

Cervical laminoforaminotomy for the treatment of cervical degenerative radiculopathy

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Object. The objective of this systematic review was to use evidence-based medicine to examine the efficacy of posterior laminoforaminotomy in the treatment of cervical radiculopathy.

Methods. The National Library of Medicine and Cochrane Database were queried using MeSH headings and key words relevant to posterior laminoforaminotomy and cervical radiculopathy. Abstracts were reviewed, and 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 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. Posterior laminoforaminotomy improves clinical outcome in the treatment of cervical radiculopathy resulting from soft lateral cervical disc displacement or cervical spondylosis with resultant narrowing of the lateral recess. All studies were Class III. The most frequent design flaw involved the lack of utilization of validated outcomes measures. In addition, few historical studies included a detailed preoperative analysis of the patients. As such, the vast majority of studies that included both pre- and postoperative assessments with legitimate outcomes measures have been performed since 1990.

Conclusions. Posterior laminoforaminotomy is an effective treatment for cervical radiculopathy. (DOI: 10.3171/2009.2.SPINE08722)

KEY WORDS • cervical spine • cervical spondylosis • laminotomy • practice guidelines • radiculopathy • treatment outcome

Recommendations

Posterior laminoforaminotomy is recommended as a surgical treatment option for symptomatic cervical radiculopathy resulting from soft lateral cervical disc displacement or cervical spondylosis with resultant narrowing of the lateral recess (quality of evidence, Class III; strength of recommendation, D).

Posterior laminoforaminotomy is recommended as a surgical method to decompress a compressed cervical nerve root resulting from soft lateral cervical disc dis-

placement or cervical spondylosis with resultant narrowing of the lateral recess (quality of evidence, Class III; strength of recommendation, D).

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

Rationale

Cervical radiculopathy is typically characterized as pain in the anatomic distribution of a single cervical

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nerve root. Sensorimotor impairment of the same nerve root may or may not be simultaneously present. Not uncommonly, multiple nerve roots may be affected simultaneously, leading to multilevel radiculopathy. Rarely, cervical myelopathy may coexist with clinically significant cervical radiculopathy. Cervical radiculopathy is usually the result of either a soft lateral disc displacement or spondylosis with resultant foraminal compromise caused either by a calcified disc, osteophyte, or both.

Herniated cervical discs causing radiculopathy may be treated from either an anterior or posterior approach. Likewise, spondylosis may be treated from either approach. The first documented description of the surgical treatment of a herniated cervical disc was by Spurling and Scoville,¹⁷ who provided a description of a posterior approach to the cervical spine for treatment of a herniated cervical disc via a laminoforaminotomy procedure.

Over the next 40 years, many reports of the surgical treatment of cervical radiculopathy via a posterior approach were published. To assess the efficacy of posterior laminoforaminotomy for decompression of the cervical nerve root(s) in cases of cervical radiculopathy, an evidence-based review of the relevant medical literature was undertaken.

Search Criteria

The group undertook a search of the National Library of Medicine (PubMed) literature and Cochrane database. Using the MeSH subject headings of “cervical” and “spine” and “surgery”, and limiting the search to human studies and the English language, we searched the period from 1966 through 2007. This review generated a broad base of studies (9589 references). We reviewed the titles and abstracts with attention to those addressing clinical management, and performed secondary searches crossing radiculopathy with surgery and cervical and radiculopathy. We then reviewed the bibliographies of selected papers for additional references of relevance.

We selected articles if they addressed issues related to the surgical management of cervical radiculopathy. Articles containing data on anterior approaches were included if they contained comparative data for posterior surgical approaches. We formulated an evidentiary table from the resulting list of articles most relevant to the topic of surgical management of cervical radiculopathy via laminoforaminotomy (Table 1).

Scientific Foundation

Laminoforaminotomy was described ~ 10 years after the initial report of the treatment of a herniated lumbar disc by Mixter and Barr¹¹ in 1934. This description of laminoforaminotomy predated the initial reports of anterior cervical discectomy by Cloward^{2,3} and Smith and Robinson¹⁶ by 10 years.

Despite its long-term use and widespread general acceptance as a surgical technique, a paucity of peer-reviewed literature was found on the use of laminoforaminotomy for cervical radiculopathy. Radhakrishnan et al.¹³ reported on their experience with a cohort of 561 patients

with cervical radiculopathy over a 14-year period, among whom 141 (26%) underwent surgery. Laminoforaminotomy was the most common approach used, and 94% of these operations were performed within 3 months of the diagnosis. These investigators found that patients with radicular pain, dermatomal sensory loss, and motor deficit were at least 8 times more likely than patients without any of these factors to undergo surgical intervention. Additional information regarding the outcomes in patients who underwent surgery were not available in this review. This study was graded Class II with respect to determining which patients were likely to undergo surgery, but did not provide useful data with respect to the results of surgical treatment.

Although numerous articles were written in the time period from 1944 until the past decade, the great majority of these were severely flawed in study design. There were no Class I or II studies written which specifically addressed the use of laminoforaminotomy in the treatment of cervical radiculopathy. The most frequent design flaw involved the lack of validated outcomes measures. In addition, few historical studies included a detailed preoperative analysis of the patients. As such, the vast majority of studies that included both pre- and postoperative assessments with legitimate outcomes measures have been performed since 1990. Due to a variety of reasons, all of these have been classified as providing Class III scientific evidence.

In 1983, Henderson et al.⁷ published a comprehensive review of 846 surgical cases performed in 736 consecutively treated patients with cervical radiculopathy using the laminoforaminotomy technique. These authors demonstrated a 96% improvement in arm pain and paresthesia, and a 98% resolution of preoperative motor deficits. Most patients (91.5%) rated their outcomes as good or excellent, and there was no statistically significant difference between the outcomes for patients with hard or soft disc herniation or cervical spondylosis. This case series provided Class III medical evidence, and is marred by nonvalidated outcome measure and nonblinded assessments.

Herkowitz et al.⁸ performed a comparison of laminoforaminotomy with anterior cervical discectomy and fusion to treat of cervical herniated discs causing radiculopathy. These authors alternated the treatment in 33 patients and had a mean follow-up of 4.2 years. Good and excellent results were obtained in 94% of patients who underwent anterior cervical discectomy and fusion, and 75% of those who underwent laminoforaminotomy; however, this difference was not statistically significant. This cohort study was graded Class III due to its small size, nonvalidated outcome measures, and nonblinded assessments.

Zeidman and Ducker²⁰ retrospectively reported on 172 patients who had undergone laminoforaminotomy for cervical radiculopathy. With a mean follow-up period of > 2 years in 77% of the patients and > 1 year in the remaining 23%, overall pain relief was reported in 97% of patients. For similar reasons as above, this study was graded Class III.

Davis⁴ reported a retrospective study of 170 patients who underwent laminoforaminotomy for compressive

TABLE 1: Evidentiary summary of studies on posterolateral cervical laminoforaminotomy and outcome

Authors & Year	Summary	Class	Conclusions
Radhakrishnan et al., 1994	561 patients w/ cervical radiculopathy studied over 14 yrs; 141 patients (26%) underwent surgery primarily by laminoforaminotomy w/in 3 mos of diagnosis.	III	Radicular pain, dermatomal sensory loss, & motor deficit were 8× more likely to undergo surgery. Study Class II w/ respect to likelihood to undergo surgery but Class III w/o respect to outcome.
Henderson et al., 1983	Review of 736 consecutive patients (846 surgeries) treated w/ laminoforaminotomy technique; 96% improvement in arm pain & paresthesia w/ 98% resolution of motor deficit; 91.5% satisfied.	III	Outcomes extremely good w/ posterolateral technique. Class III due to nonvalidated outcomes & nonblinded review.
Herkowitz et al., 1990	33 patients alternating between anterior & posterolateral surgery for radiculopathy. Mean 4.2-yr FU.	III	Good & excellent results found in 94% anterior surgery & 75% posterolateral surgery (not significant). Class III due to nonvalidated outcomes & nonblinded assessment.
Zeidman & Ducker, 1993	172 patients underwent posterolateral surgery for cervical radiculopathy. Mean FU >1 yr in 100% & >2 yrs in 77%.	III	Overall pain relief was 97%; Class III due to nonvalidated outcomes & nonblinded assessment.
Davis, 1996	170 patients underwent posterolateral foraminotomy for cervical radiculopathy. Mean 15-yr FU in 96%.	III	Good or excellent outcome of 86% using Prolo scores. Recurrence rate of 6%—usually in first 3 yrs. Class III due to nonvalidated outcome measure.
Tomaras et al., 1997	183 patients underwent posterolateral foraminotomy for cervical radiculopathy. Mean FU 19 mos.	III	Outcomes were good or excellent in 93% who were not Worker's Compensation & 78% who were. This difference was significant ($p < 0.01$). Class III due to nonvalidated outcome measures.
Kumar et al., 1998	89 patients treated w/ posterolateral foraminotomy. Mean FU 8.6 mos using Odom's criteria.	III	Good or excellent results in 95.5% w/ 6.7% recurrence rate. Class III for nonvalidated outcome measures.
Grieve et al., 2000	77 consecutive patients underwent posterolateral foraminotomy for cervical radiculopathy. Mailed questionnaire (80% response).	III	70% of group had significant (>75%) relief of pain, 23% had moderate (<75%) relief, while 7% had the same or worse pain. Deterioration after relief in 27%. Class III due to below average FU & subjective outcome measures that were nonblinded.
Witzmann et al., 2000	67 patients reviewed retrospectively w/ cervical disc displacement & radiculopathy. Outcome using Prolo scale & visual analog assessment.	III	Good & excellent results in 92% by visual analogue scale & 90% excellent result w/ Prolo scale. Class III due to nonvalidated outcome measure & nonblinded assessment.
Adamson, 2001	Retrospective review of 100 cases of cervical radiculopathy from foraminal stenosis due to soft disc or spondylosis. Tx w/ microendoscopic foraminotomy.	III	Excellent or good results in 97% of patients who returned to baseline activities & employment. Class III due to subjective outcome measures.
Rodrigues et al., 2001	51 patients w/ soft cervical disc displacement & radiculopathy treated w/ posterolateral foraminotomy; mean FU of 46 mos.	III	Total pain relief in 96% of patients w/ motor improvement in 76% & sensory improvement in 63%. Class III due to no formal outcome measures.
Fessler & Khoo, 2002	51 patients w/ cervical radiculopathy treated w/ open ($n = 26$) or microendoscopic ($n = 25$) foraminotomy.	III	Patients in both groups had 87–92% improvement w/ no differences between groups. Class III due to nonvalidated outcome measures.
Schoggl et al., 2002	32 patients w/ posterolateral foraminotomy for cervical radiculopathy, FU 34 mos. Outcomes assessed using Prolo functional economic scale.	III	Good to excellent outcomes seen in 64% w/ moderate in 18% & poor in 18%. Class III due to nonvalidated nature of Prolo scale & nonblinded assessment.
Korinath et al., 2006	363 patients retrospectively reviewed w/ soft cervical disc disease. Mean 6.1-yr FU in 292 patients (80%). Anterior surgery w/ PMMA spacer compared to posterolateral foraminotomy.	III	Odom's criteria: good & excellent in 93.6% anterior & 85.1% posterior ($p < 0.05$). Better results w/ posterior surgery in terms of operating time & periop complications. Class III due to nonvalidated outcomes & nonblinding of outcome assessors.

* The criteria for scoring each manuscript into a class are described in *Introduction and Methodology: Guidelines for the Surgical Management of Cervical Degenerative Disease*, which appears in this issue of the *Journal of Neurosurgery: Spine*. Abbreviations: FU = follow-up; PMMA = polymethylmethacrylate.

cervical radiculopathy. The mean follow-up period was 15 years in 96% of patients. Good or excellent outcomes were observed in 86% of patients, based on Prolo scores (a nonvalidated outcome measure). The recurrence rate

was 6%, with most recurrences occurring within the first 3 years of the index surgical procedure. This case series provides Class III medical evidence.

In 1997, Tomaras and colleagues¹⁸ reported their ret-

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respective case series on the use of laminoforaminotomy on 183 patients with cervical radiculopathy. Surgery was performed on an outpatient basis in all cases, and the mean follow-up period was 19 months. There were no immediate readmissions and the outcomes were good or excellent in 93% of patients who were not involved with Worker's Compensation claims, and 78% of those who were. The difference between the outcomes with respect to Worker's Compensation claims was statistically significant ($p < 0.01$).

Kumar et al.¹⁰ reported their results in a series of patients treated with foraminotomy for cervical spondylotic radiculopathy caused by osteophytes. In this retrospective review, patients with disc herniation were not included. A total of 89 patients were treated with a mean follow-up of 8.6 months. Using Odom's criteria, good or excellent results were obtained in 95.5% of patients. Further surgery for recurrent root symptoms was performed on 6.7% of the patients.

Grieve et al.⁶ reported on the results of cervical foraminotomy for spondylitic radiculopathy in 77 consecutive patients. With an 80% response rate to a mailed questionnaire, 70% of patients had complete or $> 75\%$ improvement of their preoperative pain, 23% had improvement of $< 75\%$, and 7% had the same or worsened pain. Sixteen patients (27%) reported an initial improvement in symptoms with subsequent deterioration (the overall follow-up rate was 80%). The most common postoperative complaint was neck pain (reported by 22% of patients).

Witzmann and associates¹⁹ performed a retrospective analysis of soft and hard cervical disc herniation causing radiculopathy in 67 patients. Using a laminoforaminotomy technique, they obtained 92% good and excellent results according to visual analog scale testing, and a 90% excellent result on the Prolo Functional Economic Outcome Rating Scale¹² at a mean 3-year follow-up evaluation.

Adamson¹ reported on the use of a microendoscopic method to perform a laminoforaminotomy in 2001. This retrospective report detailed 100 laminoforaminotomies performed for unilateral cervical radiculopathy resulting from soft lateral disc herniation or spondylitic foraminal stenosis. Adamson reported excellent or good results in 97% of patients who returned to their preoperative employment and baseline level of physical activity. Rodrigues et al.¹⁴ reported on 51 patients with soft cervical disc herniation causing radiculopathy. In this retrospective review, the authors reported total pain relief in 96%, motor improvement in 76%, and sensory improvement in 63% of patients. The study used no formal outcome scales in the evaluations which were performed after a mean duration of follow-up of 46 months. Schoggl et al.¹⁵ reported retrospectively on the use of posterior microforaminotomy for cervical spondylotic radiculopathy in which 32 patients were followed up for a mean of 34 months. The authors assessed outcomes using the Prolo Functional Economic Outcome Rating Scale, and reported a good to excellent outcome in 64%, moderate outcome in 18%, and a poor outcome in 18%. Because of their retrospective nature, all of these studies provide Class III medical evidence.

In 2002, Fessler and Khoo⁵ reported on the use of a microendoscopic cervical foraminotomy technique. They

compared the results of this newer procedure with those obtained using an open laminoforaminotomy technique. The open surgery group included 26 consecutive patients, and the endoscopic group was composed of the next 25 consecutive patients with either cervical root compression from foraminal stenosis or disc herniation. As such, a sequential series of patients was analyzed. The patients in both groups had between 87 and 92% symptomatic improvement, with no significant differences between the groups. This study was graded Class III because of the lack of any validated outcomes measures in the evaluation process, the lack of a simultaneous control group, and the fact that the outcome assessors were not blinded.

Korinath et al.⁹ performed a retrospective comparative analysis of 363 cases of cervical soft disc disease causing radiculopathy at a single level. Of these, 292 patients (80%) were available for long-term follow-up at 6.1 years. The authors compared anterior cervical discectomy using a polymethylacrylate spacer with a posterior foraminotomy procedure. Using Odom's criteria, the good and excellent results were found to be statistically different between the anterior (93.6%) and posterior (85.1%) groups in favor of the anterior approach ($p < 0.05$). Interestingly, statistically significant differences were detected favoring posterior surgery with respect to perioperative complications and mean operating times; however, posterior surgeries also had significantly greater need for repeated surgery to be performed at a later date. The reasons for assigning a patient into a particular group were vaguely described and not randomized in any manner. This study was graded Class III due to 80% follow-up, a nonvalidated outcome measure, and the lack of blinding.

Summary and Key Issues for Future Investigation

The preponderance of clinical studies we have described support the utility of posterior cervical laminoforaminotomy as an effective treatment for either cervical disc displacement or foraminal spondylotic stenosis causing radiculopathy.

Advantages to posterior laminoforaminotomy include sparing the motion segment. Furthermore, there is the theoretical advantage that adjacent segment disc degeneration, which is becoming increasingly recognized after anterior cervical fusion, is unlikely to occur in patients undergoing laminoforaminotomy.

Future investigation would involve identifying the ideal surgical treatment for soft lateral cervical disc displacement causing radiculopathy. Review of the current, peer-reviewed literature did not resolve whether an anterior or a posterior surgery would have better short- and long-term results. Performance of a well-designed, randomized clinical trial for patients with this clinical scenario would enable resolution of this question.

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References

1. Adamson TE: Microendoscopic posterior cervical laminoforaminotomy for unilateral radiculopathy: results of a new technique in 100 cases. **J Neurosurg** **95**:51–57, 2001
2. Cloward RB: The anterior approach for removal of ruptured cervical disks. **J Neurosurg** **15**:602–617, 1958
3. Cloward RB: Vertebral body fusion for ruptured cervical discs. **Am J Surg** **98**:722–727, 1959
4. Davis RA: A long-term outcome study of 170 surgically treated patients with compressive cervical radiculopathy. **Surg Neurol** **46**:523–533, 1996
5. Fessler RG, Khoo LT: Minimally invasive cervical microendoscopic foraminotomy: an initial clinical experience. **Neurosurgery** **51** (5 Suppl):S37–S45, 2002
6. Grieve JP, Kitchen ND, Moore AJ, Marsh HT: Results of posterior cervical foraminotomy for treatment of cervical spondylitic radiculopathy. **Br J Neurosurg** **14**:40–43, 2000
7. Henderson CM, Hennessy RG, Shuey HM Jr, Shackelford EG: Posterior-lateral foraminotomy as an exclusive operative technique for cervical radiculopathy: a review of 846 consecutively operated cases. **Neurosurgery** **13**:504–512, 1983
8. Herkowitz HN, Kurz LT, Overholt DP: Surgical management of cervical soft disc herniation. A comparison between the anterior and posterior approach. **Spine** **15**:1026–1030, 1990
9. Korinath MC, Kruger A, Oertel MF, Gilsbach JM: Posterior foraminotomy or anterior discectomy with polymethyl methacrylate interbody stabilization for cervical soft disc disease: results in 292 patients with monoradiculopathy. **Spine** **31**:1207–1216, 2006
10. Kumar GR, Maurice-Williams RS, Bradford R: Cervical foraminotomy: an effective treatment for cervical spondylitic radiculopathy. **Br J Neurosurg** **12**:563–568, 1998
11. Mixter W, Barr J: Rupture of the intervertebral disc with involvement of the spinal canal. **N Engl J Med** **211**:210–215, 1934
12. Prolo DJ, Oklund SA, Butcher M: Toward uniformity in evaluating results of lumbar spine operations. A paradigm applied to posterior lumbar interbody fusions. **Spine** **11**:601–606, 1986
13. Radhakrishnan K, Litchy WJ, O'Fallon WM, Kurland LT: Epidemiology of cervical radiculopathy. A population-based study from Rochester, Minnesota, 1976 through 1990. **Brain** **117**:325–335, 1994
14. Rodrigues MA, Hanel RA, Prevedello DM, Antoniuk A, Araujo JC: Posterior approach for soft cervical disc herniation: a neglected technique? **Surg Neurol** **55**:17–22, 2001
15. Schoggl A, Reddy M, Saringer W, Ungersbock K: Social and economic outcome after posterior microforaminotomy for cervical spondylitic radiculopathy. **Wien Klin Wochenschr** **114**:200–204, 2002
16. Smith GW, Robinson RA: The treatment of certain cervical-spine disorders by anterior removal of the intervertebral disc and interbody fusion. **J Bone Joint Surg Am** **40-A**:607–624, 1958
17. Spurling RG, Scoville WB: Lateral rupture of cervical intervertebral disc. A common cause of shoulder and arm pain. **Surg Gynecol Obstet** **798**:350–358, 1944
18. Tomaras CR, Blacklock JB, Parker WD, Harper RL: Outpatient surgical treatment of cervical radiculopathy. **J Neurosurg** **87**:41–43, 1997
19. Witzmann A, Hejazi N, Krasznai L: Posterior cervical foraminotomy. A follow-up study of 67 surgically treated patients with compressive radiculopathy. **Neurosurg Rev** **23**:213–217, 2000
20. Zeidman SM, Ducker TB: Posterior cervical laminoforaminotomy for radiculopathy: review of 172 cases. **Neurosurgery** **33**:356–362, 1993

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