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Meta-Analysis

Which is the Better of Clinical and Radiological Outcomes Between Laminoplasty versus Anterior Cervical Decompression and Fusion for Multilevel Cervical Spondylotic Myelopathy: A Meta-Analysis

Febyan Febyan [1*], I Gusti Lanang Ngurah Agung Artha Wiguna [1], I Ketut Suyasa [1]

[1] Department of Orthopaedic and Traumatology, Prof Ngoerah General Hospital, Faculty of Medicine, Udayana University, Bali, Indonesia

*** Corresponding Author:** Febyan Febyan, Department of Orthopaedic and Traumatology, Prof Ngoerah General Hospital, Faculty of Medicine, Udayana University, Bali, Indonesia. E-mail: Febyanmd@gmail.com

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Abstract

Introduction: Cervical spondylotic myelopathy (CSM) represents a significant health challenge predominantly affecting older adults, often resulting in severe neurological impairment and disability. Despite the availability of numerous studies and surgical techniques, there is no clear consensus on the optimal surgical approach for managing multilevel CSM. Anterior cervical decompression and fusion (ACDF) and posterior laminoplasty are two widely employed surgical procedures. Both techniques have unique benefits and limitations, particularly concerning clinical outcomes, preservation of cervical function, and complication profiles. This study aimed to perform a systematic review and meta-analysis to compare the clinical and radiological outcomes of ACDF versus posterior laminoplasty.

Methods: A systematic search was conducted across major databases, including PubMed, Embase, and Scopus, using a combination of relevant MeSH terms such as "cervical," "spondylosis," "myelopathy," "laminoplasty," and "ACDF". The search concluded in April 2024. Abstracts and reference lists of identified articles were independently screened by two reviewers (LAW, FBN) with disagreements resolved by a third author (IKS). The review adhered to PRISMA guidelines and included studies that compared ACDF and laminoplasty in patients with multilevel cervical spondylotic myelopathy. Eligible studies reported outcomes including Japanese Orthopaedic Association (JOA) scores, intraoperative blood loss, range of motion (ROM), and complication rates. Data extraction and statistical analysis were conducted using Review Manager 5.3, applying random effects models based on heterogeneity levels.

Results: Out of 774 identified studies, 7 met the inclusion criteria, involving 288 patients treated with ACDF and 307 with laminoplasty. The meta-analysis found no significant difference in JOA score improvements between the groups ($P = 0.62$). ACDF was associated with lower intraoperative blood loss ($P = 0.04$) and better postoperative cervical lordosis ($P<0.0001$). Laminoplasty, however, preserved postoperative range of motion better ($P<0.00001$) and had a lower complication rate (12.95% vs. 25.9%, $P = 0.0005$). These findings suggest both procedures are effective, with each offering distinct advantages based on patient-specific priorities.

Conclusion: ACDF remains a viable surgical option for managing multilevel cervical spondylotic myelopathy, particularly for patients requiring reduced intraoperative blood loss and improved cervical alignment. However, laminoplasty offers advantages in preserving postoperative ROM and has a lower overall complication rate. The choice of surgical technique should be tailored to the individual patient based on clinical presentation, surgeon expertise, and patient-specific anatomical factors. Further research is recommended to validate these findings and explore long-term outcomes.

Keywords: Cervical Spondylotic Myelopathy, Anterior Cervical Decompression and Fusion, Laminoplasty, Postoperative

Introduction

Multilevel cervical spondylotic myelopathy (CSM) is a common degenerative condition primarily affecting older adults. It results from age-related changes in the cervical spine, leading to spinal cord compression and progressive neurological deficits. The condition has significant implications, not only for individual patients but also for society as a whole, as it incurs substantial health-related and social costs. These costs stem from medical and surgical treatments, long-term rehabilitation programs, and the associated disabilities

that affect quality of life and productivity.[1]

While conservative management may provide symp tomatic relief in the early stages, surgical intervention becomes essential when neurological function deteriorates. Surgical treatment aims to decompress the spinal cord, preserve or improve cervical alignment, and enhance functional outcomes. Over the years, both anterior and posterior surgical approaches have been utilized, with anterior cervical decompression and fusion (ACDF) and posterior laminoplasty being the most commonly employed techniques.[2,3]

Despite their widespread use, no consensus exists on the optimal surgical approach for multilevel CSM. Various factors influence surgical decision-making, including the location of compression (anterior vs. posterior), the number of affected levels, the need to maintain cervical lordosis, and the surgeon's expertise in specific procedures. These variables, coupled with the evolving nature of spinal surgery, underscore the necessity of continuously updating the evidence base to guide clinical practice.[4,5]

The purpose of this study was to conduct a systematic review and meta-analysis of existing literature to compare the clinical and radiological outcomes of ACDF and laminoplasty in the treatment of multilevel CSM. This effort aimed to provide a clearer understanding of the advantages and limitations of each technique, ultimately supporting more informed surgical planning and patient management.[6]

Materials and Methods

Study Design

The study adhered to PRISMA guidelines to compare anterior cervical decompression and fusion (ACDF) with laminoplasty for multilevel cervical spondylotic myelopathy (CSM). Using a systematic review and meta-analysis, it evaluated clinical and radiological outcomes, focusing on JOA scores, range of motion, blood loss, and complication rates. Data were collected from PubMed, Embase, and Scopus, with rigorous quality checks and statistical analyses. This structured approach aimed to provide evidence-based guidance for choosing the optimal surgical technique for CSM management.[7,8]

Review Question

The review sought to answer the following questions using the population, intervention, comparison, and outcome approach: among patients with multilevel cervical myelopathy who undergo either anterior multiple ACDF or posterior laminoplasty treatment, which option yields the most clinical and radiological improvements. The researchers screened multiple medical databases, including PubMed, Embase, and Scopus, for relevant scientific reports, using a combination of keywords such as “cervical,” “spondylosis,” “myelopathy,” “laminoplasty,” and “ACDF” (MeSH). The search was last conducted in April 2023, and two reviewers (LAW and FBN) independently screened the abstracts and reference lists, with any discrepancies resolved through consultation with a third author (IKS).[9]

Inclusion Criteria & Outcomes Measurement

The following were the criteria for including studies: 1) prospective or retrospective comparative English studies comparing ACDF vs. laminoplasty in patients with multilevel cervical spondylotic myelopathy, and 2) reporting outcome measurements such as the Japanese Orthopaedic Association (JOA) score, intraoperative blood loss, range of motion (ROM), and complications. Studies involving patients with tumors, trauma, infection, prior surgery, revision surgery, combined anterior and posterior surgery, anterior corpectomy, or other posterior approaches such as laminectomy or laminectomy and fusion were excluded. The JOA score, blood loss, range of motion, and complications were evaluated as outcome variables.[10]

Quality Assessment

Two reviewers (LAW, FBN) independently reviewed each article. Any noticed discrepancies were resolved by consensus and comprehensive discussion. Included RCTs will be assessed in terms of quality by the same two independent reviewers based on 7item of Cochrane’s criteria for judging risk of bias in the ‘Risk of bias’ assessment tool, including selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias.[11]To assess publication bias, funnel plots were constructed and visually inspected for asymmetry. Egger's test was also performed to provide a statistical evaluation of potential bias. Both the visual and statistical methods found no significant evidence of publication bias.

Statistical Analysis

Data extraction was collected under basic characteristics

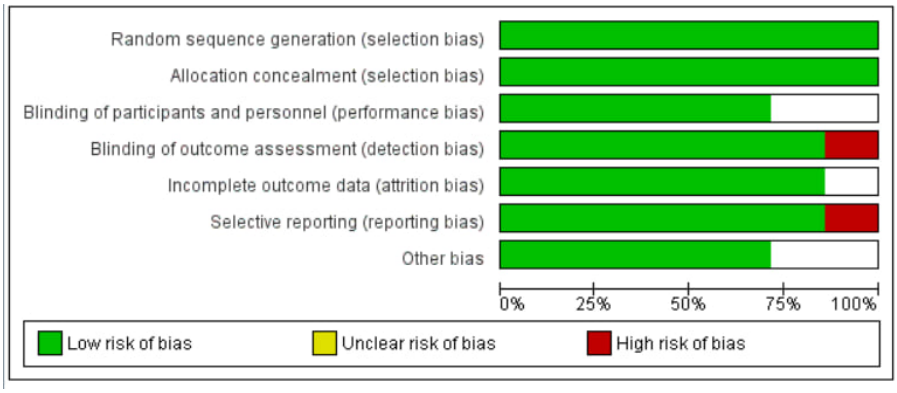

Figure 1. Risk of Biar Graph.

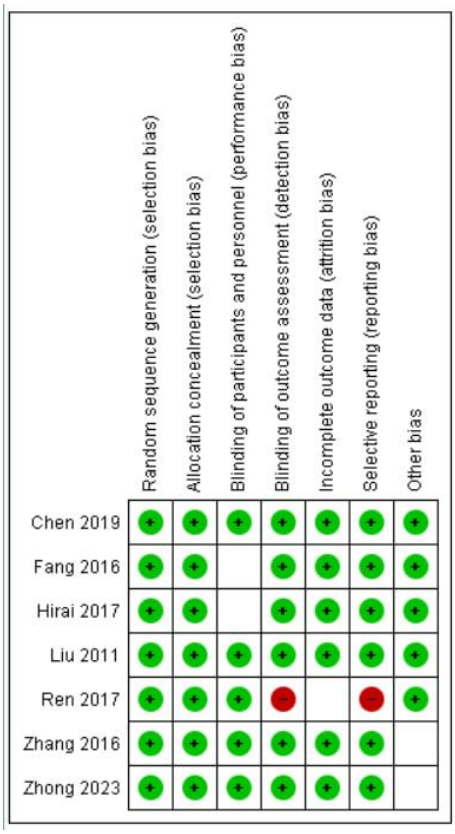

Figure 2. Risk of Bias Summary.

and outcomes using designated tables in Microsoft Excel (Microsoft Corp., Redmond, WA, USA) for all identified and included studies. When the data were available, quantitative analysis was performed using Review Manager (RevMan, computer program ver. 5.3, the Cochrane Collaboration, 2014; The Nordic Cochrane Center, Copenhagen, Denmark). Outcomes were presented in the form of forest plots. In each study, the mean difference for continuous outcome and odds ratio for dichotomous outcome with a 95% confidence interval (CI) was calculated. A fixed-effects model was used when the heterogeneity (I^2) was <50%, whereas a random-effects model was used when the heterogeneity was >50%.[12]

Results

The present investigation involved reviewing 774 articles (Figure 3) and ultimately selecting 7 studies for inclusion (Tables 1 & 2).

JOA Score

In 7 studies, including a total of 288 patients in the

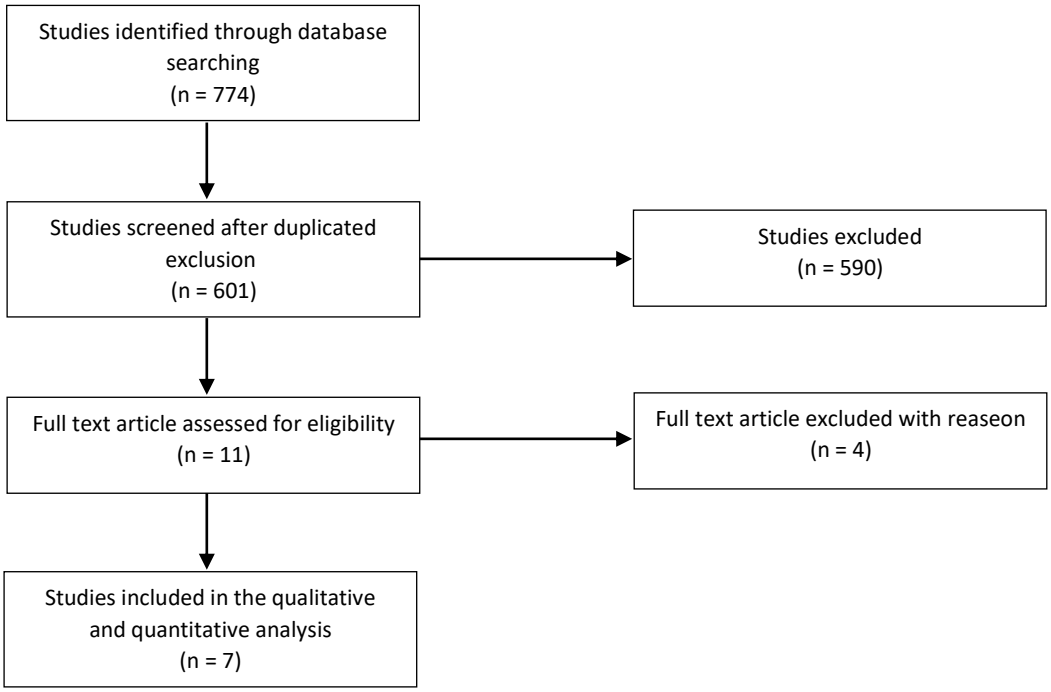

Figure 3. PRISMA for the Flowchart of Study Selection (n = 7).

Table 1. Characteristic of Studies Comparing ACDF and Laminoplasty in Multilevel CSM

No	Studies	Number of Subjects	Age	Gender	Follow Up
1	Liu 2011[4]	D: 25 L: 25	D: 54.64±11.49 L: 57.33±10.09	D: M-14 F-11 L: M-16 F-11	D: 25.40±13.76 M L: 27.47±11.06 M
2	Fang 2016[5]	D: 54 L: 56	D: 56.8±11.7 L: 58.2±12.9	D: M-54,4% L: M-58,2%	3 years
3	Zhang 2016[6]	D: 24 L: 33	D: 54.0±8.9 L: 58.4±9.7	D: M-16 F-8 L: M-24 F-9	D: 21.80±7.2 M L: 20.7±8.0 M
4	Hirai 2017[7]	D: 24 L: 27	D: 58.3 ± 9.0 L: 57.9 ± 8.7	D: M-16 F-8 L: M-23 F-4	1, 2, 3, 5, 7, 10 Y
5	Ren 2017[8]	D: 67 L: 65	D: 52.9±3.6 L: 54.6±4.0	D: M-47 F-20 L: M-45 F-20	D: 45.4±5.4 L: 47.1±6.1
6	Chen 2019[9]	D: 80 L: 56	D: 55.4±10.9 L: 63.9±10.4	D: M-60 F-20 L: M-40 F-16	D: 45.7±2.8 L: 45.7±2.7
7	Zhong 2023[10]	D: 38 L: 45	D: 53.5±10.2 L: 59.4±14.7	D: M-21 F-17 L: M-25 F-20	D: 42±20.4 L: 34.8±15.6

Table 2. Summary of Outcomes

No	Studies	JOA Score Improvement (%)	Intraoperative Blood Loss (mL)	ROM (degree)	Complications Rate
1	Liu 2011	D: 59.79±23.43 L: 59.54±29.37	D: 118.48±27.62 L: 361.11±57.80	D: 33.14±8.04 L: 36.15±10.58	D: 9/25 (36%) L: 3/27 (11.11%)
2	Fang 2016	D: 72.0±16.4 L: 70.9±15.3	D: 192±47 L: 175±39	D: 14.8±2.8 L: 16.5±3.4	D: 9/54 (16,67%) L: 5/56 (8,9%)
3	Zhang 2016	D: 55.3±19.2 L: 58.9±18.1	D: 136.7 ± 60.8 L: 316.7 ± 139.6	D: 28.5 ± 11.7 L: 34.2 ± 8.8	D: 3/24 (12.5%) L: 3/33 (9%)
4	Hirai 2017	D: 77.0 ± 24.5 L: 56.8 ± 26.9	D: 338 ± 301 L: 181 ± 96.7	D: 26.4 ± 13.1 L: 21.8 ± 13.7	D: 5/24 (20.8%) L: 2/27 (7.4%)
5	Ren 2017	D: 62.92±15.00 L: 59.55±17.58	NA	NA	D: 11/67 (16.4%) L: 9/65 (13.8%)
6	Chen 2019	D: 49.4 ± 19.8 L: 51.3 ± 21.3	D: 164.8 ± 75.5 L: 287.1 ± 55.5	D: 24.3 ± 10.9 L: 35.7 ± 9.9	D: 15/80 (18.8%) L: 9/56 (16.1%)
7	Zhong 2023	D: 55.29 ± 19.7 L: 60.5 ± 28.4	D: 102.3 ±35.8 L: 209.3 ±41.6	D: 55.1 ±9.7 L: 88.7±11.1	D: 23/38 (60.5%) L: 11/45 (24.4%)

Table 3. Table of PICO

	Inclusion	Exclusion
Population	Patient with cervical spondylotic myelopathy	Patient with myelopathy of other cause
Intervention	Patients treated with laminoplasty wither with single door or double door technique	Patients treated with conservative measures and surgery of other technique other than laminoplasty or ACDF
Control	Patients treated with anterior cervical decompression and fusion surgery	Patients treated with conservative measures and surgery of other technique other than laminoplasty or ACDF
Outcome	Primary Outcome: Japanese Association of Orthopaedic Spine and Range of Motion of the cervical spine. Secondary Outcome: Intraoperative outcome and complications	Outcomes not clearly mentioned Outcome with other parameter than our inclusion criteria.

ACDF group and 307 patients in the laminoplasty group, JOA scores were analyzed. There were no significant differences between the preoperative values (P = 0.62). At final follow-up, the mean JOA score was 61.67 ± 19.71 in the ACDF group and 59.64 ± 22.42 in the laminoplasty group. Figure 4 demonstrates that there was a statistically significant difference between the two groups (CI = -3,23 to 5.44; P = 0.62). Low heterogeneity was evident among these studies (I^2 = 44%; P = 0.10).[22]

Intraoperative Blood Loss

In 6 studies, including a total of 221 patients in the ACDF group and 242 patients in the laminoplasty group, intraoperative blood loss was analyzed. There were significant differences between the preoperative values (P = 0.04). At final follow-up, the mean intraoperative blood loss was 175,38 ± 91.28 in the ACDF group and 255.03 ± 71.7 in the laminoplasty group. Figure 5 demonstrates that there was no statistically significant difference between the two groups (CI = -174,74 to -5.04; P = 0.04). Low heterogeneity was evident among these studies (I^2 = 99%; P = 0.00001).

ROM

The ROM was reported in 6 studies for a total of 221 patients in the ACDF group and 242 patients in the laminoplasty group. The mean ROM (at final follow-up) was 21.65 ± 8.60 ACDF group and 29.32 ± 8.76 in the laminoplasty group. This difference was statistically significant (CI = -6.13 to -4.20; P<0.00001; Figure 6). The heterogeneity among these studies was high (I^2 = 97%; P<0.0001).

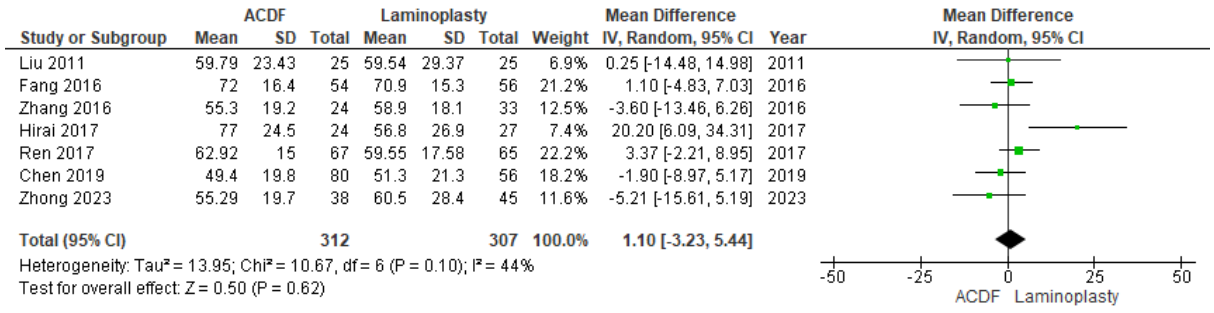

Figure 4. Forest Plot Illustrating the Comparison of JOA Score between Anterior Cervical Decompression and Fusion and Laminoplasty.

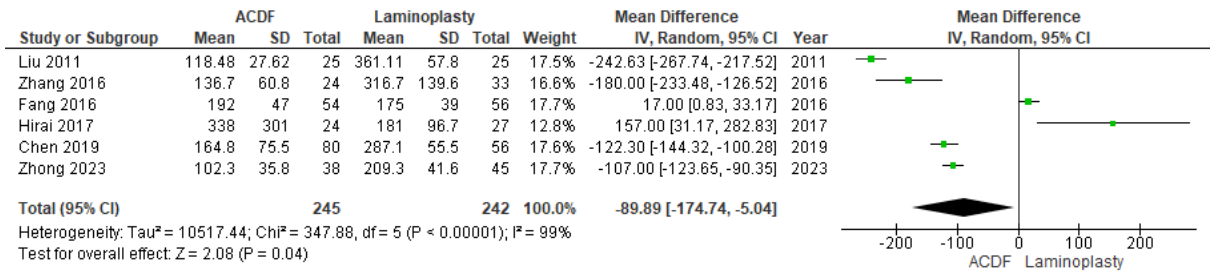

Figure 5. Forest Plot Illustrating the Comparison of Intraoperative Blood Loss between Anterior Cervical Decompression and Fusion and Laminoplasty.

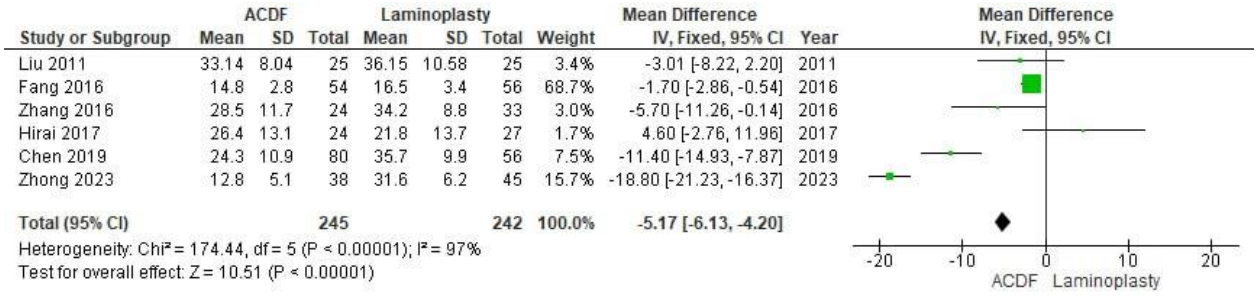

Figure 6. Forest Plot Illustrating the Comparison of ROM between Anterior Cervical Decompression and Fusion and Laminoplasty.

Complications

There are 7 papers reporting complications, with a complication rate of 25,9% (75 out of 312 cases) in the ACDF group and 12.95% (42 out of 309 cases) in the laminoplasty group. However, there were significant differences in the complication rate between the two groups, with a confidence interval of 1.38 to 3.24 (P = 0.0005, Figure 7). The heterogeneity among the studies was not significant, with an I^2 value of 15% and a P-value of 0.32.

Cervical Cobb Angle

We analyzed the pre-operative and post-operative cervical Cobb angle. In terms of pre-operative cervical Cobb angle, we analyzed 5 studies reporting the mean pre-operative Cobb angle were 12.02 ± 10.98 ACDF group and 12.55 ± 9.65 in the laminoplasty group. This difference was not statistically significant (MD 0.52, CI = -1.43 to 2.47; P = 0.60; Figure 8). The heterogeneity among these studies was low (I^2 = 0%; P = 0.68). The mean post-operative Cobb angle of the 6 included studies were 18.13 ± 7.89 ACDF group and 12.57 ± 7.66 in the laminoplasty group. This difference was statistically significant (MD -4.83, CI = -7.16 to -2.51; P<0.0001; Figure 9). The heterogeneity among these studies was low (I^2 = 72%; P = 0.003).

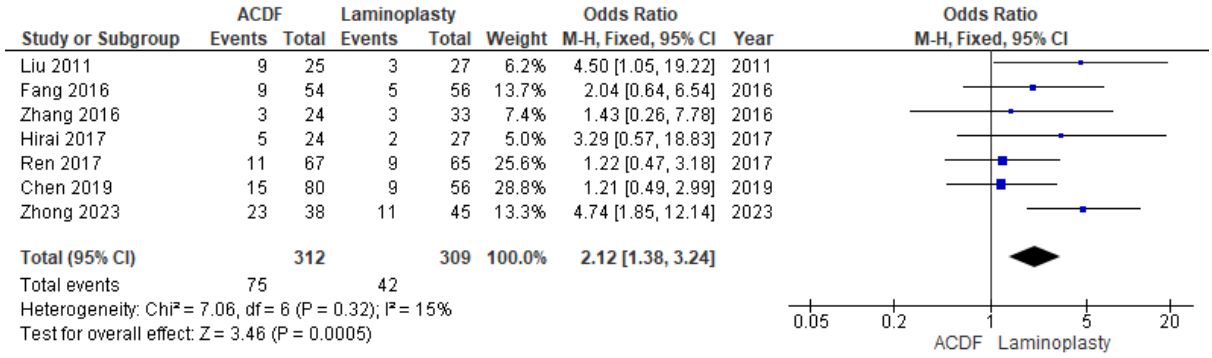

Figure 7. Forest Plot Illustrating the Comparison of Complications between Anterior Cervical Decompression and Fusion and Laminoplasty.

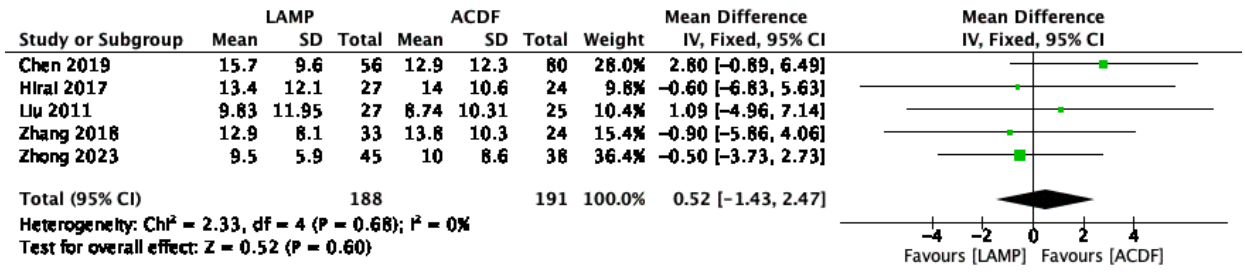

Figure 8. Forest Plot Illustrating the Comparison of Pre-operative Cobb Angle between Anterior Cervical Decompression and Fusion and Laminoplasty

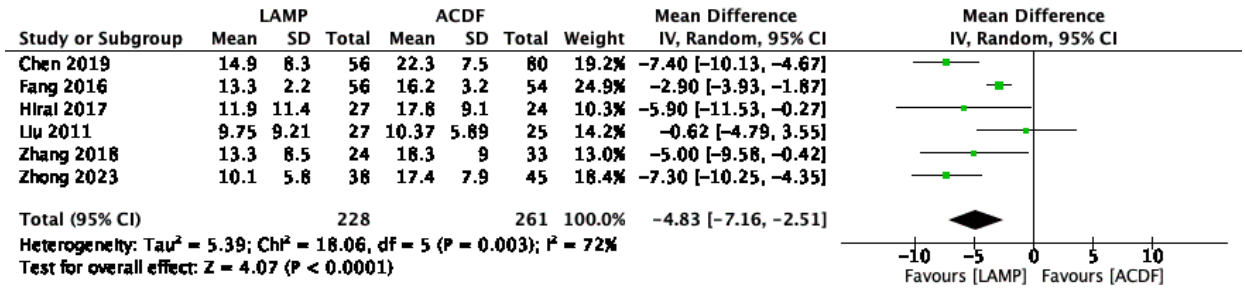

Figure 9. Forest Plot Illustrating the Comparison of Post-operative Cobb Angle between Anterior Cervical Decompression and Fusion and Laminoplasty.

Discussion

Multiple-level cervical spondylotic myelopathy is a degenerative condition frequently encountered by spine surgeons. Multiple levels are typically affected by the condition, which is primarily caused by degeneration of the intervertebral disc and the posterior elements, including joints and ligaments. Compression of the cervical spinal cord can result in clinical myelopathy, radiculopathies, and severe neurological impairments.[11]

In addition to directly relieving pressure on the ventral spinal cord, anterior approaches help restore sagittal cervical alignment by replacing intervertebral discs. In the meantime, posterior approaches can also provide indirect decompression if facet joint resection is performed. Otherwise, the posterior shift of the spinal cord may not be sufficient to relieve ventral compression, and it may persist.[12] In spite of this, facet joint injury during posterior approaches has been associated with segmental instability and the development of progressive kyphosis. In order to avoid these complications, laminoplasty was developed as an alternative to laminectomy. However, there are no conclusive data regarding the superiority of laminoplasty over laminectomy.[13]

When comparing surgical techniques for conditions affecting the spine, achieving favorable clinical outcomes is typically the primary objective. While numerous evaluation scales exist, the JOA scale is widely regarded as the gold standard for determining the clinical status of patients with cervical myelopathy. As measured by the JOA score, the current study revealed that ACDF and cervical laminoplasty yield comparable clinical outcomes. Consequently, other factors, such as intraoperative blood loss, ROM, and complication rates, play a significant role in determining the preferred surgical approach. In our meta-analysis, we discovered that ACDF was associated with better JOA score outcomes, less intraoperative blood loss, better functional postoperative ROM, and lower complication rates when compared to laminoplasty.[14]

In a study by Zhang et al. (2022), the outcome of ACDF compared to laminoplasty was also shown to be similar in terms of JOA score, VAS of the upper limb, and NDI score. ACDF patients have significantly higher postoperative intervertebral height and functional segment height. While the postoperative cervical lordosis angle in the ACDF group was significantly larger than in the LAMP group, this may be due to the stability provided by the ACDF procedure. These height and lordosis angles have been shown to be associated with less pain in postoperative spondylolisthetic myelopathy.[15,16]

A Study by Yuan et al. shows no significant difference between fusion and laminoplasty. While the fusion group has more nerve palsy complications compared to the laminoplasty group.[17] One study by Lee et al shows a different result where JOA score improvement is seen as better in the laminoplasty group, with a 15% difference. The VAS and NDI decrease can be seen in the laminoplasty group. For the secondary outcome, complications can be seen in the ACDF group. According to the author, this may be due to the approach where the risk of other tissue damage is much higher compared to posterior approach surgery.[18,19]

While studies have different results, the treatment of cervical spondylotic myelopathy remains surgical; hence, any method used for the surgery may provide a positive outcome for the patient.

This meta-analysis has several limitations that should be acknowledged. Heterogeneity among the included studies was observed, stemming from variations

in patient demographics, surgical techniques, and follow-up durations. Although a random-effects model was used to address heterogeneity, residual variability might still affect the generalizability of the results. Additionally, the small sample size (7 studies involving 595 patients) may limit the statistical power, increasing the risk of type II error. The quality of the included studies varied, and some may be at risk of bias, potentially influencing the reliability of pooled outcomes. Furthermore, the lack of long-term follow-up in most studies restricts the ability to assess sustained outcomes and late complications. Lastly, due to differences in surgical expertise and healthcare settings across studies, generalizing these results to broader patient populations requires caution. Future studies should aim to include larger sample sizes, higher-quality designs, and longer follow-up periods to validate and extend these findings.

Conclusion

Anterior Cervical Decompression and Fusion (ACDF) remains a well-established and effective surgical option for managing multilevel cervical spondylotic myelopathy (CSM). The findings of this meta-analysis highlighted that ACDF provides superior clinical outcomes compared to laminoplasty in several key aspects. ACDF was associated with better restoration of cervical lordosis, reduced intraoperative blood loss, and comparable improvements in Japanese Orthopaedic Association (JOA) scores. These advantages make it a favorable choice, particularly in patients were maintaining or improving cervical alignment is critical.

However, laminoplasty demonstrated better postoperative range of motion (ROM) preservation and a lower complication rate, underscoring its value in selected cases, especially for patients prioritizing motion preservation. Despite the distinctions, both procedures exhibited comparable overall effectiveness in addressing the neurological deficits associated with CSM.

Given the unique benefits of each technique, the study strongly highlights the importance of individualized treatment planning tailored to the specific needs of each patient. Factors such as age, activity level, comorbidities, and the degree of spinal cord compression should be carefully considered. For example, ACDF may be prioritized in patients who require optimal correction of cervical alignment and stability, while laminoplasty may be preferred for those seeking to preserve mobility and minimize postoperative complications. In this context, engaging patients in the decision-making process and weighing their personal goals and lifestyle priorities are crucial for achieving optimal outcomes.

The study underscores that no single surgical approach is universally superior, and the selection of the appropriate technique requires a collaborative effort involving the surgeon's expertise, imaging-based evaluations, and patient-centered considerations. Further high-quality research and long-term outcome evaluations are recommended to refine the understanding of these two techniques and validate the findings, providing a clearer framework for optimal surgical decision-making in multilevel CSM cases.

Conflict of Interest

The authors declare no conflicts of interest.

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