing equivalency (quality of evidence, Class III; strength of recommendation, D).

*Abbreviations used in this paper:* CSM = cervical spondylotic myelopathy; JOA = Japanese Orthopaedic Association; OPLL = ossification of the posterior longitudinal ligament.

*Technique*. Cervical fixation: there is insufficient evidence to indicate whether the addition of cervical fixation improves functional outcome.

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

## Rationale

The purpose of this systematic review was to evaluate laminectomy and posterior fusion for treatment of CSM using an evidence-based approach. The authors of many studies have examined the technique of combining posterior decompression with fusion. In this study, we included both laminectomy and laminoplasty techniques combined with posterior fusion. Laminectomy has been the traditional approach to spinal canal decompression in patients with CSM. Because of concern over deterioration from the long-term effects of resultant segmental instability and/or kyphosis, practitioners have developed alternatives to cervical laminectomy. Laminoplasty preserves the neural arch and skeletal anchors for paraspinal musculature. This modification theoretically decreases the adverse effects of laminectomy while allowing adequate canal expansion. This technique is thought to work best in patients with neutral or lordotic spines and may not fare as well in kyphotic spines. Another alternative is laminectomy and fusion, which allows posterior canal expansion and maintains stability. This modification theoretically avoids problems associated with laminectomy alone. Furthermore, with the use of internal fixation devices, it may allow reduction of kyphosis to lordosis, thereby broadening indications for posterior spine surgery in the treatment of myelopathy.

## Search Criteria

We performed a computerized search of the National Library of Medicine database and the Cochrane database of the literature published from 1966 to 2007 using keywords and MeSH headings. Search terms included "myelopathy, cervical spine, fusion, laminectomy, laminoplasty, cervical spondylotic myelopathy and ossification of posterior longitudinal ligament." A search using the subject heading "laminectomy and cervical and arthrodesis" yielded 345 citations. The following subject headings were combined: "laminectomy and outcome and arthrodesis" (244 citations) and "laminectomy and arthrodesis and myelopathy" (329 citations). We acquired a total of 614 citations after accounting for redundancy. We selected only citations in English and reviewed titles and abstracts of the articles, and culled additional references from the reference lists of the remaining articles.

Among the articles reviewed, we found 11 studies that dealt with cervical laminectomy and arthrodesis and outcome. Eight of these were internal case series examining outcome pre- and postoperatively (Evidentiary Table 1), and 3 studies compared this treatment to other modalities (Evidentiary Table 2). The Cochrane database review on surgery of cervical myelopathy published in 2006 by Fouyas et al.[2] was reviewed.

## Scientific Background

No Class I or II evidence was available to determine the efficacy for laminectomy and fusion in patients with CSM or OPLL. We compiled evidentiary tables for the 8 Class III case series (Table 1) and for the 3 Class III studies (Table 2) comparing laminectomy or laminoplasty to laminectomy and fusion. All of the studies that retrospectively reviewed the results of laminectomy and fusion demonstrated significant improvement of neurological function in the vast majority of patients (> 70%).

### *Class III Investigations*

Gonzalez-Feria[3] reported on 20 patients with CSM who underwent laminectomy with either facet wire fusion or spinous process plating augmented with polymethylmethacrylate. Five patients received Kiel bone (lyophilized bovine bone) with wires. The Kiel bone acted as a strut between anchor points. The remaining 15 patients had fixation done with a "crab plate," a long plate that anchored to the first full spinous process above and below the decompression.[3] The authors assessed follow-up using a modified Nurick scale over a period of 1–7 years. The authors reported neurological improvement in 85%. Four patients improved 1 grade, 5 improved 2 grades, and 8 improved 3 grades. There were 3 hardware failures requiring repeated operation. No critical radiographic analyses were performed. Gonzalez-Feria's paper provided Class III medical evidence. Study limitations included: retrospective small case series, multiple surgical techniques and absence of critical radiographic analysis. Although the neurological results were encouraging, it was unknown whether the fixation was effective in obtaining treatment goals.

Mauer et al.[10] reported on their experience in the treatment of 10 patients with CSM who underwent multilevel laminectomy and posterior lateral fusion using Luque rectangle and facet wires. The study evaluated patients preoperatively and postoperatively using the Harsh scale (a 6-point ordinal scale evaluating gait). The average length of follow-up was only 10.1 months with a range of 6–14 months. Nine of the 10 patients had subjective and objective improvement according to the Harsh scale. There were no neurological complications. However, the authors reported 3 wound seromas and 1 superficial infection. At follow-up, all patients were thought to have bone fusion, although follow-up dynamic radiography was not performed. This paper provided Class III evidence because of its retrospective nature, small sample size, short follow-up period, and lack of objective outcome criteria other than gait evaluation.

Epstein[1] retrospectively reviewed 5 cases of OPLL treated with laminectomy and lateral mass fusion with facet wire fixation. Patients were evaluated with the Nurick scale, over an average follow-up of 13 months (range 6–20 months). Epstein reported improvement in the Nurick scale in all 5 patients. The average Nurick score improved from 4.4 (preoperatively) to 1.4 (at follow-up). Fusion occurred by 3.6 months in all patients. This study was Class III because of the small sample size, relatively short follow-up period, and lack of documented complications.

Kumar et al.[9] retrospectively reviewed their experience in 25 patients with CSM at a mean 48-month follow-up. All patients underwent posterior laminectomy with lateral mass fusion and fixation. To be included, all patients had to have a minimum of 2 years of follow-up. The authors assessed patients preoperatively and postoperatively by the Harsh scale for gait, and postoperatively with a modified Short Form-36. The authors reported improvement on the Harsh scale in 76% of patients. Patients with less severe myelopathy (Grade IIIA or better) were statistically more likely to improve than more severely affected patients. Patients with poor outcomes according to the Harsh scale demonstrated a statistically significant increase in depression but not in social functioning. The authors did not report any change in alignment from the preoperative to postoperative period. Two patients had neurological complications, 1 from an epidural hematoma. This study provided Class III evidence showing the efficacy for laminectomy and fusion. The study was limited by its retrospective nature, the lack of precise inclusion or exclusion criteria that could have produced selection bias in indications for a posterior technique over an anterior technique, and the potentially lost patients who were excluded because they did not have a 2-year follow-up.

Huang and associates[8] retrospectively evaluated their experience in 31 patients with CSM or OPLL at a minimum of 6 months of follow-up (average 15 months). All patients underwent postoperative MR imaging at a mean of 3.8 months to assess adequacy of decompression and changes in cord signal. Clinical outcome was evaluated using the Nurick scale. Twenty-two (71%) of 31 patients had improvement in Nurick score of ≥ 1 point. The preoperative Nurick mean score was 2.6, and the postoperative score was 1.8; the difference was statistically significant. Postoperative MR imaging revealed that only 1 patient had residual mild cord compression, and this patient demonstrated significant neurological improvement. All 15 patients with preoperative myelomalacia had residual spinal cord abnormalities. There was no difference in clinical improvement between patients with or without myelomalacia. Similarly, there was no difference based on neurological recovery with regard to patient age or duration of symptoms greater or less than 12 months. Pseudarthrosis developed in 1 patient, requiring a repeated operation. The authors reported that all patients were thought to have solid arthrodeses at the last follow-up. Three deep wound infections requiring reoperation developed in 3 patients, and 2 patients had C-5 root palsies that resolved. The study of Huang and colleagues provided Class III evidence for efficacy and safety of laminectomy and fusion for CSM. The study was limited because of its retrospective study design and potential selection bias on indications for surgery. The authors did demonstrate that laminectomy and fusion at appropriately selected levels resulted in adequate ventral and dorsal decompression of the spinal canal in the majority of cases. In addition, the study demonstrated a lack of improvement in cord signal changes after surgery; however, the presence of cord signal changes did not correlate with neurological outcome.

Houten and Cooper[7] retrospectively reviewed the charts of 38 patients with CSM or OPLL and straight or lordotic spines who underwent laminectomy and lateral mass plating. The study assessed outcomes using the modified JOA and Cooper scales and on imaging. Clinical follow-up was a mean 30.2 months with a minimum 6-month follow-up. Radiographic follow-up was only a mean of 5.2 months. Significant improvement in neurological function occurred in 97% of patients. The modified JOA score improved from 12.9 to 15.6. Radiographic alignment by the cervical index was unchanged postoperatively. Postoperative MR imaging imaging revealed excellent decompression in all cases. Two neurological complications, a C-5 nerve root palsy and a radiculopathy from a misplaced screw, occurred along with one wound infection. The authors concluded that laminectomy and lateral mass fusion prevented kyphosis and resulted in neurological recovery equal to or greater than anterior approaches. However, the study did not provide a comparison group. This study provided Class III evidence for efficacy of laminectomy and fusion. Only a small percentage of patients treated for decompression were treated with this approach at the authors' institution. Furthermore, relatively short follow-up, inadequate radiographic evaluation to determine the fusion status, and potential hardware complications all limited this study.

Morio and colleagues[12] reviewed 51 patients with myelopathy from CSM or OPLL treated with French door laminoplasty and on-lay posterior lateral fusion. The authors assessed follow-up according to JOA score, radiography, and MR imaging at a mean 48 months (range 12–108 months). Overall, the JOA recovery rate was 50.9%. The average JOA score increased from 9.7 to 13.4. Significantly reduced motion was present at all fused levels, but pseudarthrosis was common. There was a significant correlation of better outcomes in patients who had < 30% of the preoperative motion. Other significant positive correlations were greater preoperative and postoperative spinal cord area and lordotic alignment. The spinal canal was adequately decompressed by MR imaging in all cases. This study provided Class III evidence for the efficacy of laminoplasty and fusion with on-lay bone graft. Similar to the report by Haminishi and Tanaka,[5] the laminoplasty technique resulted in adequate spinal canal decompression. Neurological recovery was found to be related to the preoperative severity of spinal cord compression, that is, patients with less spinal cord plasticity having better neurological outcomes. However, the lack of the control group and retrospective nature of the study limited these conclusions.

Miyazaki et al.[11] reported on 46 patients with CSM or OPLL who had spinal instability or deformity. Their patients underwent French door laminoplasty and on-lay posterolateral bone graft placement, with an average follow-up of 53 months (range 12–118 months). The authors evaluated patients using the JOA scale and plain radiography. Neurological improvement occurred in 89% of patients. The authors reported improvement of 5 JOA points in 46% of patients, 3–4 points in 13%, and 1–2 points in 30%. Radiographic results were not as encouraging, however. Kyphosis increased 40%, and fusion failed in 35% of cases. However, the authors surmised that clinical stability was achieved despite nonunion in 80% of

**TABLE 1: Summary of case series studies of laminectomy and fusion for degenerative cervical myelopathy***

| Authors & Year | Description | Results | Class | Conclusions |
|---|---|---|---|---|
| Gonzalez-Feria, 1975 | 20 patients underwent CSM laminectomy & either wire facet fusion or spinous process plate. 1–7 year FU. Outcomes modified Nurick. No radiographic analysis.. | Neurological improvement in 17/20 (85%). 4 patients improved 1 grade, 5 two grades, & 8 ≥ three grades. 2 patients had plate failure. | III | Good neurological outcomes. No radiographic analysis. |
| Miyazaki et al., 1989 | 46 patients w/ myelopathy from CSM & OPLL w/ instability or deformity. Outcome assessed w/ radiography & JOA scale. Mean FU 53 mos (range 12–118 mos). Used French door technique w/ onlay bone graft. | JOA score improved 89%. >5 points in 46%, 3–4 points in 13%, & 1–2 points in 30%. Radiographic stability achieved in only 80% & 1 case worsening. Kyphosis increased 40%. Fusion occurred in 65%. No correlation of clinical to radiographic results. One paraplegic & 1 instability complication. | III | Good neurological results despite poor radiographic ones. Stability improved but low fusion rate. Deformity increased in this difficult group. |
| Maurer et al., 1991 | 10 patients (mean age 51 yrs w/ 10-mo FU) w/ CSM treated w/ posterior laminectomies & Luque rectangle fixation/fusion. Modified Harsh scale used for FU. | 9 patients improved & 1 stayed at Grade IIIB. | III | Decompression & fusion/fixation prevents progression of myelopathy/instability after laminectomy. |
| Kumar et al., 1999 | 25 patients w/ CSM who underwent laminectomy & fusion/fixation over a 5-yr period. Avg age 60 yrs. 48-mo FU. Myelopathy measured using a modified Harsh scale. | Myelopathy improved in 76% w/ 24% stable. Those w/ Grade IIIA (difficulty walking but independent) did better than Grade IIIB (dependent on cane/crutch). Good outcome in 80%. Short Form-36 showed higher level of depression in poor outcome group ($p < 0.02$). | III | Laminectomy & arthrodesis are safe & relatively effective for patients w/ CSM. |
| Epstein, 1999 | 5 patients (avg age 73 yrs). CSM symptoms < 12 mos w/ intact lordosis; treated w/ laminectomy & wiring/facet fusion. Avg 13-mo FU. | All 5 patients improved an avg of 3 Nurick grades. | III | In intact cervical lordosis, laminectomy & fusion is effective. |
| Morio et al., 2000 | 51 patients w/ CSM & OPLL treated w/ French door laminoplasty & onlay posterior lateral fusion. FU w/ JOA & radiography at mean 48 mos (range 12–108 mos). | 50.9% recovery rate, JOA score increased from 9.7 to 13.4. Significant reduced motion at fused levels but pseudarthrosis common. Significant correlation of better outcomes in patients w/ <30% preop motion. Significant positive correlations between outcomes were associated w/ spinal cord area & lordotic alignment. Canal was adequately decompressed. | III | Decreased ROM & better alignment correlated w/ better outcomes. No discussion of pain. |
| Houten & Cooper, 2003 | 38 patients retrospectively reviewed w/ CSM or OPLL 2–3 segments, straight or lordotic spine. Treated w/ laminectomy & lateral mass plating. Assessed w/ modified JOA, Cooper scale, & radiographic results. Clinical FU mean 30.2 mos. Radiographic FU only 5.2 mos. | Significant improvement in neurological function in 97% of patients. JOA 12.9 improved to 15.6. Radiograph alignment by cervical index unchanged. Excellent decompression. 2 neurological complications: 1 C-5 palsy & injury from screw & 1 infection. | III | Laminectomy & lateral mass fusion prevents kyphosis & results in neurological recovery equal to ACDF (not proven). Avoids anterior complications. |
| Huang et al., 2003 | 32 patients in Series 1: 28 w/ CSM & 4 w/ OPLL, over 4-yr periods. Avg 15-mo FU in 31 patients (min 6 mos). Laminectomy & lateral mass fusion/fixation was used. | Nurick grade improved from avg 2.6 to 1.8 ($p < 0.0001$); 71% improved 1 grade while 29% did not improve; none worsened. Complications occurred in 18%. | III | Effective surgery; no difference in outcomes relative to age, symptoms > 12 mos, or myelomalacia. |

* The criteria for scoring each manuscript into a class are described in *Introduction and Methodology: Guidelines for the Surgical Management of Cervical Degenerative Disease* in this issue of the *Journal of Neurosurgery: Spine*. Abbreviations: ACDF = anterior cervical discectomy and fusion; FU = follow-up; ROM = range of motion.

cases. Progressive instability developed in 1 patient, and paraplegia developed 7 hours postoperatively in another. This Class III study included more seriously involved patients who had structural instability or deformity. The authors reported satisfactory neurological outcomes, but the radiographic results were poor; the noninstrumented technique of posterolateral fusion may have contributed to these poor radiographic results. Interestingly, the authors found no correlation between radiographic results and neurological outcome.

**TABLE 2: Summary of comparative studies on laminectomy and fusion for degenerative cervical myelopathy***

| Author & Year | Description | Results | Class | Conclusions |
|---|---|---|---|---|
| Gonzalez-Feria & Peraita-Peraita, 1975 | 521 patients w/ myelopathy 41 who had laminectomy & posterior fusion. Patient outcomes evaluated w/ modified Nurick scale. FU not specified. | Mean improvement of 2.0 Nurick grades was seen in fusion Group. This was better than all other Txs. | III | Laminectomy & fusion had better outcome but unclear if groups were similar & indication bias may have existed. Duration of FU not specified. |
| Heller et al., 2001 | 26 of 50 patients who fulfilled criteria (13 w/ laminoplasty & 13 w/ laminectomy & arthrodesis). Open-door laminoplasty vs lateral mass plate & decompression. Avg age was 55 yrs w/ avg FU 25–26 mos. | Nurick improved 1.2 (11 patients improved) grades w/ laminoplasty & 0.7 (7 patients improved) grades w/ fixation ($p > 0.05$). Complication rate higher for plating 3/13; pseudarthrosis 11% w/ plates. | III | Fewer complications w/ laminoplasty but both improved; uncertain if both sets of patients were eligible for same Tx. |
| Hamanishi & Tanaka, 1996 | 69 patients. Laminectomy in 35 (avg age 66 yrs) or laminectomy & fusion in 34 (avg age 58 yrs). Avg FU 3.5 years. Patients divided into acute, subacute, & insidious-onset groups. | Those w/ laminectomy were significantly older ($p < 0.004$) but had a better preop JOA score ($p < 0.03$). The level of improvement in JOA was the same (51%). Postop improvement correlated w/ duration of symptoms. | III | Multilevel decompression is effective in patients w/ CSM. Fusion does not appear to make a difference in outcome in this series. |

*Class III Comparative Studies*

Three studies compared results of laminectomy and fusion to other surgical techniques. These were all class III studies and had important methodological defects that limited their conclusions. Gonzalez-Feria and Peraita-Peraita[4] performed a multicenter retrospective review of 525 patients with CSM treated in the Iberian Peninsula. The authors used the anterior approach in 195 patients, laminectomy in 242, a combined anterior and posterior approach in 42, and laminectomy and fusion with spinous "crab plates" process plates in 41 patients. In all treatment groups, 60% of patients improved neurologically and 6.5% deteriorated. There was an overall mortality of 3%. The average improvement by Nurick scale was 0.9.

Comparison of results according to surgical method revealed that laminectomy and posterior fusion yielded significantly better neurological recovery compared to all other methods. Patients who underwent laminectomy and posterior fusion improved an average of 2.0 Nurick grades, whereas the mean improvement with the anterior approach was 1.2, and with laminectomy was 0.9. The average follow-up period was not specified. This report provided Class III evidence for the efficacy of laminectomy and fusion over other techniques. However, there were many methodological problems including surgical indication bias, lack of follow-up statistics, surgeon reporting of neurological outcomes, and lack of radiographic analysis.

Hamanishi and Tanaka[5] reported on 69 patients with CSM who underwent laminectomy or laminectomy and fusion withs on-lay bone grafting onto the lateral masses. Thirty-five patients underwent laminectomy, and 34 underwent laminectomy and fusion. Indications for fusion were instability or lack of lordosis. Outcomes were assessed at a mean of 3.5 years postoperatively using the JOA scale and percent recovery. The authors found similar rates of recovery (51% improvement in JOA score) in both groups. The time from onset of symptoms or injury strongly correlated to neurologic recovery in both groups. Radiographically, instability developed in 2 patients who did not undergo fusion, and progressive kyphosis developed in 5. In the fusion group, only an 80% fusion rate was noted, and instability developed in 2 patients. Six of 35 (17%) patients who did not undergo fusion developed kyphotic malalignment compared with 4 (12%) of 34 patients who underwent fusion. This study provided Class III evidence that fusion does not significantly add to neurological outcome. However, the 2 treatment groups were dissimilar in that the fusion group had instability or kyphosis and worse JOA scores. Any comparison of outcomes is therefore biased against the fusion group.

Heller et al.[6] performed a matched cohort study in 26 patients with CSM or OPLL who underwent either by laminoplasty or laminectomy with lateral mass plate fixation and autogenous grafting. The mean follow-up period was 26 months (range 9–46 months). Patients who underwent fusion had worse kyphosis but less maximum stenosis. The study evaluated patients using the Nurick scale, subjective symptom reporting, and gait. The authors reported no statistically significant differences in neurological recovery between the 2 groups, and there were no differences in postoperative axial pain scores. In all instances, however, the authors observed better results in the laminoplasty group. These patients had better functional outcomes as evidenced by better gains in Nurick scores; they also had a lower complication rate. Radiographically, there was no difference in alignment between the groups, although severe kyphosis developed in 1 patient who underwent fusion. There was a significant difference in complications rates between the 2 groups with no complications occurring in the laminoplasty group. In the fusion group, 2 patients experienced neurological deterioration, a deep infection developed in 1 patient, 5 patients had pseudarthrosis, 2 patients had hardware failure, and in 1 patient, adjacent degeneration requiring anterior cervical decompression and fusion oc-

curred. This study provided Class III evidence because of the selection bias that may have occurred in developing the matched cohorts and due to the small sample size that probably resulted in insufficient power to measure the primary outcome variables. Additionally, there was a surgical selection bias, as kyphotic patients were more likely to undergo fusion. The data on complications were worrisome and favored laminoplasty over laminectomy and posterior fusion with plates. However, other authors with similar studies did not report these complications after using similar fusion techniques.[7,8]

*Effect of Laminectomy and Fusion on Spinal Cord Compression*

There is evidence that laminectomy and fusion results in adequate decompression of both the ventral and dorsal aspects of the spinal cord as defined by MR imaging. Morio et al.[12] performed pre- and postoperative MR imaging at 3–6 months in 51 patients who underwent French door laminoplasty and posterolateral fusion. The spinal cord area increased by 25%, whereas the dural tube area increased by 230%. The authors found a positive correlation between larger preoperative and larger postoperative spinal cord area and recovery according to the JOA scale. Huang et al.[8] compared pre- and postoperative MR images obtained at 3.8 months in 32 patients who underwent laminectomy and posterolateral fusion. All but 1 patient had complete spinal cord decompression. Spinal cord signal changes (myelomalacia) were present in 40% of cases and did not change after surgery; this did not correlate to neurological recovery, however. Houten and Cooper[7] also reported complete decompression in all cases on postoperative MR images.

*Fusion Technique*

The technique of fusion has evolved. Initially it was performed with on-lay posterolateral bone grafting into laminoplasty troughs or into facets. Documentation of fusion success was inadequate in all studies, but there appeared to be high rates of failures. Also deformity and instability occurred in some patients despite attempted fusion. The use of lateral mass wires and screw–plate constructs theoretically resulted in more stable constructs and higher fusion success. Although high fusion rates have been reported, the follow-up was often too short and adequate radiographic evaluation was lacking. Neurological complications related to misplaced screws have been reported. Accordingly, at this time, no evidence is available to determine the best means to achieve stabilization and fusion.

## Summary

Class I or II evidence to support the use of laminectomy and fusion for treatment of myelopathy secondary to cervical spondylosis or OPLL does not exist. Class III evidence shows consistently that 70–95% of patients show postoperative neurological improvement. The overall recovery is ~ 50% of the JOA score deficit. Laminectomy and fusion consistently results in ventral and dorsal spinal cord decompression. Insufficient data are available to adequately assess whether fusion occurs, although radiographic results do not seem to correlate with neurological outcome. Complications related to fixation include hardware failure with loss of alignment, radiculopathy, screw malposition, and the need for a repeated operation.

## Key Issues for the Future

Indications for laminectomy and fusion compared with other techniques must be developed and tested with randomized, controlled studies. Theoretically laminectomy and fusion would be indicated when there is associated instability or perhaps kyphotic deformity. It is possible that fusion may result in greater neurological recovery than maintaining motion by other techniques. This hypothesis necessitates carefully designed randomized controlled studies to prove. The technique of fusion would best be evaluated using lateral mass plate or rod constructs. These techniques must be validated with long-term follow-up using dynamic radiography or CT to determine fusion status and complication rates.

### Disclosure

Administrative costs of this project were funded by the Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and Congress of Neurological Surgeons. No author received payment or honorarium for time devoted to this project. Dr. Resnick owns stock in Orthovita. Dr. Matz receives support from the Kyphon Grant for Thoracolumbar Fracture Study, and an advisory honorarium from Synthes for the cadaver laboratory. Dr. Heary receives support from DePuy Spine and Biomet Spine, and receives royalties from DePuy Spine and Zimmer Spine. Dr. Groff is a consultant for DePuy Spine. Dr. Mummaneni is a consultant for and receives university grants from DePuy Spine and Medtronic, Inc., and is a patent holder in DePuy Spine. Dr. Anderson is an owner of, consultant for, and stockholder of Pioneer Surgical Technology; a consultant for and receives non–study related support from Medtronic, Inc.; and is a patent holder in Stryker. The authors report no other conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

### References

1. Epstein NE: Laminectomy with posterior wiring and fusion for cervical ossification of the posterior longitudinal ligament, spondylosis, ossification of the yellow ligament, stenosis, and instability: a study of 5 patients. **J Spinal Disord 12:**461–466, 1999
2. Fouyas IP, Statham PF, Sandercock PA, Lynch C: Surgery for cervical radiculomyelopathy. **Cochrane Database Syst Rev 3:**CD001466, 2001
3. Gonzalez-Feria L: The effect of surgical immobilization after laminectomy in the treatment of advanced cases of cervical spondylotic myelopathy. **Acta Neurochir (Wien) 31:**185–193, 1975
4. Gonzalez-Feria L, Peraita-Peraita P: Cervical spondylotic myelopathy: a cooperative study. **Clin Neurol Neurosurg 78:**19–33, 1975
5. Hamanishi C, Tanaka S: Bilateral multilevel laminectomy with or without posterolateral fusion for cervical spondylotic myelopathy: relationship to type of onset and time until operation. **J Neurosurg 85:**447–451, 1996
6. Heller JG, Edwards CC II, Murakami H, Rodts GE: Lamino-

plasty versus laminectomy and fusion for multilevel cervical myelopathy: an independent matched cohort analysis. **Spine 26:**1330–1336, 2001
7. Houten JK, Cooper PR: Laminectomy and posterior cervical plating for multilevel cervical spondylotic myelopathy and ossification of the posterior longitudinal ligament: effects on cervical alignment, spinal cord compression, and neurological outcome. **Neurosurgery 52:**1081–1088, 2003
8. Huang RC, Girardi FP, Poynton AR, Cammisa FP Jr: Treatment of multilevel cervical spondylotic myeloradiculopathy with posterior decompression and fusion with lateral mass plate fixation and local bone graft. **J Spinal Disord Tech 16:**123–129, 2003
9. Kumar VG, Rea GL, Mervis LJ, McGregor JM: Cervical spondylotic myelopathy: functional and radiographic long-term outcome after laminectomy and posterior fusion. **Neurosurgery 44:**771–777, 1999
10. Maurer PK, Ellenbogen RG, Ecklund J, Simonds GR, van Dam B, Ondra SL: Cervical spondylotic myelopathy: treatment with posterior decompression and Luque rectangle bone fusion. **Neurosurgery 28:**680–683, 1991
11. Miyazaki K, Tada K, Matsuda Y, Okuno M, Yasuda T, Murakami H: Posterior extensive simultaneous multisegment decompression with posterolateral fusion for cervical myelopathy with cervical instability and kyphotic and/or S-shaped deformities. **Spine 14:**1160–1170, 1989
12. Morio Y, Yamamoto K, Teshima R, Nagashima H, Hagino H: Clinicoradiologic study of cervical laminoplasty with posterolateral fusion or bone graft. **Spine 25:**190–196, 2000

Manuscript submitted October 18, 2008.
Accepted February 19, 2009.
*Address correspondence to:* Paul G. Matz, M.D., Neurosurgery and Neurology, LLC, 232 South Woods Mill Road, Chesterfield, Missouri 63017. email: matzpg@yahoo.com.