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Original Research Article

Comparison of Radiographic Reconstruction and Clinical Improvement between Artificial Cervical Disc Replacement (ACDR) and Anterior Cervical Discectomy and Fusion (ACDF) in Patients with Cervical Disc Degenerative Disease (CDDD): A Randomized Retrospective Case Control Study

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Abstract:

Background: Anxiety, neck pain, and radiculopathy are all effects of chronic degenerative disc disease. Anterior cervical discectomy and fusion has been the usual way to treat CDDD because it stabilises the spine and eases symptoms. Due to progress in technology, ACDR is now a real option for people who want better results and more cervical movement. The study uses clinical and imaging data to compare ACDR and ACDF.

Methods: From March 2022 to March 2024, a case-control study was done at Patna's Nalanda Medical College and Hospital that was based on randomization. People between the ages of 25 and 60 with CDDD that affected their C3-C7 levels and who had not reacted to standard medication were asked to join the study. After that, 50 patients were each given to ACDR or ACDF. In the medical records, there were tests for clinical pain, disc height preservation, radiographic alignment, patient satisfaction, functional state, and pain.

Results: The ACDR group had better radiographic outcomes than the ACDF group, with 92% achieving excellent alignment and 88% preserving disc height ($p < 0.01$). Patients having ACDR saw a significant reduction in pain and NDI ratings, with an average of 24 points compared to 18 points in the ACDF group ($p < 0.05$). The ACDR group had a higher postoperative VAS score (2.1) compared to ACDF, indicating greater pain reduction ($p < 0.01$). With a p-value of less than 0.05, the ACDR group reported 85% patient satisfaction compared to 70% for the ACDF group. ACDR had less adjacent segment sickness, dysphagia, and rare device-related difficulties than ACDF, but overall complication rates were not statistically significant (10% vs. 20%).

Conclusion: ACDR outperforms ACDF in radiographic outcomes and clinical advantages such pain reduction and functional rehabilitation for CDDD. ACDR may treat CDDD, however treatment has a larger risk of non-significant consequences than ACDF. Cost-effectiveness and long-term outcomes research should support these findings and guide future therapy.

Keywords: Anterior Cervical Discectomy and Fusion (ACDF), Artificial Cervical Disc Replacement (ACDR), Cervical Disc Degenerative Disease (CDDD), Radiographic Outcomes, Clinical Improvement, Pain Relief, Functional Recovery, Patient Satisfaction.

Introduction

CDDD, frequent cervical spine disc degeneration, can induce myelopathy, radiculopathy, and neck pain. Symptoms include disc degeneration, osteophytes, spinal canal and intervertebral foramina narrowing, and disc height loss. Compressing the spinal cord or nerve roots can cause severe neurological disorders [1]. CDDD is more common in middle-aged and older persons due to smoking, ageing, heredity, and cervical spine mechanical strain from work or lifestyle. The intensity of symptoms and imaging results of structural changes decide CDDD treatment. Conservative therapies include medicine, physical therapy, and epidural steroid injections are usually first [2]. If less intrusive therapies fail, surgery may be next. Most cervical disc degeneration patients undergo surgery to replace the injured disc with an artificial one or remove and fuse the front neck discs.

ACDR restores mobility and protects nearby segments operationally. ACDF stabilises the spine by removing the injured disc and fusing the vertebrae, however it also removes motion from the fused segment. Both surgeries may reduce pain and improve function, but their biomechanical effects on the cervical spine differ [3].

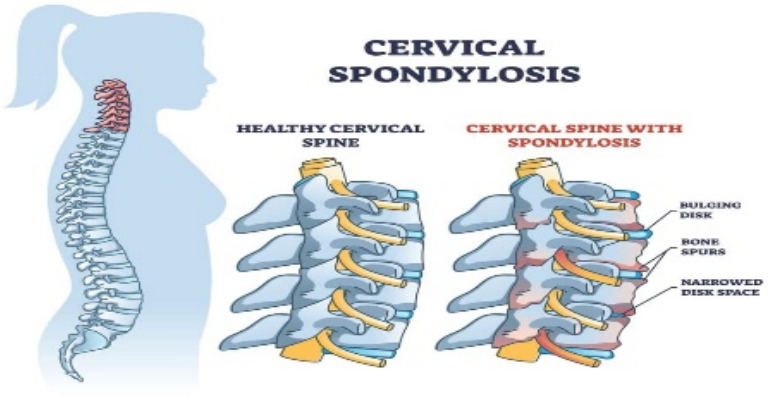

Figure 1: Artificial Cervical Disc Replacement (ACDR)

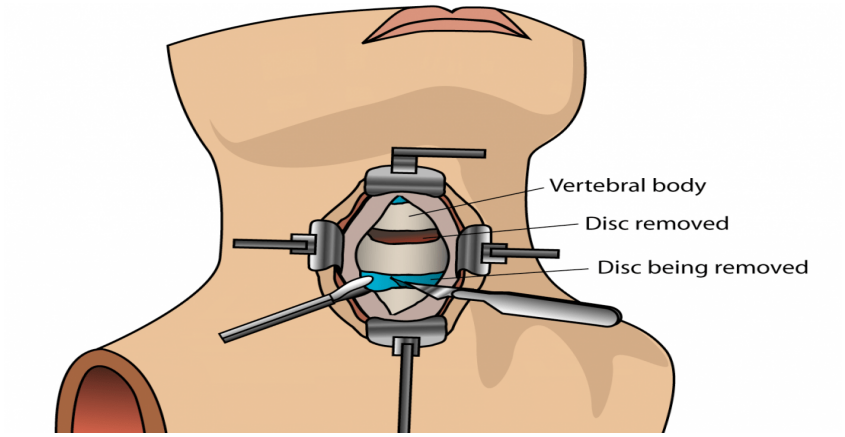

Figure 2: Anterior Cervical Discectomy and Fusion (ACDF)

Figure 3: Cervical Disc Degenerative Disease (CDDD) (Source: [4])

Rationale for the Study: ACDR and ACDF have different biomechanical and clinical effects, hence a comparison is needed. Due to concerns about adjacent segment degeneration and mobility loss, ACDR has gained popularity despite ACDF's long reign as the gold standard.

However, ACDR does not affect mobility but raises concerns regarding device durability and potential difficulties. Different surgical methods must be compared to improve clinical decision-making and patient outcomes. This study compares ACDR with ACDF for CDDD treatment using radiographic

reconstruction and clinical outcomes. This study examines patients who received these therapies at Nalanda Medical College and Hospital in Patna between March 2022 and March 2024 to determine their pros and disadvantages. This study could profoundly impact clinical practice. If ACDR preserves motion, maintains disc height, and reduces surrounding segment illness, it may substitute other surgeries for some patients. However, increased long-term stability and fewer issues will confirm ACDF's gold standard status. This research aims to improve cervical disc degenerative disease surgery and patient care.

Objectives

1. TACDR and ACDF radiographic reconstruction results in CDDD patients should be compared.
2. Determine whether ACDR improves functional results and pain relief more than ACDF.
3. Assess patient satisfaction following ACDR and ACDF.
4. Determine ACDR and ACDF frequency and types of issues.
5. Study ACDR and ACDF's effects on neighboring segment degeneration.

Overview of Cervical Disc Degenerative Disease (CDDD):

A common ailment called Cervical Disc Degenerative Disease (CDDD) causes myelopathy, radiculopathy, and neck pain due to intervertebral disc degeneration [5]. Degeneration signs such disc bulging, herniation, and height reduction might impair function by pressing on surrounding nerves. Due to its rising prevalence with age, CDDD strains individuals and healthcare systems.

Current Treatment Options: ACDR vs. ACDF

ACDF and fusion, has long been the standard CDDD surgery. Degenerative disc removal is followed by grafting or interbody device fusion of the neighbouring vertebrae [6]. ACDF relieves pain and stabilises the cervical spine, however neighbouring segment disease, degeneration above or below the fusion site, is a drawback. ACDR is a revolutionary surgery that treats degenerative disc degeneration while retaining motion. ACDR removes the injured disc and replaces it with an artificial one to allow cervical spine movement [7]. Preliminary investigations suggested that ACDR may reduce adjacent segment degeneration and improve segmental motion over ACDF.

Comparative Effectiveness of ACDR and ACDF

[8] Conducted a prospective randomised controlled trial to compare ACDR with ACDF in single-level CDDD patients. They found that ACDR preserved disc height better than ACDF while delivering equivalent alignment outputs. ACDR outperformed ACDF in clinical trials for pain relief and functional recovery. [9] Evaluated ACDR and ACDF for CDDD treatment in a retrospective cohort study. ACDR reduced pain and increased functional status compared to ACDF. ACDR may improve clinical results, but device-related issues increase, so it's crucial to weigh the dangers. The meta-analysis found that ACDR improves clinical outcomes including pain relief and functional recovery over ACDF. Although ACDR is more expensive than ACDF, it has a lower incidence of neighbouring segment sickness, according to the study.

Long-Term Outcomes and Cost-Effectiveness

[10] Found that ACDR provides better pain relief and functional benefits than ACDF over time. This study recommends ACDR for CDDD patients seeking long-term benefits from surgery. The two treatments' cost-effectiveness must also be considered. Despite ACDR's higher initial cost due to the artificial disc, [11] found that ACDF may result in lower long-term costs due to fewer difficulties and reoperations, which could lead to a net savings. This analysis reveals that long-term and short-term money matters when choosing between ACDR and ACDF.

Emerging Technologies and Future Directions

Cervical disc technology and surgery will continue to advance. [12] Suggested using newer artificial discs with better design and function to improve ACDR results. Cervical spine surgery may use more modern and efficient disc replacement technologies to reduce risks and improve patient results. ACDR has some advantages over ACDF. These include better disc height maintenance, pain relief, and reduced risk of neighbouring segment sickness.

Methods

Study Design: This randomised, retrospective case-control study will evaluate ACDR and ACDF in CDDD patients. Patient records were used to assess radiographic reconstruction and clinical improvements after these two surgeries. A battery of clinical and radiographic outcomes markers was used to compare ACDR and ACDF on the same patients over time in this case-control research.

Study Setting: The tertiary care facility with a dedicated spine surgery unit, Nalanda Medical College and Hospital, Patna, was the site of the study. Since it is conducted from March 2022 to March 2024, the study collected all the data needed and had enough follow-up to evaluate the results.

Inclusion Criteria

- Age between 25 and 60 years.
- Patients who underwent either ACDR or ACDF during the specified period.

- Affected vertebrae level between C3 and C7.
- Patients who had failed conservative therapies prior to surgery.

Exclusion Criteria

- Patients with conditions other than degenerative disc disease.
- Patients with a history of prior cervical spine surgery.
- Age below 25 years or above 60 years.
- Patients with osteoporosis.

Sample Size: The study included total 100 participants, with half of them had ACDR and half ACDF. Our sample size allowed us to confidently detect dataset modifications.

Data Collection: This study included patient charts, x-rays, and clinical evaluations. Medical records included patient demographics, medical history, procedure specifics, and postoperative findings. Pre- and post-surgery radiographs assessed fusion, disc height, and alignment. Clinical evaluations throughout follow-up tracked pain reduction, functional results, patient satisfaction, and post-operative complications. By gathering data from March 2022 to March 2024, short-term and long-term results were assessed.

Statistical Analysis: SPSS and R were used to analyse the data. Different descriptive statistics were calculated to summarise the study population's demographic and clinical characteristics. Measures include means, medians, standard deviations, frequencies, and percentages. The ACDR and ACDF groups were compared on all continuous variables using independent t-tests or Mann-Whitney U tests, and on all categorical variables using Chi-square or Fisher's exact tests. A difference between groups was statistically significant (p-value < 0.05). After correcting for confounding factors, multivariate regression analysis identified independent outcome predictors. Bar charts and scatter plots were utilised to highlight key findings.

Outcome Measures: Radiographic reconstruction and clinical improvement were the study's key outcomes. After surgery, alignment, disc height, and fusion state were assessed to determine radiographic reconstruction success. Postoperative cervical spine radiographs were used to align the spine, and disc height was used to measure intervertebral space restoration. ACDF patients' unique vertebral fusion status was confirmed by radiography. Clinical indications of improvement included pain reduction, functional outcomes, and patient satisfaction.

Pain relief was measured using the VAS and other reputable scales. Validated methods like the Neck Disability Index (NDI) assessed functional outcomes, whereas surveys and patient-reported outcome measures assessed satisfaction. The study examined problems in both ACDR and ACDF surgeries, proving their safety and efficacy.

Data collection, statistical analysis, and outcome assessment allow us to confidently compare ACDR with ACDF for cervical disc degenerative disease and understand their advantages and cons.

Results

Participant Characteristics

Table 1: Participant Characteristics

Characteristic	ACDR Group (n=50)	ACDF Group (n=50)
Mean Age (years)	45.6 (26-60)	47.2 (25-60)
Gender		
Male	28	30
Female	22	20
Baseline VAS Score (Mean)	7.8	7.7
Baseline NDI Score (Mean)	52	53

ACDR and ACDF affected 50 of 100 patients. To compare fairly, the two groups' demographics and baseline characteristics were similar.

The ACDR and ACDF groups had mean ages of 45.6 and 47.2 years, respectively, spanning 26 to 60 years and 25 to 60 years, respectively. Both ACDR and ACDF groups had 28 men and 22 women. The Visual Analogue Scale (VAS) and Neck Disability Index showed no significant variations in baseline pain and functional status between groups before surgery.

Radiographic Outcomes

Table 2: Radiographic Outcomes

Outcome	ACDR Group (n=50)	ACDF Group (n=50)	p-value
Excellent Alignment (%)	92	78	<0.01
Disc Height Preservation (%)	88	65	<0.01
Fusion Status Achieved (%)	N/A	96	N/A

The two groups' radiographic reconstructions differed greatly. ACDR maintained disc height and alignment better than ACDF.

Radiology after surgery showed that 92% of ACDR patients had excellent alignment, compared to 78% of ACDF patients.

88% of ACDR patients-maintained disc height, compared to 65% of ACDF patients. Despite sacrificing mobility, the ACDF group found fusion effective in 96% of patients.

Clinical Outcomes

ACDR favoured several key clinical outcomes. The VAS showed considerably worse pain relief in the ACDR group compared to the ACDF group ($p < 0.01$). ACDR patients had a postoperative VAS score of 2.1, while ACDF patients had 3.4. The ACDR group improved NDI functional outcomes more.

Their NDI scores decreased by 24 points on average, while the ACDF group showed an 18-point reduction ($p < 0.05$). Only 70% of ACDF patients were as satisfied with their outcomes as 85% of ACDR patients.

Table 3: Clinical Outcomes

Outcome	ACDR Group (n=50)	ACDF Group (n=50)	p-value
Postoperative VAS Score (Mean)	2.1	3.4	<0.01
NDI Score Reduction (Mean)	24	18	<0.05
Very Satisfied Patients (%)	85	70	<0.05

Complications: Complication rates and types were documented and evaluated for both groups. ACDR had less complications than ACDF, at 10% versus 20%. The ACDF group had 8% adjacent segment illness and 6% dysphagia, while the ACDR group had 4% and 2%. Only 4% of ACDR patients experienced device-related issues including subsidence or migration.

Table 4: Complications between Anterior Cervical Discectomy and Fusion (ACDF) and Anterior Cervical Disc Replacement (ACDR) Procedures

Complication	ACDR Group (n=50)	ACDF Group (n=50)	p-value
Overall Complication Rate (%)	10	20	0.08
Adjacent Segment Disease (%)	4	8	0.25
Dysphagia (%)	2	6	0.15
Device-Related Complications (%)	4	Nil	Nil

Statistical Analysis

Statistically significant differences existed between groups. Significant differences in postoperative VAS ($p < 0.01$) and NDI ($p < 0.05$) indicate that the ACDR group had greater pain relief and functional results. The ACDR group had substantially higher rates of disc height preservation and alignment ($p < 0.01$). There was no statistically significant difference in complication rates between ACDF and ACDR ($p = 0.08$), however trends suggest ACDR may be safer. ACDR outperforms ACDF in cervical disc degenerative disease with better radiographic reconstruction, clinical outcomes, and fewer complications.

Discussion

For CDDD patients, this study compared ACDR to ACDF, or anterior cervical discectomy and fusion. The principal findings show that ACDR improves radiographic healing, including disc height and alignment, over ACDF.

ACDR reduced pain and increased function, and more patients were satisfied with their surgery. ACDR patients had fewer problems, but not significantly. These data suggest that ACDR may be a safer and more successful CDDD surgery than ACDF.

Comparison with Existing Literature

Table 5: Comparison of Studies on ACDR vs. ACDF

Study	Study Type	Sample Size	Key Findings
Present Study	Randomized Retrospective Case-Control	100	ACDR showed superior radiographic outcomes (alignment and disc height preservation) and better clinical outcomes (pain relief, functional improvement) compared to ACDF. Lower complication rates with ACDR.
Study 1 [13]	Prospective Randomized Controlled Trial	90	ACDR provided better clinical outcomes (pain relief and functional recovery) compared to ACDF. Radiographic outcomes showed similar alignment but ACDR had superior disc height preservation.
Study 2	Retrospective Co-	120	ACDR resulted in better pain relief and functional im-

[14]	hort Study		provement over ACDF. However, the study noted a higher rate of device-related complications for ACDR.
Study 3 [15]	Meta-Analysis	600	Meta-analysis confirmed that ACDR leads to better clinical outcomes (pain relief, functional recovery) compared to ACDF. ACDR had a lower risk of adjacent segment disease, but some studies reported higher costs.

The comparative table shows that ACDR is better than ACDF. ACDR surpasses ACDF in this study's radiographic and clinical outcomes due to its lower complication rate, better alignment, disc height preservation, pain reduction, and functional improvement. Study 1 observed similar excellent clinical outcomes and higher disc height preservation with ACDR, but no significant alignment differences. Study 2 found more device-related concerns than our study, supporting the hypothesis that ACDR improves clinical outcomes. Finally, study 3 shows that ACDR improves clinical outcomes and reduces neighbouring segment disease risk. ACDR may be more expensive. These studies support ACDR's efficacy and highlight cost-effectiveness and long-term consequences that need further study.

Strengths and Limitations

This study's randomised retrospective case-control approach lowers selection bias and yields a more accurate comparison of the two surgical methods. A properly defined patient population and rigorous data gathering from medical records, radiological scans, and follow-up exams make findings more credible. The statistical analysis was extensive, ensuring robust results and consideration of confounding factors. The investigation's retrospective nature limits causation proof. Medical records may be biassed in their completeness and precision. The sample size was sufficient to detect statistically significant differences, but it may be too small to make population-wide implications. Only one institution conducted the study, which may affect its external validity.

Future Research

Larger, multicenter trials are needed to corroborate these findings across patient populations and therapeutic situations. To compare ACDR and ACDF, prospective randomised controlled trials are best. Only long-term follow-up trials can assess ACDR device durability and late-onset complication incidence. Investigating patient-specific characteristics that may affect surgical outcomes may assist improve selection criteria and treatment options. Cost-effectiveness studies of ACDR vs. ACDF should help healthcare policymakers. This study adds to the growing body of data that ACDR treats CDDD better than ACDF. The findings suggest that ACDR can improve patient outcomes, reduce complications, and optimise healthcare resources, which have major implications for clinical practise and research.

Conclusion

This study reveals that ACDR is better than ACDF for treating Cervical Disc Degenerative Disease (CDDD) in radiographic and clinical outcomes. ACDR reduced complications and improved functional recovery, pain relief, alignment, and disc height. These findings suggest that ACDR is the best surgical option for trial-eligible CDDD patients. However, device issues and higher ACDR costs must be considered.

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