Same-segment and adjacent-segment disease following posterior cervical foraminotomy

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Object. The cervical foraminotomy was pioneered in the 1940s to address radicular symptoms via a posterior approach, but the long-term outcome has not been adequately studied.

Methods. The authors retrospectively analyzed data obtained from 303 patients (188 male and 115 female, mean age 49.2 years) who had consecutively undergone a single-level posterior foraminotomy for cervical radiculopathy between 1972 and 1992. The median follow-up duration was 7.1 years. The major end point studied was the development of symptomatic adjacent- or same-segment disease. Incidence rates per 1000 person-years were calculated, and the natural history of the disease was predicted using Kaplan–Meier survivorship analysis.

In 15 (4.9%) of 303 patients, symptomatic adjacent-segment disease developed, yielding a rate of 6.4/1000 person-years at risk. This included nine (2.9%) of 303 patients requiring reoperation, yielding a rate of 3.8/1000 person-years. Kaplan–Meier survivorship analysis suggested a relatively stable annual 0.7% rate for developing adjacent-segment disease, with a 10-year rate of 6.7%. Ten patients developed same-segment disease, yielding a risk rate of 3.9/1000 person-years.

Kaplan–Meier survivorship analysis demonstrated a 5- and 10-year risk rate of developing same-segment disease of 3.2 and 5.0%, respectively.

Conclusions. Although additional study is needed, analysis of the present data suggests that posterior foraminotomy is associated with a low rate of same- and adjacent-segment disease.

KEY WORDS • cervical spine • foraminotomy • adjacent-segment disease • intervertebral disc

T he posterior approach to the cervical spine was pioneered by Frykholm and later modified by Scoville et al., and with Whitcombe. In the original studies of the posterior approach, excellent results were established. The authors stated, “Simple ‘keyhole’ facetectomy by the posterior approach is the treatment of choice for lateral rupture of a cervical intervertebral disk. Results are among the most rewarding in neurosurgery.” In the sentinel study by Scoville et al., 175 patients underwent follow-up study for 5 or more years, and the authors reported a 97% cure rate. No late occurrences were reported, and surgical treatment failed in only one patient. Interestingly, it has also been reported that in only 2% of patients did a second symptomatic herniated disc develop at a different location. In the 1960s, the authors of several studies confirmed these results.

More recently, attempts have been made to demonstrate the effectiveness of the posterior foraminotomy. In a number of studies, 91 to 98% of the patients have noted good or excellent satisfaction. Unfortunately, these studies included a small number of patients and a short mean follow-up period of only 2.3 years. Furthermore, none of these studies were conducted to explore the imaging progression of cervical spondylosis and to determine the incidence of adjacent-segment disease.

Henderson et al. performed the most comprehensive study of posterior foraminotomy to date. In this retrospective study of 736 patients who underwent 846 procedures, the authors reported an overall patient satisfaction of 91.5%, with a 1.5% incidence of minor operative complications. There was no significant difference in results between patients with hard and soft discs. The same-level recurrence rate was 3.3%, with a 5.2% incidence of radiculopathy at a nonoperated level, and contralateral radiculopathy at any level in 5.6% of patients. Although this study was extensive, adjacent-segment disease was not a specified end point, and the varying follow-up durations were not accounted for in the analysis.

Abbreviations used in this paper: CI = confidence interval; NSAID = nonsteroidal antiinflammatory drug.
Clinical Material and Methods

Between 1972 and 1992, 325 consecutive patients underwent single-level, unilateral posterior cervical foraminotomies for cervical radiculopathy. Twenty-two patients were excluded for several reasons: traumatic radiculopathy, malignant neoplasm, previous cervical surgery, or concomitant posterior arthrodesis.

Typically, the treatment protocol was as follows: a staff surgeon and staff neurologist obtained history, general physical health, and complete neurological data regarding strength, sensation, and reflexes. The indications for operative intervention included failure of cervical orthosis, physical therapy, and NSAID agents to relieve radicular symptoms or weakness. It has been our practice to avoid surgery, especially posterior nonfusion procedures, in patients whose sole complaint was axial neck pain. Unilateral posterior cervical foraminotomy was performed in patients with both soft and hard intervertebral discs. Thus, patients were not included if axial neck pain or imaging-documented cervical instability was noted. Preoperatively, all patients underwent plain radiography and myelography, in addition to computed tomography (after 1980) and magnetic resonance imaging (after 1984). A standard posterior foraminotomy, as previously described,16,17 was performed in all cases. All patients were examined after the procedure. The severity and location of any symptoms, the patient’s work status and level of daily activity, and the findings of a complete neurological examination, which included strength, sensory, and reflex testing, were documented.

Because of the nature of our practice, we believe the majority of patients with radicular symptoms would return to our institution for care. Therefore, to ascertain cases of adjacent- or same-segment disease, each patient’s complete medical record was reviewed. We used the criteria of Hilibrand, et al.,7 in which a diagnosis is based on new radicular symptoms referable to the same or an adjacent degenerated level on two consecutive visits. In addition to patient demographics and characteristics, the time of the event or the date of the last disease-free visit was recorded. Diagnostic reimaging or electromyography was performed when necessary. The outcome of nonoperative and operative treatment of new disease at a same or adjacent level was evaluated using the same criteria.

Finally, overall clinical outcome was described based on the criteria of Smith and Robinson18 and used in the Hilibrand7 study. Specifically, outcomes were described as excellent (no pain, no medication, and normal activity and work status), good (mild pain, occasional NSAID use, and normal activity and work status), fair (moderate pain, frequent NSAID use, restricted activity, and limited work status), and poor (severe pain, narcotic use, incapacitation, and work disability).

Statistical Analysis

Since follow-up durations varied from patient to patient, estimates of adjacent- and same-segment disease-free survival rates were calculated using Kaplan–Meier methods8 with cases censored at death or last follow-up examination, the latter being defined as the last visit to the Mayo Clinic in Rochester. Reported event rates and 95% CIs are based on a formula of 1 minus the Kaplan–Meier estimate. Incidence rates per 1000 person-years at risk of adjacent-segment disease were calculated by multiplying 1000 times the cumulative number of events divided by the total person-years at risk. We did not use the Kaplan–Meier survivorship method for patients complaining only of axial neck pain. Although we are confident that those with radicular symptoms would return to our healthcare system, we believe that patients complaining of only axial pain might seek the treatment of their local primary care physician.

Results

There were 325 single-level, unilateral posterior foraminotomies performed at our institution between 1972 and 1992. Of these, 22 cases were excluded due to lack of information (10 patients), previous cervical surgery (eight patients), trauma (two patients), malignancy (one patient), and protracted workers’ compensation negotiations (one patient), resulting in 303 eligible patients. Of these patients, 188 (62%) were male and 115 (38%) were female (Table 1). The mean age was 49.4 years (range 7.7–81.8 years). Patients underwent follow up for a median of 8.0 years (range 0–33 years). There were six recorded deaths: one at approximately 4 months, one at 8 years, one at 8.5 years, one at 10.5 years, one at 12 years, and one at 29 years. The frequency of surgery at each cervical level is summarized in Fig. 1. Of the 303 surgical procedures performed, a herniated disc was found in 169 patients (55.8%), an osteophyte in 83 (27.4%), and both in 41 (13.5%). Two patients (0.7%) had soft tissue–induced nerve root compression, and no pathological basis for radiculopathy was noted in eight patients (2.6%).

Symptomatic adjacent-segment disease, same-segment disease, or axial neck pain developed in 32 patients (10.6%). In 30 of these patients (9.9%), symptoms developed following a symptom-free period. Of these patients, 18 had increased medication requirements, 22 had an in-

![TABLE 1](image-url)
Postforaminotomy same- and adjacent-segment disease

Symptomatic adjacent-segment disease developed in 15 of the 303 patients, or 4.1/1000 person-years at risk. Kaplan–Meier estimates of 1-, 5-, and 10-year rates of adjacent-segment disease were 0.9% (95% CI 0–2.1%), 1.9% (95% CI 0–3.7%), and 6.7% (95% CI 2.8–10.6%), respectively (Table 2). The disease-free survival curve suggests a relatively stable rate of developing adjacent-segment disease in the 10 years following surgery (Fig. 2 upper).

Of the 15 patients with symptomatic adjacent-segment disease, 13 suffered worse pain and 10 experienced increased weakness. Conservative management involving physical therapy, pain medication, and lifestyle modification was used successfully in six patients. The nine patients in whom conservative treatment failed were offered additional procedures to treat their new disease.

The motion segments at greatest risk of adjacent-level disease were C5–6 and C6–7. Adjacent-segment disease occurred following five of 69 C5–6 procedures and following five of 174 procedures at the C6–7 level.

Same-segment disease developed in 10 of 303 procedures, or 3.9 per 1000 person-years at risk. Among those developing same-segment disease, the median time to the event was 1.2 years (range 0.2–6.9 years). Rates at 1, 5, and 10 years were estimated to be 2.2% (95% CI 0.3–4.1%), 3.2% (95% CI 0.8–5.5%), and 5.0% (95% CI 1.9–8.1%) (Table 3). Figure 2 lower shows estimated same-segment disease-free survival up to 20 years. Among those patients with same-segment disease, nine patients had an ipsilateral radiculopathy, and one patient had a contralateral radiculopathy. Three patients underwent a second surgery to ensure resolution of symptoms, and all returned to their baseline functional and pain status. Of these patients, four had C-6 radiculopathies, five had C-7 radiculopathies, and one had a C-8 radiculopathy.

Seven patients developed symptoms of axial neck pain. Among these, the median time to the postoperative event was 3.9 years (range 0.8–9.9 years). No patient with only axial neck pain underwent reoperation. Of the patients with axial neck pain, three were originally diagnosed with a C-6 radiculopathy, three with a C-7 radiculopathy, and one with a C-8 radiculopathy.

Overall, of the 278 for whom full follow-up information was available, there were 232 excellent and 36 good outcomes (96.4%). Of the patients with new symptoms—either same-segment, adjacent-segment, or axial—17 had excellent outcomes, six had good outcomes, four had fair outcomes, and three were lost to follow up.

**Discussion**

Based on the results obtained in our study, we found a 10-year cumulative incidence of adjacent-segment disease following unilateral posterior foraminotomy of 6.7% and a cumulative incidence of same-segment disease of 5.0%.

Henderson and associates studied the recurrence rate of patients undergoing posterolateral foraminotomy. They noted that recurrent symptoms (ipsilateral same-segment disease) developed in 3.3% of the patients, and symptoms at a nonoperated site developed in 10.8% during a mean follow-up duration of 2.8 years. Unfortunately, there are a number of reasons why it is not possible to compare our results with those obtained in the study by Henderson and colleagues. First, the results of the latter are based on the last follow-up examination, and thus their rate analysis does not account for the varying follow-up lengths. Put simply, there is no survivorship analysis. Second, Henderson and colleagues do not differentiate between nonadjac ent- and adjacent-segment disease, which makes comparison of adjacent-segment disease difficult. Third, the authors excluded patients if disc fragments were removed, whereas 69.2% of the patients in our study had documented discectomy at the time of surgery. Finally, Henderson and colleagues performed one-level procedures in 31.3% of patients, implying that 68% had multilevel or bilateral procedures. In our study, we specifically excluded patients who had undergone multilevel or bilateral procedures to delineate clearly the presence or absence of adjacent-segment disease.

Gore has provided insight into the natural history of cervical spine disease in a study on the incidence of radicul and axial pain in previously asymptomatic patients seen over a 10-year period. Gore was able to follow up 159 patients throughout 10 years. Of these patients, some type of pain developed in 24 patients, of whom 17 (10.7%) had symptoms of axial or posterior neck pain and two (1.3%) had radicular pain. In our study, radicular pain (same- or adjacent-segment disease) developed in 8.2% of

### Table 2

<table>
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<tr>
<th>Year</th>
<th>Cumulative Events</th>
<th>Cumulative Lost to FU</th>
<th>No. at Risk†</th>
<th>KM Event Rate (%)</th>
<th>95% CI</th>
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* FU = follow up; KM = Kaplan–Meier.
† At time zero, 301 patients were at risk. Two patients were excluded because their censor date was unavailable.

![Figure 1](image-url) Bar graph demonstrating the number of patients and the number of treated intervertebral segments.
the patients, and axial neck pain developed in 2.3% of the patients. There are important distinctions between the two studies that we believe account for the differences in the rates of axial neck pain. Symptoms in the Gore study were elicited when a survey was conducted at the end of the 10-year follow-up period. In our study, patients were deemed symptomatic if they presented to their physician twice. In the Gore study, 46% of symptomatic individuals did not see their physician, and 33% with symptoms were treated with over-the-counter pain relievers. It is likely that many of those patients complaining of axial neck pain would not have been included as positive end points in our study. Although not specifically described, four patients had pain following trauma, and this was an exclusion criterion in our study.

In the population-based study conducted by Radhakrishnan and colleagues in Rochester, Minnesota, the annual age-adjusted incidence of radicular symptoms was 83.2/100,000, peaking in the 50 to 54-year age group. The most commonly involved nerve root levels (in descending order) were C-7 (60.3%), C-6 (22.9%), C-5 (8.6%), and C-8 (8.1%). Twenty-six percent of patients eventually required surgery. The demographic features did not differ significantly between our study population and the aforementioned, and they reflect no selection bias toward surgery. Thus, our population represents a clinically relevant cohort of patients. Unfortunately, because Radhakrishnan et al. did not record the incidence of symptoms at a new disc level, we are unable to compare our results with the natural history of cervical radiculopathy.

In the present study, 96.4% of patients had good or excellent outcomes at the final follow-up examination. In addition, recurrent symptoms developed in only 9% of patients. The posterior foraminotomy allows nerve root decompression without loss of a motion segment. Hypothetically, postoperative hypermobility can lead to premature development of further cervical degeneration; our low rates of adjacent- and same-segment recurrent radiculopathy put this claim in doubt. It is possible that our rate of adjacent-segment disease approaches the rate of disease at a nonoperated level.

**Study Limitations**

This study is limited to single-level, unilateral procedures. Cases involving multilevel procedures are not discussed as the cases are too few. In addition, imaging variables are not addressed, as there traditionally has been limited imaging follow-up information. This is a multisurgeon study, however, and we believe this is not limiting because the procedure does not have a steep learning curve and most of the surgeons perform 30 to 50 posterior cervical disc procedures annually at our institution.

Two additional limitations are short follow-up duration for some patients and the potential for informative censoring. Twelve percent of patients had fewer than 10 days of follow up, and 22% had fewer than 100 days of follow up. Because we used time-to-event methods, however, we are not assuming these patients were always event free—rather, only that the event did not occur prior to their last visit. Although patients for whom the follow-up period was short contribute little to the Kaplan–Meier estimates, rather than choosing an arbitrary minimum follow-up duration, we preferred to take into account the known disease-free period for each patient. Although we believe that few, if any, radicular symptoms would be undocumented, this is still a possibility.

As with any retrospective analysis, informative censoring must be considered. We believe that because the majority of patients with recurrent symptoms would return to our institution, it seems likely that our rate estimates are

![Fig. 2. Line graphs showing Kaplan–Meier probability estimates of freedom from adjacent-segment (upper) and same-segment (lower) disease following unilateral posterior foraminotomy.](image)

**TABLE 3**

Kaplan–Meier estimated rates of same-segment disease*

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Posterior laminoforaminotomy is a durable procedure for lateral cervical disc disease.

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References


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