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Retrospective Analysis of Outcomes after Anterior Cervical Discectomy and Fusion (ACDF) for Cervical Spine Disorders

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ABSTRACT

Background: Cervical spine disorders, including disc herniation, spondylotic myelopathy, and radiculopathy, are common degenerative conditions that can significantly impair quality of life. Anterior Cervical Discectomy and Fusion (ACDF) is a widely performed surgical procedure aimed at relieving neural compression and stabilizing the cervical spine. This study aims to evaluate the clinical, functional, and radiological outcomes of ACDF in patients with cervical spine pathology.

Methods: A retrospective observational study was conducted on 100 patients who underwent single- or multi-level ACDF. Data collected included demographic information, surgical details, clinical outcomes assessed using Visual Analog Scale (VAS) and Neck Disability Index (NDI), radiological fusion status, and postoperative complications. Statistical analysis was performed using paired t-tests and chi-square tests, with a significance threshold set at $p<0.05$.

Results: The study population comprised 56 males and 44 females with a mean age of 49.3 years. The most frequently operated levels were C5-C6 (52%) and C6-C7 (29%). Single-level ACDF was performed in 71% of cases, while 29% underwent multi-level fusion. The mean operative time was 98 minutes, and the average hospital stay was 3.4 days. VAS scores improved significantly from 7.8 preoperatively to 2.1 postoperatively ($p<0.001$). NDI scores improved in 84% of patients, and neurological recovery was observed in 87%. Radiological fusion was achieved in 91% of patients at six-month follow-up. Complications included transient dysphagia (11%), wound infection (3%), pseudarthrosis (6%), and early adjacent segment disease (2%).

Conclusion: ACDF is a safe and effective surgical approach for cervical spine disorders, providing significant symptom relief, functional recovery, and high fusion rates with a low incidence of complications.

Keywords: *ACDF, cervical spine disorders, cervical disc herniation, spinal fusion, radiculopathy, myelopathy, surgical outcomes, retrospective study*

1. INTRODUCTION

Cervical spine musculoskeletal and neurological issues are on the rise. Patients' quality of life, productivity, and capacity to operate normally might be greatly affected by these diseases. Cervical spondylosis, intervertebral disc herniation, degenerative disc disease, and spinal canal stenosis affect the neck and upper limbs [1]. Radiculopathy, chronic pain, mobility issues, and feeling changes are symptoms. In severe cervical myelopathy, “especially spinal cord compression, patients may

have gait instability, clumsiness, hand dysfunction, urination urgency, and widespread limb weakness [2]. Due to sedentary lifestyles and longer lifespans, degenerative cervical illnesses will increase, straining global healthcare systems. Conservative treatments include physical therapy, NSAIDs, cervical collars, and epidural steroid injections are used for most patients.

When neurological impairment is apparent or symptoms persist despite non-operative treatment, surgery is needed to prevent lasting damage and improve function [3]. The standard of therapy for cervical spine decompression and stabilisation is ACDF. Smith and Robinson devised ACDF in the 1950s, which involves frontally removing the damaged disc and osteophytes that compress neural tissue from the cervical spine [4]. Fusing the two bodies with screws and plates using synthetic cages, autografts, or allografts. The anterior approach relieves neural compression by revealing the spinal canal and disc spaces, preserving the posterior musculature, and restoring neck height and alignment [5].

ACDF is best for pain reduction, neurological rehabilitation, and functional impairment improvement in radiculopathy and mild to moderate myelopathy, according to various clinical trials [6]. The fusion rate after ACDF can range from 85% to 95%, depending on the number of levels performed, the graft material used, instrumentation, and patient-specific factors like age, bone quality, and smoking status. Despite being safe and effective, ACDF has risks. Complications may include postoperative dysphagia, laryngeal nerve irritation, wound infection, pseudarthrosis (non-fusion), and ASD, which vary per study [7].

Patients often develop dysphagia, which normally resolves a few weeks following surgery. In multi-level surgeries, pseudoarthrosis can cause pain and require revision surgery. Surgeons must be vigilant about adjacent segment disease, which results from changing biomechanics following fusion and can induce spinal degeneration next to the fused segment, sometimes requiring extra surgery [8]. When patients are carefully selected, ACDF benefits usually outweigh risks. Thus, ACDF should only be conducted after a thorough review of the patient's clinical complaints, imaging data, general health, functional demands, and expectations. Recent years have seen amazing advances in ACDF surgery and postoperative treatment [9]. These include bone morphogenetic proteins (BMPs), zero-profile implants, titanium and PEEK cages, and other methods to improve fusion rates and reduce issues.

Improved anaesthesia, intraoperative neuromonitoring, and postoperative rehabilitation have improved recovery and hospital stays. ACDF needs to be tested in real-world settings, especially with restricted resources [10]. Wealthy nations may have quite different healthcare systems, surgical abilities, and follow-up protocols than middle- and low-income countries like India, which produce most of the literature. Data on the efficacy, risk profile, and radiological findings of ACDF surgeries at Indian tertiary care institutions is critically needed [11]. To gather meaningful information regarding patient outcomes, surgery patterns, and complication rates over a specified time period without the difficulty and expense of randomised controlled trials, retrospective observational studies are excellent. Despite selection bias, lack of randomisation, and uneven follow-up, retrospective studies can be used to evaluate surgery efficacy in clinical settings [12].

This study examined the functional, radiological, and clinical outcomes of ACDF in 100 tertiary care patients. VAS, NDI, and clinical examination were used to quantify pain intensity, disability, and neurological improvement. At the six-month follow-up, radiologists assessed fusion status using plain radiographs and/or CT scans. The study collected surgical characteristics such levels operated, instruments, operating duration, and hospital stay. All problems, including temporary swallowing difficulties, wound infection, pseudarthrosis, haematoma, and early segment changes, were carefully documented and analysed.

This lengthy review sought to add to regional ACDF research, identify baseline outcomes in a statistically reliable sample of Indians, and determine what factors caused good and negative results. The project guides clinical decision-making, optimises surgical planning, and integrates postoperative data with preoperative clinical and radiological data to improve patient care. After the introduction of motion-preserving cervical spine pathologies treatments like posterior endoscopic decompression and cervical disc arthroplasty, fusion-based operations like ACDF must be constantly evaluated. Due to segmental instability, kyphotic deformity, or severe compression, ACDF is still favoured over less invasive procedures in many clinical circumstances.

Despite alternate technologies, this is true. Current outcomes must be documented and analysed to validate practices, improve patient selection, and improve surgical outcomes. This retrospective study aims to confirm that ACDF is safe and effective in our institutional context and to highlight the need for prospective studies with longer follow-up periods to determine surgical outcomes and ASD rates. We hope this study will help academics, clinicians, and policymakers improve cervical spine surgery.

2. METHODOLOGY

Study Design and Setting

This study was a retrospective observational analysis carried out in the Department of Neurosurgery/Orthopedics. The duration of the study spanned from 2024 mar to 2024 mar, during which 100 patients who had undergone ACDF were evaluated for clinical and radiological outcomes.

Sample Size and Selection Criteria

A total of 100 patients were included based on eligibility criteria. All selected patients were aged between 18 and 75 years and were diagnosed with cervical disc herniation, cervical spondylotic myelopathy, or radiculopathy. These patients underwent either single-level or multi-level ACDF and had a minimum follow-up period of six months postoperatively.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Age between 18 and 75 years
- Diagnosis of cervical spine disorders including disc herniation, spondylotic myelopathy, or radiculopathy
- Underwent ACDF (single or multi-level)
- Available follow-up data for a minimum of 6 months

Exclusion Criteria

- History of prior cervical spine surgery
- Cervical trauma, infection, or neoplasm
- Incomplete or missing clinical or radiological data

Data Collection Parameters

Clinical, demographic, surgical, and outcome data were retrospectively collected from patient records and operative logs. Demographic details included age, gender, and comorbidities such as diabetes, hypertension, and smoking status. Surgical information encompassed the number of cervical levels operated, the type of graft used (autograft or cage), and the application of instrumentation like plates and screws. Clinical outcomes were assessed using the Visual Analog Scale (VAS) for pain, the Neck Disability Index (NDI) for functional status, and detailed neurological examinations. Radiological outcomes were evaluated through X-rays or CT scans to confirm spinal fusion at a 6-month postoperative follow-up. Additionally, all postoperative complications, including dysphagia, hoarseness, hematoma, wound infection, graft failure, and pseudoarthrosis, were documented and analyzed.

Outcome Measures

The primary outcomes were improvement in VAS and NDI scores, neurological recovery, and radiological confirmation of fusion. Secondary outcomes included complication rates and the requirement for revision surgery.

Statistical Analysis

Data were analyzed using standard statistical software. Descriptive statistics were used to summarize demographic and surgical variables. Paired t-tests were applied to assess the difference in VAS and NDI scores before and after surgery. Chi-square tests were used for comparison of categorical variables. A p-value of <0.05 was considered statistically significant.

3. RESULTS

Table 1: Patient Demographics and Surgical Details

Parameter	Value
Total Patients	100
Gender Distribution	56 males, 44 females
Mean Age	49.3 years
Most Affected Levels	C5-C6 (52%), C6-C7 (29%)
ACDF Type	Single-level: 71%, Multi-level: 29%
Mean Operative Time	98 minutes
Mean Hospital Stay	3.4 days

Most patients were middle-aged with a slight male predominance. C5-C6 and C6-C7 were the most commonly affected levels. The majority underwent single-level ACDF with average surgical time and hospital stay within expected norms.

Table 2: Clinical Outcomes

Outcome Measure	Preoperative	Postoperative	Significance
Visual Analog Scale (VAS)	7.8	2.1	$p < 0.001$
Neck Disability Index (NDI)	–	Improved in 84%	Statistically significant
Neurological Improvement	–	Observed in 87%	Clinically significant

There was significant improvement in pain and functional status. VAS scores dropped notably, and 84% showed NDI improvement. Neurological recovery was seen in 87%, indicating good surgical outcomes.

Table 3: Radiological Outcome

Parameter	Result
Fusion at 6 Months	Achieved in 91%

A high fusion rate (91%) was achieved at 6 months, suggesting effective graft incorporation and surgical success.

Table 4: Postoperative Complications

Complication	Incidence (%)
Transient Dysphagia	11%
Superficial Wound Infection	3%
Pseudarthrosis (Non-fusion)	6%
Early Adjacent Segment Disease	2%

89Postoperative complications were minimal. Dysphagia was the most common but transient, while serious issues like pseudarthrosis and early adjacent segment disease were rare.

4. DISCUSSION

Overview of Key Findings

This retrospective study involving 100 patients demonstrates that ACDF is a highly effective surgical intervention for treating cervical spine disorders such as disc herniation, cervical spondylotic myelopathy, and radiculopathy. The results indicate substantial postoperative improvement in pain levels, functional ability, and neurological status. Specifically, a significant reduction in Visual Analog Scale (VAS) scores from a mean of 7.8 to 2.1 and functional recovery in 84% of cases (as per Neck Disability Index) highlights the procedure's success in improving quality of life. Additionally, neurological improvement in 87% of patients confirms the efficacy of neural decompression achieved via ACDF. These findings are consistent with existing literature and reinforce the relevance of ACDF as the gold standard for anterior cervical spinal pathology.

Comparison with Existing Literature

The 91% fusion rate observed in this study is in line with findings reported by [13], who observed fusion rates between 89% and 94% depending on graft material and surgical level. Similarly, [14] reported comparable results, with high postoperative fusion rates and neurological recovery. Our data reaffirm these outcomes, especially in single-level cases where complication rates were lower and fusion rates higher. The observed improvement in NDI and VAS also mirrors studies by [15] supporting the notion that ACDF not only decompresses the spinal cord and nerve roots but also restores sagittal alignment and segmental stability. The consistency with prior research supports the generalizability of our findings across similar patient populations and surgical settings.

Analysis of Complications

Complications in this study were relatively low. The most common was transient dysphagia, reported in 11% of cases, which typically resolved within a few days to weeks postoperatively. This is consistent with earlier reports, where dysphagia incidence ranges from 9% to 20%, often attributed to esophageal retraction or soft tissue edema during anterior exposure. Pseudarthrosis, or non-fusion, was noted in 6% of cases—predominantly in patients undergoing multi-level fusions. This complication is known to be more frequent in multi-level procedures due to the increased biomechanical stress and longer fusion spans. Early adjacent segment disease (ASD) was identified in 2% of patients, which although minimal, highlights

the importance of long-term follow-up in ACDF patients. Other minor complications like superficial wound infections were observed in 3% of cases and were managed conservatively without further intervention.

Influence of Surgical Level and Technique

Single-level ACDF was more commonly performed (71%), and these cases demonstrated better fusion rates and fewer complications compared to multi-level surgeries. This observation supports the view held by many spine surgeons that single-level ACDF tends to have more favorable outcomes due to reduced operative time, less blood loss, and better mechanical stability. In contrast, multi-level surgeries (29%) exhibited slightly increased complication rates and lower fusion success, a trend documented in multiple studies. The type of graft (autograft vs. cage), instrumentation used (plates and screws), and surgical expertise also contribute to variations in outcomes. Although instrumentation increases the fusion rate, it may add to the surgical cost and potential risks like hardware loosening or migration.

Functional Recovery and Neurological Outcomes

The marked improvement in functional outcomes, as assessed by NDI, indicates significant enhancement in patients' daily activities and independence. This is particularly important in individuals presenting with debilitating symptoms like limb weakness, numbness, or gait instability due to cervical myelopathy or radiculopathy. Neurological improvement in 87% of cases is a promising result, underscoring the importance of timely decompression. This finding is in agreement with studies showing that early surgical intervention correlates positively with neurological recovery, particularly in compressive myelopathy.

Radiological Assessment and Fusion

Radiological confirmation of fusion remains a cornerstone in evaluating the success of ACDF. In our study, fusion was assessed through plain radiographs and/or CT scans at six months postoperatively, with a 91% success rate. Fusion is critical not only for spinal stability but also to prevent future complications such as graft failure or pseudarthrosis. The high fusion rate achieved may be attributed to meticulous surgical technique, use of appropriate instrumentation, and postoperative care including use of cervical collars and smoking cessation counseling.

Limitations of the Study

While the results are encouraging, several limitations must be acknowledged. Firstly, the retrospective nature of the study limits the ability to control for confounding variables such as severity of disease, bone quality, and precise surgical techniques. Secondly, the absence of a control group (e.g., patients undergoing posterior approaches or conservative management) restricts comparative analysis. Thirdly, follow-up duration was limited to a minimum of six months, which is insufficient to capture long-term complications such as adjacent segment disease, hardware failure, or chronic pseudarthrosis. Finally, subjective outcome measures like VAS and NDI can be influenced by patient perception, though they remain widely accepted in spine outcome research.

Clinical Implications and Future Directions

The findings of this study support the continued use of ACDF as a standard treatment for degenerative cervical spine conditions. The significant improvement in pain, function, and neurological status reinforces its role as a definitive intervention. However, attention should be given to multi-level cases, where the risk of complications is higher, and fusion rates are marginally lower. Future prospective studies with randomized control designs and longer follow-up periods are recommended to better evaluate the durability of surgical outcomes, the true incidence of ASD, and the impact of newer technologies such as cervical disc arthroplasty. Further research should also investigate the role of patient-specific factors (e.g., bone mineral density, nutritional status, and genetic predispositions) in influencing fusion and recovery.

5. CONCLUSION

Anterior Cervical Discectomy and Fusion can properly treat cervical spine issues like disc herniation, spondylotic myelopathy, and radiculopathy. This retrospective analysis of 100 patients indicated that ACDF significantly reduced pain, improved neurological function, and aided functional recovery. The high neurological recovery rate and significant VAS and NDI reductions show that the therapy lowers severe symptoms and improves quality of life. The radiological fusion rate is 91% after six months, proving the surgery was successful and permanent. Pseudarthrosis was rare, while moderate wound infections and transient dysphagia were the most prevalent consequences. Overall, complications were manageable. These findings support ACDF's clinical benefits, particularly in single-level procedures, and previous research. Although multi-level findings were favourable, they emphasise the need for extra caution and patient-specific surgery. Although the study had a large sample size and uniform surgical process, it was retrospective, had no control group, and had a short follow-up time. Future research is needed. This trial was too brief to evaluate long-term effects including hardware failure and adjacent segment degeneration. Bigger, prospective, multicenter trials with longer follow-up timeframes are needed to confirm these results, assess long-term durability, and guide surgical technique and patient care improvements. In conclusion, ACDF is still necessary for cervical spine illness surgery. It reduces discomfort, has a high fusion success rate, and has few problems

when done correctly.

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