Anterior corpectomy versus posterior laminoplasty: is the risk of postoperative C-5 palsy different?

Gurpreet Gandhoke, M.D.,1 Jau-Ching Wu, M.D.,1–3 Nathan C. Rowland, M.D., Ph.D.,1 Scott A. Meyer, M.D.,1 Camilla Gupta, B.A.,1 and Praveen V. Mummaneni, M.D.1

1Department of Neurological Surgery, University of California, San Francisco, California; 2Department of Neurosurgery, Neurological Institute, Taipei Veterans General Hospital; and 3Institute of Pharmacology, School of Medicine, National Yang-Ming University, Taipei, Taiwan

Object. Both anterior cervical corpectomy and fusion (ACCF) and laminoplasty are effective treatments for selected cases of cervical stenosis. Postoperative C-5 palsies may occur with either anterior or posterior decompressive procedures; however, a direct comparison of C-5 palsy rates between the 2 approaches is not present in the literature. The authors sought to compare the C-5 palsy rate of ACCF versus laminoplasty.

Methods. The authors conducted a retrospective review of 31 ACCF (at C-4 or C-5) and 31 instrumented laminoplasty cases performed to treat cervical stenosis. The demographics of the groups were similar except for age (ACCF group mean age 53 years vs laminoplasty group mean age 62 years, p = 0.002). The mean number of levels treated was greater in the laminoplasty cohort (3.87 levels) than in the ACCF cohort (2.74 levels, p < 0.001). The mean preoperative Nurick grade of the laminoplasty cohort (2.61) was higher than the mean preoperative Nurick grade of the ACCF cohort (1.10, p < 0.001).

Results. The overall clinical follow-up rate was 100%. The mean overall clinical follow-up was 15 months. There were no significant differences in the estimated blood loss or length of stay between the 2 groups (p > 0.05). There was no statistical difference between the complication or reoperation rates between the 2 groups (p = 0.184 and p = 0.238). There were 2 C-5 nerve root pareses in each group. Three of the 4 patients recovered full deltoid function, and the fourth patient recovered nearly full deltoid function at final follow-up. There was no statistical difference in the rate of deltoid paresis (6.5%) between the 2 groups (p = 1).

Conclusions. Both ACCF and laminoplasty are effective treatments for patients with cervical stenosis. The authors found no difference in the rate of deltoid paresis between ACCF and laminoplasty to treat cervical stenosis.

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Key Words • cervical laminoplasty • anterior cervical corpectomy and fusion • C-5 palsy • deltoid palsy

Temporary C-5 paresis or palsy involving the deltoid and/or biceps brachii muscles may occur after cervical spinal surgery. The actual etiology, risk factors, and prognostic factors for C-5 palsy remain uncertain. The incidence has been frequently reported in series of cervical decompression surgery to range from 0% to 17%,34,36,37

Both ACCF and laminoplasty are accepted procedures to treat cervical stenosis.10,18–21 In the literature, there are currently more reports of C-5 palsy with posterior cervical decompression surgery than with anterior cervical surgery.3,6–9,12–15,17,22,29,30,35,36 However, anterior cervical decompressive procedures such as ACDF or ACCF have also been reported to be associated with postoperative C-5 palsy.3,5,7,27,34,36,37 Despite the knowledge that a C-5 palsy is a risk of either procedure, the relative risk of C-5 palsy with anterior versus posterior surgery remains uncertain.

We hypothesized that there would be no difference in the postoperative C-5 palsy rate between ACCF and instrumented open-door laminoplasty.

Methods

Patient Demographics

We reviewed the records of all patients with cervical stenosis involving the C4–5 level who were treated with ACCF or laminoplasty between 2006 and 2011. All operations were performed by a single neurosurgeon (PVM). Patients with traumatic fractures of the cervical spine, prisoners, and patients with tandem neurological conditions such as polio were excluded. Between 2006
and 2011, 62 consecutive patients who met the inclusion and exclusion criteria were selected. Of this total group, 31 had undergone ACCF and 31 had undergone laminoplasty (Table 1).

**Anterior Cervical Corpectomy and Fusion Group.** All 31 patients undergoing ACCF had 2 or more levels of stenosis (involving C4–5 due to OPLL) (in 9) or degenerative spondylosis (in 22). Eight patients had a C-4 corpectomy, 22 patients had a C-5 corpectomy, and 1 patient had C-4 and C-5 corpectomies. Of the 8 C-4 corpectomy patients, 1 also had a nonadjacent C-6 corpectomy and 3 had an additional adjacent ACDF. Of the 22 patients who had C-5 corpectomies, 4 patients also had concomitant C-6 corpectomies and 8 had an additional adjacent ACDF (Fig. 1).

There were 18 male patients and 13 female patients in this group, with a mean age of 53 years. The mean number of levels treated (disc spaces) was 2.7. The mean preoperative and postoperative Nurick grades were 1.10 and 0.74, respectively.

**Laminoplasty Group.** During the same period, the senior author (P.V.M.) performed 31 laminoplasty operations in patients with cervical stenosis due to either OPLL or degenerative spondylosis that included decompression of the C4–5 spinal canal level. All patients had 3 or more levels of stenosis, and none had cervical kyphosis. Patients who required extension of decompression to C-2 or T-1 with fusion were not included in this cohort.

The mean age in the laminoplasty group was 62 years. There were 24 male patients and 7 female patients. A mean of 3.87 levels were treated. Of the 31 patients who underwent laminoplasty, 15 had degenerative spondylosis and 16 had segmental OPLL.

There was no statistical difference regarding sex between the laminoplasty and ACCF groups (p > 0.05), but there was a statistically significant difference between the ages of the patients in the laminoplasty cohort (mean age 62 years) and the ACCF cohort (mean age 53 years) (p = 0.002). The mean preoperative Nurick grade in the laminoplasty cohort (2.61) was significantly higher (p < 0.001) than the preoperative Nurick grade (1.10) in the ACCF cohort (Table 2).

**Patient Assessment**

**Perioperative Data.** Perioperative data were collected for all patients and included EBL, number of levels treated, LOS, complications, and reoperations. Intraoperative monitoring with somatosensory and motor evoked potentials and electromyography was performed during all index surgeries. The incidence of postoperative C-5 paresis was also documented.

**Clinical Outcome.** Deltoid paresis/palsy was evaluated using the MRC scoring system. Overall functional outcomes were evaluated by comparing preoperative and postoperative Nurick grades.

**Statistical Analysis**

Continuous data were analyzed using standard parametric and nonparametric tests. Categorical data were evaluated using contingency table analysis. A p value < 0.05 was considered statistically significant.

**Surgical Technique**

**Anterior Cervical Corpectomy and Fusion Group.** All patients underwent a minimum of a C-4 and/or C-5 ACCF with the use of a PEEK cage, local autograft, and anterior plate fixation. Additional stenotic levels were decompressed with either ACDF or another level of ACCF during the same operation.

The corpectomy was performed using a drill, and the adjacent discs were removed using curettes and pituitary rongeurs. The bone from the corpectomy was used as local autograft. A matchstick drill bit was used to drill down to the posterior longitudinal ligament. The posterior longitudinal ligament was elevated using a blunt tip nerve hook, which was then incised and removed to thoroughly decompress the dura. In cases of OPLL, a central region of ossification was occasionally left in place if a plane could not be easily developed between the OPLL and dura. The superior and inferior posterior lip were then removed using the matchstick drill bit and undercut with a Kerrison rongeur. Bilateral foraminotomies were performed at each level to ensure adequate foraminal decompression. The corpectomy cage size was then determined using a trial, and the appropriate PEEK cage filled with local autograft was placed. Anterior plate fixation was performed using a nontranslational plate (Atlantis, Medtronic) with the use of variable screws on the superior fixation points and fixed screws on the inferior fixation point (Fig. 2).

**TABLE 1: Inclusion and exclusion criteria for the ACCF and laminoplasty groups**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>ACCF</th>
<th>Laminoplasty</th>
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<tr>
<td>inclusion</td>
<td>degenerative cervical spinal canal stenosis or OPLL w/ ant compression involving the C-4 &amp;/or C-5 levels</td>
<td>multi-level cervical spinal canal stenosis due to degenerative spondylosis or OPLL involving the C-4 &amp; C-5 levels</td>
</tr>
<tr>
<td>exclusion</td>
<td>prior ant cervical op involving the C4–5 level</td>
<td>prior posterior cervical op involving the C4–5 level</td>
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<tr>
<td></td>
<td>traumatic fractures of the cervical spine</td>
<td>traumatic fractures of the cervical spine</td>
</tr>
<tr>
<td></td>
<td>extension of compression levels to C-2 or T-1</td>
<td>extension of compression levels to C-2 or T-1</td>
</tr>
<tr>
<td></td>
<td>other neurological diseases (e.g., polio, MS, &amp; CMT disease)</td>
<td>other neurological diseases (e.g., polio, MS, &amp; CMT disease)</td>
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<tr>
<td></td>
<td>cervical kyphosis</td>
<td>cervical kyphosis</td>
</tr>
<tr>
<td></td>
<td>posterior cervical fusion</td>
<td>posterior cervical fusion</td>
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* ant = anterior; CMT = Charcot-Marie-Tooth; MS = multiple sclerosis.
Laminoplasty Group. There are several commonly used techniques for laminoplasty, including single- and double-hinged door with or without instrumentation. All patients underwent open-door laminoplasty with titanium miniplates (Centerpiece, Medtronic) without bone graft. A drill with a matchstick bur was used to open the hemilamina on the side with more symptoms. A shallow trough was scored on the contralateral hemilamina with the same drill bit, and this side was used as a hinge to open the laminoplasty. The hinged, open-door laminoplasty was secured using a preshaped titanium miniplate, and small screws were placed through the plate apertures into the lateral mass on one side and into the opened hemilamina on the other side. An additional unilateral posterior foraminotomy on the plated side was carried out only if cervical radiculopathy was also present. Patients underwent laminoplasty from C-3 to C-5, C-6, or C-7 depending on the extent of the stenosis (Fig. 3).

Results

The clinical follow-up rate of all patients was 100%. The mean clinical follow-up period was 15 months (12 months for ACCF patients and 18 months for laminoplasty patients). Of the total 62 patients, 4 developed deltoid paresis. Three of the 4 patients recovered full deltoid function, and the fourth patient recovered nearly full deltoid function at final follow-up. Three of the 4 patients developed deltoid paresis immediately postoperatively, and the remaining patient developed deltoid paresis on the next day following a reoperation for a collapsed laminoplasty segment. Three of the 4 patients had a severe deltoid paresis (MRC motor Grade 1–2/5) and the remaining patient had a mild deltoid paresis (MRC motor Grade 3/5). In the ACCF group, the deltoid paresis rate was 6.5% (2 deltoid pareses). One of these cases had full recovery of deltoid function, but the other patient had only a partial recovery (MRC motor Grade 4/5) of deltoid function. The deltoid paresis rate for the laminoplasty group was also 6.5% (2 deltoid pareses). These resolved completely by 18 months postoperatively (Table 3).

Perioperative Data

The mean number of levels treated in the ACCF group was 2.7. The mean EBL was 278 ml, and the mean hospital stay was 3.8 days. Six patients developed postoperative dysphagia, and 1 patient required temporary nasogastric tube placement. All dysphagia cases resolved completely. There were no infections or reoperations in the ACCF group.
Intraoperative monitoring with somatosensory and motor evoked potentials and electromyography was used during all index surgeries. We found that only 1 of the 4 patients with deltoid palsy had an intraoperative decrease in motor evoked potentials, but this occurred during the corpectomy and not during the nerve root decompression portion of the procedure. The remaining 3 patients did not show any change on intraoperative monitoring.

The mean number of levels treated for the laminoplasty group was 3.87. The mean EBL was 171 ml, and the mean hospital stay was 3.8 days. The reoperation rate for the laminoplasty group was 9.7% (2 wound infections and 1 collapsed laminoplasty segment that caused restenosis). The patients with wound infections were treated with a wound debridement, and all hardware was left in place. These patients were given 6 weeks of intravenous antibiotics followed by 12 months of oral antibiotics. In the patient with the collapsed laminoplasty segment, the hinged side of C-4 had fractured into the spinal canal. This was corrected by performing a laminectomy of C-4. This patient then developed a temporary C-5 nerve root paresis 1 day after the reoperation (1 of the 2 patients with a deltoid paresis in the laminoplasty group). There were no perioperative deaths, but during the follow-up period, 3 patients (all in the laminoplasty group) died of causes not related to the surgery. As previously noted, the laminoplasty group was significantly older and had more severe myelopathy than did the ACCF group.

**Clinical Measurement**

There were no significant differences in the EBL and the LOS between the 2 groups (p > 0.05), and the overall complication rate between the 2 groups was not statistically different. The rate of reoperations (0% for ACCF and 9.7% for laminoplasty, p = 0.238) was not significantly different between the groups. There was no difference in the rate of deltoid paresis (p = 1) between the 2 groups. There was a statistically significant improvement in the Nurick grades for the laminoplasty group (p < 0.001). The Nurick grades for the ACCF group also improved, but this trend did not reach statistical significance (p = 0.144).

**Discussion**

The etiology of postoperative C-5 paresis is not known. Potential causes include local nerve root trauma during surgery, nerve root traction caused by shifting of the cord following decompression surgery (that is, the “tethering phenomenon”), or spinal cord ischemia due to decreased blood supply from radicular arteries.2,11,26 None of the above hypotheses has been proven, and evidence to refute each can be found in the literature.

The fact that the C-5 root appears highly susceptible to injury may be related to several anatomical features of the cervical spine. First, the superior articular process of C-5 protrudes in a more anterior direction than at other levels, and the rootlets of C-5 are shorter than those of other segments. Furthermore, the C-5 segment is usually the point at which the extent of posterior shift of the cord is greatest. Using cadavers, Tsuzuki et al.32,33 demonstrated that impingement of the nerve root occurs inside the uncovertebral joint with backward shifting of the spinal cord after laminoplasty.

In a literature review of C-5 palsy after decompression...
Risk of postoperative C-5 palsy

Sakaura et al. reported that 92% of C-5 palsies occur unilaterally, and the remaining 8% affect muscles bilaterally. The vast majority of C-5 palsies occur within a week after surgery. Paresis of C-6, C-7, or C-8 in isolation or combination has been reported with a much lower incidence, although some of these patients may actually have had a brachial plexitis rather than a nerve root palsy.

A C-5 palsy may occur on a spectrum from immediately postoperatively up to several weeks after the surgery. Komagata et al. reported a series of 305 patients undergoing laminoplasty, of whom 13 developed postoperative C-5 palsy; in 4 of these 13 patients, the onset of motor palsy occurred on the day of the surgery. In another recent paper, Nassr et al. included patients undergoing multilevel cervical corpectomy, corpectomy with posterior fusion, posterior laminectomy and fusion, and laminoplasty. The overall incidence of C-5 nerve palsy was 42 of 630 cases, and, as the authors stated, "the time of initial onset of the C-5 palsy symptoms ranged from immediately postoperatively to 2 months postoperatively."

Sakaura et al. reported that the overall rates of differences in recovery for severe (grade of muscle power of 1–2 of 5 on manual muscle testing) and mild (grade of muscle power 3–4/5) cases of deltoid paresis were not statistically significant, and patients with C-5 palsy generally experienced neurological and functional recovery.

We defined C-5 palsy strictly as motor paresis of the deltoid muscle and did not include sensory deficits in the C-5 distribution. In our study, we had 2 cases of deltoid paresis in both of the ACCF and the laminoplasty groups. All of the 4 cases were unilateral. Three of the 4 cases had immediate postoperative deltoid paresis, and the other patient developed a deltoid paresis 1 day after he underwent revision surgery to repair a collapsed laminoplasty segment.

In our series, we had 1 case of mild (MRC motor Grade 3–4/5) and 3 cases of severe (MRC motor Grade 1–2/5) deltoid pareses. At final follow-up, 3 of the 4 cases of deltoid paresis recovered fully, and the fourth patient (who had severe MRC motor Grade 1/5 deltoid paresis after an ACCF) recovered strength to an MRC motor grade of 4/5.

Overall, we found no significant differences in the rates of deltoid paresis between patients undergoing ACCF and those undergoing laminoplasty to treat cervical stenosis.

TABLE 3: Postoperative MRC grades of deltoid palsy and their time to complete improvement

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Patients w/ Deltoid Palsy</th>
<th>Postop Grade of Deltoid Palsy</th>
<th>Immediately Postop</th>
<th>At Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCF</td>
<td>2</td>
<td>1 (3/5); 1 (2/5)</td>
<td>5/5 at 5 mos; 4/5 at 9 mos</td>
<td></td>
</tr>
<tr>
<td>Laminoplasty</td>
<td>2</td>
<td>1 (2/5); 1 (2/5)</td>
<td>5/5 at 12 mos; 5/5 at 18 mos*</td>
<td></td>
</tr>
</tbody>
</table>

* This patient recovered after the second operation on postlaminoplasty Day 2 for a collapsed laminoplasty segment.

However, the latency between the onset of the C-5 paresis and recovery to a useful level (< 3, 3–6, and > 6 months) was significantly longer for the severe cases than for the mild cases.

Conclusions

We found that ACCF and laminoplasty procedures lead to neurological improvements in myelopathic patients. The rate of C-5 paresis appears to be similar in patients with cervical stenosis undergoing decompression surgery with either ACCF or laminoplasty involving the C-5 level, although time to improvement in the laminoplasty group was longer than in the ACCF group. Patients with postoperative C-5 paresis generally have a good prognosis for functional recovery, but the cases of severe deltoid paresis (grade of muscle power 1–2/5) require a longer time to recover than do the mild cases.

Disclosure

Dr. Mummaneni is a past consultant for DePuy Spine and Medtronic. He receives other financial support (royalties) from DePuy Spine and Quality Medical Publishers.
Author contributions to the study and manuscript preparation include the following. Conception and design: Wu, Mummaneni. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Drafting the article: Wu, Gandhoke, Rowland, Meyer. Critically revising the article: Wu, Gandhoke, Rowland, Mummaneni. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Wu. Statistical analysis: Wu, Gandhoke, Meyer. Administrative/technical/material support: Mummaneni. Study supervision: Mummaneni.

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Current affiliation for Dr. Meyer: Atlantic Neurosurgical Specialists, Morristown, New Jersey.
Address correspondence to: Jau-Ching Wu, M.D., Department of Neurosurgery, Neurological Institute, Taipei Veterans General Hospital, Room 509, 17F, No. 201, Shih-Pai Road, Sec. 2, Beitou, Taipei 11217, Taiwan. email: jauching@gmail.com.