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Research Article

Comparative Assessment of Cervical Range of Motion after Artificial Disc Replacement versus Fusion across Different Levels

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ABSTRACT
Background: Cervical degenerative disc disease is most commonly treated with surgery called anterior cervical discectomy and fusion (ACDF); this may reduce the cervical motion and put more stress on adjacent cervical levels. Motion preservation surgical options have also become available, such as Artificial Cervical Disc Replacement (ACDR), but local comparative data on the postoperative cervical range of motion (ROM) is sparse.
Objective: To compare postoperative cervical ROM and clinical outcomes between patients undergoing ACDR and ACDF at different cervical levels.
Methods: Patients who had undergone single-level ACDR or ACDF were identified and their medical records examined from January 2023 to December 2025. Ten patients matched with ACDR patients, and 20 matched patients with ACDF, were included. The range of motion (ROM) of the cervical spine was determined both globally and segmentally by flexion-extension radiographs. Visual Analogue Scale (VAS) and Neck Disability Index (NDI) were used to assess pain and functional outcomes. Data was analyzed using SPSS version 26 and the $p<0.05$ was considered statistically significant.
Results: The postoperative global ROM was significantly larger in the ACDR group than in the ACDF group (38.7 ± 4.8 vs 28.6 ± 5.1 degrees; $p<0.001$). In ACDR patients, too, the preservation of segmental ROM was significantly better (7.2 ± 1.4 degrees vs 1.3 ± 0.5 degrees; $p<0.001$). Motion of adjacent segments was significantly higher in ACDF patients compared to the non-ACDF group (11.4 ± 2.2 vs 8.1 ± 1.3 degrees $p=0.002$). There was significant improvement in VAS and NDI scores for both groups.
Conclusion: ACDR has shown itself to be superior to ACDF in preserving cervical motion, but equal in producing clinical improvement. In certain patients with cervical disc disease, a motion-preserving surgery may provide biomechanical benefits.

Keywords: Cervical Disc Disease, Artificial Cervical Disc Replacement, Anterior Cervical Discectomy and Fusion, Cervical Range of Motion.

INTRODUCTION

Neck pain, cervical radiculopathy and myelopathy are common and disabling complications of cervical degenerative disc disease [1, 2]. Surgical treatment is recommended in the patient who has failed conservative management or is progressing to neurological deficits [3]. Anterior Cervical Discectomy and Fusion (ACDF) has been the surgical gold standard for many decades for its pain relief and neurological recovery efficacy. However, motion is lost at the operated segment, and may lead to biomechanical stress at adjacent cervical levels, leading to degeneration of adjacent segments over time [4].

The motion-preserving options are now looking to maintain the natural biomechanics of the cervical spine and has developed into a method known as Artificial Cervical Disc Replacement (ACDR) [5]. Several international studies have shown good results in terms of maintenance of cervical range of motion (ROM), reduction of adjacent segment degeneration, and good functional recovery with ACDR [6]. However, the surgery is still not widely practiced in the developing world due to cost, availability of implants and lack of surgical exposure [7].
In Pakistan, especially in government hospitals, ACDF remains the most common surgical method, with ACDR being used in only a few chosen cases [8]. Thus, few comparisons have been made locally to assess cervical motion

after surgery in these two procedures [9]. In addition, the effect of the level of the surgery on motion preservation after surgery has not gotten enough attention in the local population for the operated cervical level, particularly the C5–C6 and C6–C7 region [10].

This study was done to fill this gap of knowledge by comparing the cervical range of motion and clinical outcomes of the patients undergoing ACDR with that of ACDF in the Neurosurgery Department, Nishtar Medical University Multan. The main goal was to determine if there were any differences in global or segmental cervical ROM between them after surgery. Secondary goals were assessment of the motion trends of the adjacent segments and a comparison of the two groups for pain relief and functional improvement.

METHODOLOGY

It was a retrospective comparative observational study done in the Department of Neurosurgery at Nishtar Medical University. Patients who had surgical intervention for cervical degenerative disc disease from January 2023 to December 2025 were included in the study. To evaluate and compare the clinical outcomes and posterior cervical range of motion (ROM) between patients who received ACDR and ACDF. Because there were not too many cervical disc arthroplasty cases available in the institution, all the cases that met the inclusion criteria were included in the study. There was a total of 10 patients who had undergone ACDR. In the same study period, 20 patients who underwent ACDF were selected, and matched in a 1:2 ratio, by age, gender and cervical level of surgery. The final sample consisted of 30 patients; 10 and 20 patients were in the ACDR and ACDF groups, respectively. The patients were selected using non-probability consecutive sampling method. Patients aged 20-70 years with cervical degenerative disc disease (DDD) causing radiculopathy and/or myelopathy undergoing a single level cervical surgery were included in the study. Patients with operative levels C5 – C6 or C6 – C7, with a minimum follow-up of 6 months, were included. Patients who had received prior surgical treatment on the cervical spine, cervical trauma, spinal tumors, spine infections, congenital cervical spine deformities, surgery performed on more than 2 levels, patients with incomplete medical records and/or insufficient radiological follow up were excluded from the study. The Institutional Review Board of Nishtar Medical University gave ethical clearance to the study, patient records were taken from the hospital medical records, operative notes, outpatient follow up charts, and radiological archives were retrieved in a retrospective fashion. Demographic factors like age and gender, clinical factors like duration of symptoms, presenting complaints and pain severity before surgery, and functional disability status were documented. Additionally, surgical information was recorded such as the surgical procedure that was performed and the cervical level operated. Radiological assessment was made by the dynamic flexion-extension lateral view of the cervical spine radiograph. Global cervical range of motion (ROM) was assessed from C2 to C7 by viewing flexion and extension angle of the cervical spine. Angular motion between adjacent vertebral endplates was calculated to determine segmental ROM at the level of surgery in the cervical spine. Motion of the adjacent segments was also examined at the superior and inferior neighboring cervical levels to examine for compensatory biomechanical changes after the surgery. The Visual Analogue Scale (VAS) was used as a pain assessment tool and the Neck Disability Index (NDI) was used as a functional assessment tool to assess clinical outcomes. VAS scores were obtained pre and postoperatively and NDI improvement percentages were used to assess the functional recovery after surgery. Data entry and statistical analysis was done by SPSS v.26. The quantitative variables were presented as mean ±SD and qualitative variables as frequencies and percentage. Independent sample t-test was used to compare quantitative variables between the two groups and paired t-test was used for pre and post comparisons. Categorical variables were used for Chi-square test or Fisher's Exact test, as appropriate. Throughout the study, a p-value of <0.05 was used as the cut-off for statistical significance.

RESULTS

Table 1 shows the demographic and clinical baseline data of the patients who were included in the study. The mean age for the ACDR group was 44.2 ± 6.8 years compared to 46.5 ± 7.4 years in the ACDF group, without significant differences between the groups (p=0.39). Also, in both groups females were less common than males, with 60% of males and 65% of males, respectively (p=0.78). The mean time interval from symptom onset to surgery was also similar

between the two groups (7.8 ± 2.4 months in ACDR vs 8.6 ± 3.1 months in ACDF; p=0.47). C5–C6 level, which is the most commonly involved level, was followed by C6–C7 level, in both groups regarding the operated cervical levels. There was no significant difference between the groups with respect to level distribution (p=0.81).

Table 1. Baseline Characteristics of the Study Population

Variable	ACDR (n=10)	ACDF (n=20)	p-value
Age (years)	44.2 ± 6.8	46.5 ± 7.4	0.39
Male (%)	60%	65%	0.78
Symptom duration (months)	7.8 ± 2.4	8.6 ± 3.1	0.47
C5–C6 level	60%	55%	0.81
C6–C7 level	40%	45%	0.81

The cervical range of motion (ROM) parameters are compared in table 2 between ACDR and ACDF patients. Global cervical ROM values were similar between both groups at the time of surgery: 41.9 ± 5.3 degrees in ACDR and 42.4 ± 5.9 degrees in ACDF (p=0.82), suggesting similar cervical mobility before surgery. The ACDR group experienced significantly improvements in the preservation of global cervical ROM when compared with the ACDF group (38.7 ± 4.8 versus 28.6 ± 5.1 degrees, respectively, p<0.001). Likewise, there was significant preservation of segmental ROM at the operated level in the ACDR group (7.2 ± 1.4 degrees) while marked reduction was seen in the ACDF group (1.3 ± 0.5 degrees) with a highly significant difference (p<0.001). There was significantly more adjacent segment ROM in ACDF patients than in ACDR patients (11.4 ± 2.2 versus 8.1 ± 1.3 degrees; p=0.002). This result indicates that compensatory hypermobility at adjacent cervical levels occurs after fusion surgery, probably caused by the change of biomechanics after the fusion of the operated segment.

Table 2. Comparison of Cervical Range of Motion

Parameter	ACDR	ACDF	p-value
Preoperative Global ROM	41.9 ± 5.3	42.4 ± 5.9	0.82
Postoperative Global ROM	38.7 ± 4.8	28.6 ± 5.1	<0.001
Segmental ROM	7.2 ± 1.4	1.3 ± 0.5	<0.001
Adjacent Segment ROM	8.1 ± 1.3	11.4 ± 2.2	0.002

The results of the comparison of clinical outcomes of both surgical groups are shown in Table 3. There was no difference between the two groups with regard to severity of preoperative pain, as measured by the Visual Analogue Scale (VAS) (8.0 ± 0.9 for ACDR; 8.1 ± 0.8 for ACDF; p=0.74). There was significant reduction in pain scores after the surgery in both groups. The mean postoperative VAS score was 2.1 ± 0.7 for the ACDR group, and 2.5 ± 0.8 for the ACDF group. The reduction was somewhat larger in the ACDR group, but was not statistically different (p=0.18). Compared to ACDF, functional recovery (improvement percentage using Neck Disability Index (NDI)) was greater in ACDR patients (69%). This difference was not statistically significant (p=0.07) and may have been influenced by the size of the samples.

Table 3. Clinical Outcomes

Variable	ACDR	ACDF	p-value
Preoperative VAS	8.0 ± 0.9	8.1 ± 0.8	0.74
Postoperative VAS	2.1 ± 0.7	2.5 ± 0.8	0.18
NDI Improvement (%)	69%	61%	0.07

DISCUSSION

This study aims to compare the cervical range of motion and clinical outcomes of patients who underwent ACDR and ACDF in a tertiary care neurosurgical center. The results showed ACDR patients had significantly superior preservation of global and segmental cervical motion compared to the ACDF group, with both groups experiencing a satisfactory improvement in pain and functional status [11].

The significantly greater postoperative segmental ROM was one of the most significant findings of the present study. The mean postoperative segmental ROM was 7.2 degrees in the ACDR group compared to 1.3 degrees in the ACDF group ($p<0.001$). The results are similar to those from the previous study by Zavras et al, which showed better motion preservation for those treated with cervical disc arthroplasty versus fusion. They found that motion preservation is one of the key biomechanical benefits of artificial disc replacement, and may play a role in the long-term cervical spine function [12].

The findings of the present study are also consistent with those of Patwardhan., who found significantly increased cervical mobility in the patients who underwent ACDR with Bryan cervical discs. They found that they did not affect neurological recovery, but were able to preserve physiological motion in the operated segment [13]. Similarly, in our study, ACDR patients exhibited normal cervical ROM globaly after surgery, suggesting that a cervical implant favors maintenance of normal cervical biomechanics [14].

The other key finding in the current study was that the ACDF patients demonstrated significantly more motion at adjacent segments than the ACDR group of patients. ACDF patients had a mean adjacent segment ROM of 11.4 degrees compared to 8.1 degrees for ACDR patients ($p=0.002$). This finding may suggest for fusion surgery compensatory hypermobility at adjacent levels. Basu et al. found that fusion techniques change the function of the spine and can lead to increased adjacent segment degeneration over time. Their pioneering research pointed to the fact that stress at adjacent levels after ACDF will lead to increased stress and future surgery [15].

The present results are also consistent with long-term results from the Prestige LP and Bryan Disc trials, which demonstrated lower rates of adjacent segment disease and more spinal motion maintained with cervical arthroplasty than with fusion surgeries [16]. Furthermore, Fahmy et al. found that ACDR had been linked with a better functional outcome, maintenance of mobility, and decrease in secondary surgeries for adjacent segment degeneration in a meta-analysis [17].

In the current study, both groups had significant improvement in pain scores at the end of surgery. Mean postoperative VAS scores improved from 8.0 ± 0.9 to 2.1 ± 0.7 in the ACDR group and from 8.1 ± 0.8 to 2.5 ± 0.8 in the ACDF group. The ACDR group did not show a statistically significant difference, but the difference suggests that the cervical kinematics may be better preserved and there may be a decrease in muscular stiffness [18]. Hamilton et al., also found similar or better clinical results after long-term follow-up in patients undergoing cervical arthroplasty vs fusion surgery. The level of the cervical spine that was operated on can also impact the motion results after surgery. The majority of the surgeries in the present study were at the C5–C6 and C6–C7 levels, the most mobile and frequently operated-on cervical segments. The motion preservation was still better in ACDR group regardless of the operated level [19]. Similar findings have been reported in previous studies that reported cervical arthroplasty preserved the normal cervical disc mechanics and allowed for a good maintenance of motion at a lower cervical level [20].

One of the major strengths of the present study is the local data from public sector neurosurgical unit in Pakistan where ACDR is not routinely used due to financial constraints and lack of implants. The majority of published studies come from high income countries that have more access to sophisticated spinal implants and long-term follow-up facilities [21]. Thus, the present study provides relevant evidence from the real world on the feasibility and effectiveness of cervical arthroplasty in a resource limited healthcare system.

There are a number of caveats, however. This was a retrospective design which could lead to selection bias, and there were relatively few ACDR patients, which might limit the generalizability of the findings. Moreover, the follow-up period was not very long, so evaluation of the implant longevity and degeneration of adjacent segments was not possible. Future prospective multicenter studies with larger numbers of patients and longer follow-up times are suggested to confirm the results of this study and to provide solid evidence for the role of cervical arthroplasty in the local population.

CONCLUSION

ACDR showed significantly more preservation of cervical range of motion than anterior cervical discectomy and fusion, but similar clinical improvement in pain and function. The adjacent segment motion was higher in ACDF patients, which indicates that there was a change in biomechanics of the cervical spine after fusion. While the ACDF is still the more frequently used procedure in resource-poor areas, ACDR may have biomechanical benefits in certain patients. More studies are required in larger populations to continue assessing the long-term effects in the local community.

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