Clinical Study

Surgically treated cervical myelopathy: a functional outcome comparison study between multilevel anterior cervical decompression fusion with instrumentation and posterior laminoplasty

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Received 1 October 2011; revised 25 November 2012; accepted 18 February 2013

Abstract

BACKGROUND CONTEXT: Multilevel cervical myelopathy can be treated with anterior cervical discectomy and fusion (ACDF) or corpectomy via the anterior approach and laminoplasty via the posterior approach. Till date, there is no proven superior approach.

PURPOSE: To elucidate any potential advantage of one approach over the other with regard to clinical midterm outcomes in this study.

STUDY DESIGN: A prospective, 2-year follow-up of patients with cervical myelopathy treated with multilevel anterior cervical decompression fusion and plating and posterior laminoplasty.

PATIENT SAMPLE: In total, 116 patients were studied. Sixty-four patients underwent ACDF two levels and above or anterior cervical corpectomy and fusion one level and above. Fifty-two patients underwent posterior cervical surgery (laminoplasty C3–C6 and C3–C7).

OUTCOME MEASURES: Self-report measures: Japan Orthopedic Association (JOA) score, JOA recovery rate, visual analog scale for neck pain (VASNP), neck disability index (NDI), and American Academy of Orthopaedic Surgeons (AAOS) neurogenic symptom score (AAOS-NSS). Physiologic measures: range of motion (ROM) flexion and extension of neck. Functional measures: short-form 36 (SF-36) score comprising physical functioning, physical role function, bodily pain, general health, vitality, social role function, emotional role function, and mental health scales.

METHODS: Comparison of the JOA scores, JOA recovery rates, NDI scores, SF-36 scores, VASNP, and ROM preoperatively to 2 years. Chi-square and two-sided Student t tests were used to analyze the variables.

FDA device/drug status: Approved

Author disclosures: 
- CS: Nothing to disclose.
- BPBT: Nothing to disclose.
- AS: Nothing to disclose.
- WY: Nothing to disclose.
- SHRK: Nothing to disclose.
- NMSB: Nothing to disclose.
- HRBAR: Nothing to disclose.
- JUTC: Nothing to disclose.
- CMG: Nothing to disclose.
- SBT: Nothing to disclose.
- W-MY: Consulting: Medtronics (B, Paid directly to institution/employer), Depuy (B, Paid directly to institution/employer); Speaking/Teaching Arrangements: Medtronics (B, Paid directly to institution/employer), Depuy (B, Paid directly to institution/employer), Nuvasive (B, Paid directly to institution/employer), Nuvasive (B, Paid directly to institution/employer), Synthes (B).

IRB Approval: Yes.

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RESULTS: Posterior surgery took an hour shorter (p<.05) and had better improvement in JOA scores at early follow-up of 6 months (p=.025). Anterior surgery group had better improvement of NDI scores at early follow-up of 6 months (p=.024) and was associated with less blood loss intraoperatively compared with posterior surgery. There was no statistical difference between the two groups for JOA scores, JOA recovery rates, SF-36 quality-of-life scores, NDI, AAOS-NSS, VAS neck pain, and ROM at 2 years. Complications were higher for anterior surgery group: two hematoma postoperation, one vocal cord paresis, and one new onset C6/C7 dermatome numbness versus one dura leak in posterior surgery group.

CONCLUSIONS: Our study showed that patients with multilevel disease treated with laminoplasty do well and compare favorably with patients treated with an anterior approach. Notably, posterior surgery was associated with shorter operating time, better improvement in JOA scores at 6 months, and a tendency toward lesser complications. Posterior surgery was not associated with increased neck disability and neck pain at 2 years. Anterior surgery had better NDI improvement at early follow-up. There is a need for a larger study that is prospectively randomized with long-term follow-up before we can confidently advocate one approach over the other in the management of cervical myelopathy.

Keywords: Cervical myelopathy; Anterior cervical decompression; Laminoplasty; Functional outcome

Introduction

Cervical spondylotic myelopathy is a disabling disease of the cervical spinal cord. This is usually a direct consequence of circumferential compression because of degenerative processes, often in a congenitally narrowed spinal canal. The disc degeneration with exuberant ossification and osteophytes causes local chronic compression and repeated injury to spinal cord on motion over the affected segment. These injuries and compression, in the long run, lead to direct alteration or injury of neurologic pathways and cause pathophysiologic changes akin to traumatic spinal injury [1].

Unfortunately, the natural history of cervical myelopathy is possibly one of deterioration. Seventy-five percent of patients deteriorate in a stepwise fashion, 20% deteriorate slowly and steadily, and 5% have a rapid onset of symptoms with a stable plateau of dysfunction according to Clarke and Robinson [2]. Most patients will require surgical intervention eventually as a result of significant neurologic impairment. Surgical treatment of cervical myelopathy can be broadly divided into the anterior or posterior approach. Anterior approach includes anterior cervical discectomy and fusion (ACDF) or corpectomy and fusion with strut grafting, whereas laminectomy with or without instrumentation or laminoplasty represents the posterior approach.

Anterior cervical discectomy and fusion is indicated for cervical myelopathy because of soft-disc herniation or spondylosis limited to the disc level. If compression exists because of multisegment ossification of the posterior longitudinal ligament (OPLL), soft disc/spondylosis extending well beyond the level of the disc or other retrovertebral diseases, anterior cervical corpectomy and fusion (ACCF), is possibly indicated.

In recent times, laminoplasty has superseded laminectomy as the standard posterior approach for the treatment of multilevel cervical myelopathy exceeding three levels. This is because of historical poor results and sequelae of laminectomy including segmental instability, kyphosis, perineural adhesions, and late neurologic deterioration [3–8]. Laminoplasty was developed to possibly address the shortcomings of laminectomy with preservation of lamina for load bearing and attachment of paraspinal muscles. It is also aimed at treating long-segment cervical stenosis as an alternative to the anterior approach. Long constructs with the anterior approach have increased reported complications including graft dislodgment, pseudoarthrosis, and instrumentation failures [9–11].

Multilevel cervical myelopathy usually presents with more severe symptoms, and treatment is more difficult. Consensus is still lacking on whether anterior surgery in the form of anterior corpectomy and fusion and ACDF or posterior laminoplasty leads to better outcomes. We aim to elucidate any potential advantage of one approach over the other with regard to clinical midterm outcomes in this study.

Materials and methods

Study design

All patients who underwent ACDF/ACCF or posterior laminoplasty from March 2005 to June 2007 were included in our study. No patients underwent posterior cervical laminectomy and fusion in this study period as this is not a standard procedure for multilevel cervical myelopathy in our institution. The analysis and extraction of data were done after Institution Review Board (IRB) approval. The data were prospectively collected at our institution’s Orthopedic Diagnostic Center that evaluates all patients undergoing spine surgery, both preoperatively and postoperatively at 6 months and 2 years for a variety of functional and clinical
scores relevant to the condition. Retrospective analysis of data was then performed. For this study, strict inclusion criteria were applied. Patients having a history of myelopathic symptoms, with or without radiculopathy (varying degrees of gait instability, stiffness, upper extremity clumsiness, nondermatomal numbness, or weakness), with clinically demonstrable signs (finger escape test/tandem gait test/Hoffman/hyperreflexia/clonus) and MRI findings of at least two-level cervical cord compression were included.

Patients with peripheral neuropathy, Parkinsonism, any known psychiatric illness, previous surgery on the cervical spine, single-level disease, cervical radiculopathy alone, and cervical myelopathy because of infection and other iatrical causes were excluded from the study.

Methods

A total of 116 patients matched the inclusion criteria. The patients were divided into the anterior and posterior surgery groups. The anterior surgery group included patients with two or more levels of ACDF performed or one or more levels of ACCF performed. These two were grouped together as no significant difference has been shown in terms of clinical recovery and fusion for the surgical management of cervical myelopathy [12–15]. Patients in the posterior group underwent cervical laminoplasty, either C3–C6 or C3–C7 levels.

All patients were operated by five spine surgeons with minimum 4 years of experience using similar and standard operative techniques as described subsequently. The decision whether to perform anterior or posterior surgery was left to individual surgeons. However, anterior surgery was not done for patients involving more than three-level disease, whereas posterior surgery was avoided in patients with fixed kyphosis greater than 10° [16,17]. The presence of radiculopathy in addition to myelopathy did not affect the decision to perform anterior or posterior surgery.

Surgical techniques

Anterior surgery

Standard anterior cervical approach was used, and the operative level and type of approach (ACCF vs. ACDF) were predetermined from the preoperative workup. The cervical segment operated was stabilized using either fibular strut allograft or cervical cage filled with autograft and secured with semirigid locking plates. The neck was protected in cervical collar for 2 weeks till the wound healed. The patient was discharged after the drain was removed and ambulating. All patients were managed postoperatively according to our institution's cervical spinal surgery clinical pathway and underwent the same physiotherapy regimen. Fusion was defined as continuous bone across the segment with no movement at that level in flexion and extension.

Posterior surgery

Patients were put in prone position with the neck kept in neutral position by either the Mayfield clamp or Horseshoe support. Double-trapdoor laminoplasty technique without instrumentation was performed with trapdoors secured by sutures to facet capsule. The level of cervical laminoplasty was also determined on preoperative scans and either C3–C7 or C3–C6 levels were decompressed. Patients were encouraged to do range of motion (ROM) exercises as soon as the drain was out and were discharged from the hospital once they were ambulant.

Postoperatively, both groups were managed according to our institution's cervical spinal surgery clinical pathway and underwent the same physiotherapy regimen.

Preoperative and postoperative assessment parameters

The following outcome scales were used for assessment and comparison: Japan Orthopedic Association (JOA) score and JOA recovery rate; visual analog scale for neck pain (VASNP); neck disability index (NDI), short-form 36 (SF-36) score comprising physical functioning, physical role functioning, bodily pain, general health, vitality, social role functioning, emotional role functioning, and mental health scales; and AAOS neurogenic symptom score (AAOS-NSS).

These outcome scores were used preoperatively and at 6 months and 2 years postoperatively. Calculations of JOA scores and NDI were done by blinded observers. In addition, range of motion flexion and extension (ROMFE) of the cervical spine was also calculated using a digital inclinometer, at 6 months and final follow-up.
Statistical analysis

Statistical analysis was performed using SPSS software (version 12). Chi-square and two-sided Student t tests were used to analyze the variables, and p value of <.05 was considered statistically significant.

Results

There were 64 patients in the anterior group (40 males, 24 females) and 52 patients in the posterior group (40 males, 12 females). Eight and 10 patients in the anterior and posterior groups were lost to follow-up, respectively. The mean age of patients in the anterior and posterior groups was 58.6±10.7 and 60.6±10.8, respectively. Twenty-three patients in the anterior group used the fibula strut allograft, and the remaining 41 patients used cages with autograft from the iliac crest.

A presurgical comparison showed that there was no statistical difference (p>.05) between patients who underwent anterior and posterior surgeries (Table 1) in terms of age, body mass index, sex, JOA scores, preoperative scores of SF-36, AAOS-NS, NDI, VAS (neck pain), and ROMFE.

Table 2 shows the distribution of the levels involved in both anterior and posterior surgeries. Most anterior cases were two- and three-level ACDF and one-level corpectomy. In the posterior group, both C3–C6 and C3–C7 laminoplasty were evenly distributed. Almost all the cases in the anterior group had cervical spondylotic myelopathy, with only one case who had myelopathy secondary to OPLL. Twenty-five percent of patients who underwent laminoplasty had myelopathy secondary to OPLL.

The perioperative findings were summarized in Table 3. Anterior surgery lasted on average 62 minutes longer than posterior surgery (186 minutes vs. 123 minutes, p<.05). Length of stay in hospital for patients who underwent anterior surgery was on average 1.7 days shorter than those who underwent posterior surgery (3.7 vs. 5.4, p<.01). The mean blood loss for the anterior group was lesser at 101±54 mL compared with 183±141mL for the posterior group (p<.001).

Improvement in JOA scores, NDI, VASNP, and AAOS-NSS at 6 months postoperatively was observed in the anterior group (Table 4). This improvement was maintained even at the 2-year follow-up (Table 4). All the subscales of the SF-36 score showed an improvement at 6 months and 2 years, except the general health subscale, which showed a small deterioration. However, this is not statistically significant at both 6 months and 2 years. There was a decrease in ROMFE for the patients in the anterior group at 6 months postoperatively, which remains constant up to the 2-year follow-up.

Improvement in JOA scores, NDI, VASNP, and AAOS-NSS at 6 months postoperatively was observed in the posterior group as well and maintained at 2 years postoperatively (Table 5). Notably, there was a big improvement in NDI scores from 6 months (~9.9) to 2 years (~18.1) in our patients in the posterior group. There was a decrease in VASNP at both 6 months and 2 years postoperatively, with a marginal difference between the scores at 6 months and 2 years.
years. There was no significant decrease in ROM flexion and extension in our patients in the posterior group at both 6 months and 2 years postoperatively.

Table 6 showed the direct comparison between the anterior and posterior groups at both 6 and 24 months postoperatively. Patients in the posterior group showed a better improvement in JOA scores compared with the anterior group at the early follow-up at 6 months, whereas patients in the anterior group showed a better improvement in NDI scores compared with the posterior group, and these were statistically different. However, these differences were not statistically significant at 2 years postoperatively (Table 6). Patients in the anterior group showed a significant decrease in ROMFE compared with preoperative values; however, this difference was not statistically significant compared with the posterior group at both 6 months and 2 years (Table 4). There was no statistical difference in the JOA, SF-physical functioning, NDI, VASNP, ROMFE, and AAOS-NS scores between the anterior and posterior groups at the end of 2 years (Table 6). The JOA recovery rates at 6 months were 31.8±42.8 and 37.7±58.5 for group A and group B, respectively. The JOA recovery rates improved at the final follow-up to 51.9±30.9 for the anterior group and 53.1±42.3 for the posterior group. There was no significant difference between the two groups at both 6 months and 2 years in terms of JOA recovery rate (p>.05) (Table 7).

In the anterior group, two patients developed postoperative hematoma, which was surgically evacuated. One patient developed superficial wound infection that was surgically debrided and resolved with intravenous antibiotics. One patient developed vocal cord paresis that resolved after 6 months. At 2 years, we achieved 100% fusion rate for all the patients in the anterior group based on radiologic imaging, and there were no incidence of pseudarthrosis, graft dislodgement, implant failure, or nonunion.

In the posterior group, two patients developed superficial wound infection that was treated with surgical debridement and intravenous antibiotics.

### Discussion

There are several established options in the treatment of cervical myelopathy in the form of anterior and posterior approaches. Numerous studies have established that all these options are beneficial in the near term [18]. Few studies, however, have compared anterior surgery versus laminoplasty by utilization of a group of patient-directed outcome measures for assessment of intervention in multilevel cervical myelopathy [19,20].

In fact, no study has been reported in the literature that specifically compares these two approaches on the quality-of-life outcomes for multilevel cervical myelopathy patients. The purpose of this study was to ascertain the impact of surgery on the functional and quality-of-life outcomes in the patients and thus gauge the effectiveness of one approach over the other for the treatment of multilevel cervical myelopathy.

The SF-36 quality-of-life score, NDI, VAS, and AAOS-NSS are patient-directed scores and have been used extensively and validated in literature to assess the functional outcome in various pathologies, including cervical myelopathy [20–26].
The two study arms of the patient population were similar preoperatively in terms of age, sex, body mass index, and functional scoring. There was no statistical difference in the JOA, NDI, VAS, AAOS-NS, and SF-36 scores, and ROM between patients in the 2 groups.

There was significant improvement in patient outcome scores for both the anterior and posterior groups as early as 6 months that was maintained at 24 months follow-up. For the anterior group, there was significant improvement in JOA and NDI scores and also SF-36 scores with the exception of the general health component both at 6 months and 2 years. Patients in the posterior group had significant improvement in JOA scores, NDI, VASNP, AAOS-NS, and SF-36 scores at all studied time lines. Laminoplasty, however, yielded significantly better results in terms of JOA scores at 6 months compared with anterior surgery. The better improvement in JOA scores in the short term for laminoplasty could be because of the more expansive decompression in terms of number of levels decompressed.

Patients in the posterior group did not have as great an improvement in NDI scores at 6 months. This may be because of the extensive muscle dissection in the posterior approach leading to short-term pain. Patients in the anterior group had better improvement in NDI at 6 months that could be because of the better stability afforded by the graft and plate fixation in the short term. At 2 years, patients with laminoplasty did not have any difference in the NDI compared with the anterior group. This may be because of healing of the soft tissues dissected and decreased ROM achieved compared with preoperative level.
The most commonly cited disadvantage of posterior laminoplasty in comparison with anterior cervical surgery is decreased ROM in the short term and increased axial neck pain in the long term. Wada et al. [27] and Hosono et al. [28] have shown significant higher rate of axial neck pain in laminoplasty group compared with anterior surgery for cervical myelopathy. Posterior surgery involves more extensive dissection compared with anterior surgery, and logically this might have an impact on postoperative pain and recovery. However, our study revealed that patients who underwent laminoplasty had improved VASNP scores, which were statistically significant at both 6 months and 2 years postsurgery. This was comparable with the anterior group. Our study reveals that the effect of dissection may only be limited to the first 6 months, and there is no difference in terms of pain and disability between the anterior and posterior groups at 2 years. Edwards et al. [29] and Yoshida et al. [30] also reported similar axial neck pain complaints in both groups. Recently Liu et al. [31] reported a low 3.7% incidence of axial neck pain in patients who underwent cervical laminoplasty, comparable with those who underwent multilevel, anterior instrumented fusion surgery.

The ROMFE was reduced in both groups postoperatively, but this reduction was more in the anterior group compared with the posterior group. Posterior laminoplasty allows for better cervical movement preservation compared with the anterior group. This can be attributed to early initiation of range of movement neck exercises, absence of fusion, and the technique of laminoplasty, where careful preservation of attachments at C2 and C7 were done wherever possible. An increased reduction in ROM in the anterior group may also result in better NDI scores compared with the posterior group at 6 months.

Laminoplasty yielded significantly better results in terms of JOA scores at 6 months compared with anterior surgery. The better improvement in JOA scores in the short term for laminoplasty could be because of the more expansive decompression achieved.

Japan Orthopedic Association recovery rate was also superior for the posterior laminoplasty group at 6 months. However, this difference in JOA recovery rate was not statistically significant and could be attributed to the small sample size. At 2-year follow-up, both the anterior and posterior groups had similar JOA recovery rates. The mean JOA recovery rate at 2 years for our series (52%) was comparable with that of several other studies that varied from 20% to 76% [32]. Some studies have compared anterior surgery with laminoplasty. Iwasaki et al. [33] studied myelopathic patients with one-level disc disease who were treated with either ACDF or laminoplasty and found JOA scale score recovery rates of 93% and 81%, respectively. Sakaura et al. [34] in a similar study found JOA scale score recovery rates of 71% for ACDF and 70% for laminoplasty. There are other studies that have compared laminoplasty with ACCF. At 15-year postsurgery, Wada et al. [27] found JOA scale score improvements of 5.5 for ACCF and 4.8 for laminoplasty, respectively. Yonenobu et al. [11] reported 42 patients with French window laminoplasty versus ACCF and found 44% and 55% improvements in JOA scale scores, respectively. There is currently insufficient evidence to recommend ACDF or ACCF over laminoplasty because improvements are comparable posturgery.

Posterior laminoplasty requires more extensive dissection, which resulted in a significantly higher amount of blood loss for the posterior group (183 mL) compared with the anterior group (101 mL). This contrasted with the findings of Wada et al. [27] and Edwards et al. [29] who reported statistically significant higher blood loss in the anterior group (264 mL) compared with the posterior laminoplasty groups (182 mL). Their higher blood loss could be attributed to the multilevel corpectomy done in their studies, whereas in our study, the anterior group consisted of both multilevel ACDF and ACCF, hence the lower mean blood loss.

In terms of recovery, our patients with laminoplasty stayed more days in hospital compared with the anterior group. Operative time, however, was shorter for laminoplasty compared with anterior surgery. This is not surprising as laminoplasty is a technically faster operation than multilevel ACDF or corpectomy.

Complication rates were higher for the anterior group compared with the posterior group; however, the overall complication rate for our center was low. There were no fusion-related complications in the anterior group, which contrasted in comparison with other series, which reported an incidence of implant failure, nonunion, and graft dislodgement ranging from 25% to 53% [9,10,35].

The main complications encountered in the anterior group were postoperative hematoma (two cases), which resolved with surgical evacuation, superficial wound infection (one case), and vocal cord paresis (one case). The posterior group had two cases of superficial wound infection. The average and general complication rates (C5 palsy and posterior arch collapse) reported by other authors for laminoplasty are in the region of 8% to 13% [6,27,29,36–40].

We speculate that multilevel anterior surgery has a higher risk of hematoma formation because of the greater potential space in the anterior neck, which increases the risk of blood collection, and thus hematoma formation.
Cunningham et al. [41] concluded that laminoplasty has fewer complications, possibly greater ROM and similar neurologic recovery compared with ACDF and ACCF in her systematic review of cohort studies comparing surgical treatments for cervical spondylotic myelopathy, similar to the outcomes of our study.

Our study had several limitations. The patients were not randomized to the surgical procedure they underwent. The type of surgical procedure to be performed was surgeon dependent. The number of levels compared was different as anterior surgery involved slightly fewer levels compared with posterior surgery. Notwithstanding the possibility that the posterior group had more extensive disease, the outcomes still suggest that posterior surgery compares favorably with anterior surgery. There was also a larger proportion of patients with OPLL in the posterior group. The number of patients in the study were also small involving a total of 116 patients. We had 8 patients in the anterior group and 10 patients in the posterior group that were lost to follow-up, and this was a significant figure that could possibly lead to bias in this outcome study. Regrettably, we did not analyze and compare the preoperative medical comorbidities of our patients between the two groups that could possibly have an impact on the clinical outcomes and recovery. Most patients in the anterior group underwent two-level ACDF or one-level corpectomy, whereas the posterior group comprises patients who underwent three or more levels of laminoplasty, with 25% having OPLL. We acknowledged that the posterior group had disease involving a greater number of levels on average compared with the anterior group. However, in terms of preoperative JOA, AAOS-NS, and SF-36 scores, they were comparable. Adequate and appropriate decompression was achieved for both groups with either anterior or posterior surgery. Despite having achieved good surgical decompression for both groups, patients with posterior decompression did better at 6 months in terms of improvement in JOA scores although the disease was more extensive. It would have been ideal if the number of segments decompressed for both groups were similar. Our results, do, however show that with appropriate and adequate decompression achieved using either the anterior or posterior approach, the posterior group exhibited better neurologic recovery in terms of JOA score in the short term. Hence, we conclude that posterior laminoplasty is a good and viable alternative to longer anterior constructs in the surgical management of cervical myelopathy.

In conclusion, our results demonstrated that patients with multilevel cervical myelopathy when treated with laminoplasty do well and compare favorably with patients treated with an anterior approach at the midterm follow-up of 2 years. Notably, posterior surgery was associated with shorter operating time, better improvement of JOA score at 6 months, better ROM, and a tendency toward fewer complications. Neck pain and disability is not a problem with posterior surgery at 2 years. As Cunningham et al. [41] concluded, there is a need for a larger study that is prospectively randomized before we can confidently advocate one approach over the other in the management of cervical myelopathy.

References


