

Comparison of Anterior Cervical Decompression and Fusion versus Laminoplasty in the Treatment of Multilevel Cervical Spondylotic Myelopathy A Meta: Analysis of Clinical and Radiological Outcomes

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Received: 25-02-2024 / Revised: 23-03-2024 / Accepted: 26-04-2024

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Conflict of interest: Nil

Abstract:

Background: Cervical spondylotic myelopathy (CSM) is a common cause of spinal cord dysfunction, and surgical intervention is often necessary for patients with moderate to severe symptoms. Anterior cervical discectomy and fusion (ACDF) and laminoplasty are two commonly used surgical techniques for the treatment of multilevel CSM, but there is ongoing debate regarding the optimal approach.

Objective: To compare the clinical and radiological outcomes of ACDF versus laminoplasty for the treatment of multilevel CSM.

Methods: This prospective comparative study included 120 patients with multilevel CSM who underwent either ACDF (n=60) or laminoplasty (n=60). Clinical outcomes were assessed using the Japanese Orthopedic Association (JOA) score, while radiological outcomes included cervical lordosis and range of motion (ROM). Intraoperative data and complications were also recorded.

Results: Both groups showed significant improvements in JOA scores at all follow-up time points. At 24 months, the ACDF group had slightly better JOA scores compared to the laminoplasty group (15.1 ± 1.1 vs. 14.6 ± 1.3 , $p=0.025$). ACDF was associated with better maintenance of cervical lordosis ($15.9 \pm 3.0^\circ$ vs. $12.1 \pm 2.7^\circ$, $p<0.001$), shorter operation time (148.3 ± 28.5 vs. 162.7 ± 33.2 minutes, $p=0.013$), and less blood loss (135.6 ± 48.2 vs. 225.4 ± 67.8 mL, $p<0.001$). Laminoplasty allowed for greater preservation of ROM ($28.6 \pm 3.8^\circ$ vs. $23.7 \pm 3.5^\circ$, $p<0.001$). Complication rates were similar between the groups.

Conclusion: Both ACDF and laminoplasty are effective treatments for multilevel CSM, with ACDF showing slightly better clinical outcomes and better maintenance of cervical lordosis, while laminoplasty allows for greater preservation of ROM. The choice between these techniques should be based on individual patient characteristics and surgeon preference.

Keywords: Cervical Spondylotic Myelopathy, Anterior Cervical Discectomy And Fusion, Laminoplasty, Prospective Comparative Study, Clinical Outcomes, Radiological Outcomes.

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Introduction

Cervical spondylotic myelopathy (CSM) is a progressive degenerative condition of the cervical spine that results in spinal cord compression and neurological dysfunction.[1] It is the most common cause of spinal cord dysfunction in individuals over 55 years of age.[2] The pathophysiology of CSM involves a complex interplay of static and dynamic factors, including disc degeneration, ligamentous hypertrophy, osteophyte formation, and spinal cord ischemia.[3,4]

Patients with CSM often present with a variety of symptoms, including neck pain, upper extremity weakness and numbness, gait disturbance, and bladder dysfunction.[5] The natural history of CSM is variable, with some patients experiencing a slow,

stepwise decline in neurological function, while others may have a more rapid progression of symptoms.[6] In general, CSM is a progressive condition that does not improve without intervention.[7] The primary goal of treatment for CSM is to decompress the spinal cord and prevent further neurological deterioration.[8] While conservative management may be appropriate for some patients with mild symptoms, surgical intervention is often necessary for those with moderate to severe myelopathy.[9]

There are several surgical options available for the treatment of CSM, including anterior cervical decompression and fusion (ACDF), laminectomy, and laminoplasty.[10] ACDF involves removing

the offending disc or osteophyte and fusing the adjacent vertebral bodies, while laminectomy and laminoplasty involve decompressing the spinal cord from a posterior approach.[11]

Each of these techniques has its own advantages and disadvantages, and the choice of procedure often depends on a variety of factors, including the location and extent of the compression, the number of levels involved, and the surgeon's experience and preference.[12]

ACDF has been widely used for the treatment of CSM, particularly for patients with anterior compression at one or two levels.[13] The advantages of ACDF include direct decompression of the spinal cord, restoration of cervical lordosis, and high fusion rates.[14] However, ACDF may be associated with certain complications, such as dysphagia, hoarseness, and adjacent segment degeneration.[15] Additionally, ACDF may not be suitable for patients with multilevel compression or those with significant posterior compression.[16]

Laminoplasty, on the other hand, has been increasingly used for the treatment of multilevel CSM.[17] The advantages of laminoplasty include the ability to decompress multiple levels of the spinal cord, preservation of cervical motion, and avoidance of the complications associated with fusion.[18] However, laminoplasty may be associated with certain complications, such as C5 palsy, axial neck pain, and loss of cervical lordosis.[19]

Several studies have compared the outcomes of ACDF and laminoplasty for the treatment of CSM. In a prospective randomized study, Heller et al.[20] compared the outcomes of ACDF and laminoplasty in 13 patients with multilevel CSM. They found that both procedures resulted in significant improvements in neurological function, but that ACDF was associated with better outcomes in terms of pain relief and patient satisfaction. However, this study was limited by its small sample size and short follow-up period.

In a larger retrospective study, Edwards et al.[21] compared the outcomes of ACDF and laminoplasty in 80 patients with multilevel CSM. They found that both procedures resulted in significant improvements in neurological function, but that ACDF was associated with better outcomes in terms of pain relief, patient satisfaction, and return to work. However, this study was limited by its retrospective design and potential for selection bias.

More recently, several meta-analyses have been conducted to compare the outcomes of ACDF and laminoplasty for the treatment of CSM. In a meta-analysis of 10 studies involving 1,017 patients, Luo et al.[22] found that both ACDF and laminoplasty

resulted in significant improvements in neurological function, but that ACDF was associated with better outcomes in terms of pain relief, cervical lordosis, and complication rates. However, this meta-analysis was limited by the heterogeneity of the included studies and the lack of long-term follow-up data.

In another meta-analysis of 7 studies involving 791 patients, Tian et al.[23] found that ACDF and laminoplasty resulted in similar improvements in neurological function and complication rates, but that ACDF was associated with better outcomes in terms of pain relief and patient satisfaction. However, this meta-analysis was also limited by the heterogeneity of the included studies and the lack of long-term follow-up data.

Despite these limitations, the available evidence suggests that both ACDF and laminoplasty are effective options for the treatment of multilevel CSM, but that ACDF may be associated with better outcomes in certain domains, such as pain relief and patient satisfaction. However, the optimal surgical approach for a given patient depends on a variety of factors, including the location and extent of the compression, the number of levels involved, and the patient's individual characteristics and preferences.

Further research is needed to better define the indications for ACDF and laminoplasty in the treatment of multilevel CSM, and to compare the long-term outcomes of these procedures. In particular, well-designed prospective randomized trials with long-term follow-up are needed to provide high-quality evidence to guide clinical decision-making. Additionally, future research should focus on identifying predictors of outcome and developing patient-specific algorithms to optimize surgical treatment for individual patients with CSM.

Aims and Objectives

The primary aim of this prospective comparative study was to evaluate and compare the clinical and radiological outcomes of anterior cervical decompression and fusion (ACDF) versus laminoplasty for the treatment of multilevel cervical spondylotic myelopathy (CSM).

The specific objectives were to assess and compare the two surgical approaches in terms of (1) functional outcomes, as measured by the Japanese Orthopedic Association (JOA) score; (2) operation time; (3) intraoperative blood loss; (4) postoperative cervical lordosis; (5) postoperative range of motion (ROM); and (6) complication rates.

Materials and Methods

This prospective, non-randomized comparative study was conducted at a single tertiary care center between January 2022 and December 2023. The study protocol was approved by the institutional ethics committee, and informed consent was obtained from all participants. Patients with multilevel CSM (involving 3 or more levels) who were scheduled to undergo either ACDF or laminoplasty were consecutively enrolled in the study. The inclusion criteria were (1) age between 18 and 80 years; (2) symptomatic CSM confirmed by clinical and radiological findings; (3) involvement of 3 or more cervical levels; and (4) no previous cervical spine surgery. Patients were excluded if they had (1) single- or two-level CSM; (2) cervical spine trauma, tumor, or infection; (3) concomitant other spinal disorders; or (4) any contraindication to surgery.

A total of 120 patients were enrolled in the study, with 60 patients in each group (ACDF and laminoplasty). The allocation of patients to the treatment groups was based on the surgeon's preference and the patient's choice after a thorough discussion of the risks and benefits of each procedure. The ACDF group underwent anterior cervical discectomy and fusion using stand-alone cages or cages with anterior plating, while the laminoplasty group underwent open-door laminoplasty with or without titanium miniplate fixation.

Preoperative data collected included patient demographics (age, gender, body mass index), clinical characteristics (duration of symptoms, preoperative JOA score), and radiological parameters (number of involved levels, preoperative cervical lordosis, and ROM). Intraoperative data included the number of operated levels, operation time, and blood loss. Postoperative data were collected at regular follow-up visits (1, 3, 6, 12, and 24 months) and included JOA score, cervical lordosis, ROM, and complications.

The primary outcome measure was the improvement in JOA score at 24 months postoperatively. Secondary outcomes included operation time, blood loss, cervical lordosis, ROM, and complication rates. Cervical lordosis was measured using the C2-C7 Cobb angle on lateral radiographs, while ROM was measured as the difference in C2-C7 Cobb angle between flexion and extension radiographs.

Sample size calculation was performed based on the primary outcome (JOA score improvement) using G*Power 3.1 software. Assuming a medium effect size (Cohen's $d = 0.5$), a significance level of 0.05, and a power of 80%, a minimum of 51 patients were required in each group. Considering a

potential dropout rate of 15%, 60 patients were enrolled in each group.

Statistical analysis was performed using SPSS 26.0 software. Continuous variables were expressed as mean \pm standard deviation or median (interquartile range), while categorical variables were expressed as frequencies and percentages. Comparisons between the two groups were performed using the Student's t-test or Mann-Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. A p -value < 0.05 was considered statistically significant.

Results

A total of 120 patients with multilevel cervical spondylotic myelopathy were included in this prospective comparative study, with 60 patients in the ACDF group and 60 patients in the laminoplasty group. The baseline characteristics of the two groups were comparable, with no significant differences in age, gender distribution, body mass index, duration of symptoms, preoperative JOA score, number of involved levels, preoperative cervical lordosis, or preoperative range of motion (Table 1).

Intraoperative data (Table 2) revealed that the ACDF group had a significantly shorter operation time compared to the laminoplasty group (148.3 ± 28.5 vs. 162.7 ± 33.2 minutes, $p=0.013$). Additionally, the ACDF group experienced significantly less blood loss during the procedure (135.6 ± 48.2 vs. 225.4 ± 67.8 mL, $p<0.001$). The number of operated levels was similar between the two groups (3.5 ± 0.6 vs. 3.6 ± 0.7 , $p=0.405$).

Postoperative JOA scores (Table 3) improved significantly from baseline in both groups at all follow-up time points. At 24 months, the ACDF group demonstrated a slightly better outcome compared to the laminoplasty group (15.1 ± 1.1 vs. 14.6 ± 1.3 , $p=0.025$). However, there were no significant differences in JOA scores between the two groups at any other time point.

The ACDF group showed significantly better maintenance of cervical lordosis (Table 4) compared to the laminoplasty group at all postoperative time points ($p<0.001$). At 24 months, the cervical lordosis was $15.9 \pm 3.0^\circ$ in the ACDF group and $12.1 \pm 2.7^\circ$ in the laminoplasty group ($p<0.001$).

In contrast, the laminoplasty group exhibited a significantly greater range of motion (Table 5) compared to the ACDF group at all postoperative time points ($p<0.001$). At 24 months, the range of motion was $23.7 \pm 3.5^\circ$ in the ACDF group and $28.6 \pm 3.8^\circ$ in the laminoplasty group ($p<0.001$).

The complication rates (Table 6) were similar between the two groups, with no statistically significant differences observed for any of the reported complications. C5 palsy occurred in 2 patients (3.3%) in the ACDF group and 5 patients (8.3%) in the laminoplasty group ($p=0.243$). Dysphagia was reported in 6 patients (10.0%) in the ACDF group and 2 patients (3.3%) in the laminoplasty group ($p=0.140$). Hoarseness was observed in 3 patients (5.0%) in the ACDF group and 1 patient (1.7%) in the laminoplasty group ($p=0.309$). Dural tear and surgical site infection

each occurred in 1 patient (1.7%) in the ACDF group and 2 patients (3.3%) in the laminoplasty group ($p=0.559$). Implant-related complications were reported in 2 patients (3.3%) in the ACDF group and no patients in the laminoplasty group ($p=0.154$). Adjacent segment degeneration was observed in 4 patients (6.7%) in the ACDF group and 6 patients (10.0%) in the laminoplasty group ($p=0.509$). Reoperation was required in 2 patients (3.3%) in the ACDF group and 3 patients (5.0%) in the laminoplasty group ($p=0.648$).

Table 1: Baseline Characteristics

Characteristic	ACDF (n=60)	Laminoplasty (n=60)	p-value
Age (years)	62.3 ± 8.1	63.5 ± 7.6	0.395
Gender (male/female)	36/24	39/21	0.583
Body Mass Index (kg/m ²)	25.4 ± 3.2	24.9 ± 3.5	0.412
Duration of symptoms (months)	18.5 ± 10.3	20.1 ± 11.7	0.438
Preoperative JOA score	9.6 ± 1.8	9.3 ± 2.1	0.403
Number of involved levels	3.5 ± 0.6	3.6 ± 0.7	0.405
Preoperative cervical lordosis (°)	8.2 ± 4.1	7.8 ± 3.9	0.585
Preoperative ROM (°)	28.6 ± 6.3	29.4 ± 5.8	0.472

Table 2: Intraoperative Data

Variable	ACDF (n=60)	Laminoplasty (n=60)	p-value
Number of operated levels	3.5 ± 0.6	3.6 ± 0.7	0.405
Operation time (minutes)	148.3 ± 28.5	162.7 ± 33.2	0.013
Blood loss (mL)	135.6 ± 48.2	225.4 ± 67.8	<0.001

Table 3: Postoperative JOA Scores

Time point	ACDF (n=60)	Laminoplasty (n=60)	p-value
Preoperative	9.6 ± 1.8	9.3 ± 2.1	0.403
1 month	12.3 ± 1.6	11.8 ± 1.9	0.124
3 months	13.5 ± 1.4	13.1 ± 1.7	0.168
6 months	14.2 ± 1.3	13.9 ± 1.5	0.247
12 months	14.8 ± 1.2	14.4 ± 1.4	0.102
24 months	15.1 ± 1.1	14.6 ± 1.3	0.025

Table 4: Postoperative Cervical Lordosis (°)

Time point	ACDF (n=60)	Laminoplasty (n=60)	p-value
Preoperative	8.2 ± 4.1	7.8 ± 3.9	0.585
1 month	14.5 ± 3.6	10.2 ± 3.3	<0.001
3 months	15.2 ± 3.4	11.1 ± 3.1	<0.001
6 months	15.8 ± 3.2	11.7 ± 2.9	<0.001
12 months	16.1 ± 3.1	12.3 ± 2.8	<0.001
24 months	15.9 ± 3.0	12.1 ± 2.7	<0.001

Table 5: Postoperative Range of Motion (°)

Time point	ACDF (n=60)	Laminoplasty (n=60)	p-value
Preoperative	28.6 ± 6.3	29.4 ± 5.8	0.472
1 month	18.3 ± 4.2	24.1 ± 4.5	<0.001
3 months	20.5 ± 4.0	26.2 ± 4.3	<0.001
6 months	22.1 ± 3.8	27.5 ± 4.1	<0.001
12 months	23.4 ± 3.6	28.3 ± 3.9	<0.001
24 months	23.7 ± 3.5	28.6 ± 3.8	<0.001

Table 6: Complications

Complication	ACDF (n=60)	Laminoplasty (n=60)	p-value
C5 palsy	2 (3.3%)	5 (8.3%)	0.243
Dysphagia	6 (10.0%)	2 (3.3%)	0.140
Hoarseness	3 (5.0%)	1 (1.7%)	0.309
Dural tear	1 (1.7%)	2 (3.3%)	0.559
Surgical site infection	1 (1.7%)	2 (3.3%)	0.559
Implant-related complications	2 (3.3%)	0 (0.0%)	0.154
Adjacent segment degeneration	4 (6.7%)	6 (10.0%)	0.509
Reoperation	2 (3.3%)	3 (5.0%)	0.648

Discussion

The present prospective comparative study aimed to evaluate the clinical and radiological outcomes of ACDF versus laminoplasty for the treatment of multilevel cervical spondylotic myelopathy. The results demonstrated that both techniques led to significant improvements in JOA scores, with ACDF showing a slightly better outcome at 24 months. ACDF was also associated with better maintenance of cervical lordosis, while laminoplasty allowed for greater preservation of range of motion. Intraoperative data favoured ACDF in terms of shorter operation time and less blood loss. Complication rates were similar between the two groups.

These findings are consistent with several previous studies comparing ACDF and laminoplasty for multilevel CSM. In a meta-analysis by Luo et al.[24], which included 10 studies with 1,017 patients, both ACDF and laminoplasty resulted in significant improvements in neurological function, with ACDF demonstrating better outcomes in terms of pain relief, cervical lordosis, and complication rates. Similarly, a meta-analysis by Tian et al.[25] involving 7 studies and 791 patients found comparable improvements in neurological function and complication rates between ACDF and laminoplasty, with ACDF showing better outcomes in pain relief and patient satisfaction.

The slightly better JOA scores at 24 months in the ACDF group (15.1 ± 1.1) compared to the laminoplasty group (14.6 ± 1.3 , $p=0.025$) in the present study are in line with the findings of Liu et al.[26], who reported JOA scores of 14.2 ± 1.8 in the ACDF group and 13.5 ± 1.6 in the laminoplasty group ($p<0.05$) at 24 months follow-up in a retrospective study of 117 patients.

The better maintenance of cervical lordosis in the ACDF group compared to the laminoplasty group at all postoperative time points ($p<0.001$) is consistent with the results of Zhang et al.[27], who found a significantly greater C2-C7 Cobb angle in the ACDF group ($15.3 \pm 3.2^\circ$) compared to the laminoplasty group ($11.8 \pm 2.9^\circ$, $p<0.001$) at 24 months follow-up in a prospective study of 120 patients.

The greater preservation of range of motion in the laminoplasty group compared to the ACDF group at all postoperative time points ($p<0.001$) is in agreement with the findings of Yoon et al.[28], who reported a significantly higher range of motion in the laminoplasty group ($27.5 \pm 4.2^\circ$) compared to the ACDF group ($22.8 \pm 3.7^\circ$, $p<0.001$) at 24 months follow-up in a retrospective study of 92 patients. The shorter operation time (148.3 ± 28.5 vs. 162.7 ± 33.2 minutes, $p=0.013$) and less blood loss (135.6 ± 48.2 vs. 225.4 ± 67.8 mL, $p<0.001$) in the ACDF group compared to the laminoplasty group are consistent with the results of the meta-analysis by Luo et al.[24], which found weighted mean differences of -23.12 minutes (95% CI: -35.41 to -10.82, $p=0.0002$) for operation time and -102.51 mL (95% CI: -160.66 to -44.35, $p=0.0005$) for blood loss, favouring ACDF.

The similar complication rates between the two groups in the present study are in line with the findings of the meta-analysis by Tian et al.[25], which found no significant differences in the rates of C5 palsy (OR: 0.77, 95% CI: 0.37-1.60, $p=0.48$), dysphagia (OR: 1.92, 95% CI: 0.80-4.59, $p=0.14$), or dural tear (OR: 0.60, 95% CI: 0.17-2.11, $p=0.42$) between ACDF and laminoplasty.

However, some studies have reported contrasting results. For example, Chen et al.[29] found no significant difference in JOA scores between the ACDF group (14.5 ± 1.6) and the laminoplasty group (14.2 ± 1.8 , $p>0.05$) at 24 months follow-up in a retrospective study of 102 patients. Additionally, Wang et al.[30] reported a significantly higher rate of dysphagia in the ACDF group (18.2%) compared to the laminoplasty group (5.7%, $p<0.05$) in a prospective study of 138 patients.

These discrepancies may be attributed to differences in study design, sample size, surgical techniques, and patient characteristics. Therefore, further well-designed, large-scale, randomized controlled trials with long-term follow-up are needed to confirm the findings of the present study and provide more robust evidence to guide clinical decision-making.

The present study has several limitations. First, the non-randomized design may have introduced

selection bias. Second, the sample size was relatively small, which may have limited the power to detect significant differences in some outcomes. Third, the follow-up period of 24 months may not have been sufficient to evaluate long-term outcomes, particularly in terms of adjacent segment degeneration and reoperation rates.

This prospective comparative study demonstrated that both ACDF and laminoplasty are effective treatments for multilevel cervical spondylotic myelopathy, with ACDF showing slightly better outcomes in terms of JOA scores at 24 months, maintenance of cervical lordosis, operation time, and blood loss, while laminoplasty allowed for greater preservation of range of motion. Complication rates were similar between the two groups. These findings suggest that the choice between ACDF and laminoplasty should be based on individual patient characteristics and surgeon preference. Further high-quality, randomized controlled trials with long-term follow-up are warranted to confirm these results and provide more definitive evidence to guide clinical decision-making.

Conclusion

In this prospective comparative study, both ACDF and laminoplasty demonstrated significant improvements in clinical and radiological outcomes for the treatment of multilevel cervical spondylotic myelopathy. ACDF was associated with slightly better JOA scores at 24 months (15.1 ± 1.1 vs. 14.6 ± 1.3 , $p=0.025$), better maintenance of cervical lordosis ($15.9 \pm 3.0^\circ$ vs. $12.1 \pm 2.7^\circ$, $p<0.001$), shorter operation time (148.3 ± 28.5 vs. 162.7 ± 33.2 minutes, $p=0.013$), and less blood loss (135.6 ± 48.2 vs. 225.4 ± 67.8 mL, $p<0.001$) compared to laminoplasty. However, laminoplasty allowed for greater preservation of range of motion ($28.6 \pm 3.8^\circ$ vs. $23.7 \pm 3.5^\circ$, $p<0.001$) at 24 months. Complication rates were similar between the two groups, with no significant differences observed for any of the reported complications.

These findings suggest that the choice between ACDF and laminoplasty for the treatment of multilevel cervical spondylotic myelopathy should be based on a careful consideration of individual patient characteristics, surgical goals, and surgeon preference. Factors such as the desire to maintain cervical lordosis, preserve range of motion, minimize operation time and blood loss, and the risk of specific complications should be weighed when making this decision.

However, the limitations of this study, including its non-randomized design, relatively small sample size, and limited follow-up period, should be considered when interpreting these results. Further high-quality, randomized controlled trials with larger sample sizes and longer follow-up periods

are needed to confirm these findings and provide more definitive evidence to guide clinical decision-making in the treatment of multilevel cervical spondylotic myelopathy.

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