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ORIGINAL ARTICLE

Clinical and Radiographic Outcomes Following Anterior Cervical Discectomy and Fusion Using Integrated Anchor Fixation – A Single-Centre Experiences

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ABSTRACT

Background*: Anterior cervical discectomy and fusion (ACDF) is a widely accepted surgical intervention for cervical degenerative disc disease. Integrated anchor fixation systems have emerged as an alternative to traditional anterior plating, offering reduced soft tissue disruption and lower complication rates while maintaining biomechanical stability. Aim of the study: To evaluate the clinical and radiographic outcomes, fusion rates, and complication profiles following ACDF using an integrated anchor fixation system in patients with symptomatic cervical degenerative disc disease.* ***Methods & Materials****: This prospective observational study included 60 patients who underwent ACDF with an integrated anchor fixation device at a single tertiary center. Preoperative and 12-month postoperative outcomes were assessed using the Visual Analog Scale (VAS) for neck and arm pain, Neck Disability Index (NDI), and SF-36 Physical and Mental Component Scores. Radiographic parameters included segmental and global cervical lordosis, disc height, fusion status, and cage subsidence. Subgroup analysis was conducted between single- and two-level procedures.* ***Result****: Significant improvements were observed in all clinical metrics at 12 months: VAS-neck decreased from 7.9 ± 1.2 to 2.3 ± 1.1 ($p < 0.001$), VAS-arm from 7.3 ± 1.3 to 1.9 ± 1.2 ($p < 0.001$), and NDI from 53.2 ± 8.6% to 16.1 ± 6.3% ($p < 0.001$). SF-36 PCS and MCS improved by 17.2 and 16.2 points, respectively ($p < 0.001$). Radiographic analysis showed significant gains in segmental lordosis (2.1° to 6.0°, $p < 0.001$) and disc height (4.3 mm to 6.3 mm, $p < 0.001$). Fusion was achieved in 95% of cases. Subsidence (>2 mm) occurred in 8.3%, and dysphagia was reported in 11.7% at one month. Two-level ACDF cases had lower fusion rates (83.3% vs. 97.8%, $p = 0.045$) and higher dysphagia incidence (33.3% vs. 6.7%, $p = 0.023$) compared to single-level cases.* ***Conclusion****: ACDF with integrated anchor fixation resulted in substantial improvements in pain, function, and radiographic alignment, with high fusion rates and a low incidence of complications. These findings support the use of integrated fixation as a safe and effective alternative to traditional anterior plating, particularly in single-level procedures.*

Keywords: *Anterior cervical discectomy and fusion (ACDF); integrated anchor fixation; cervical spine; zero-profile implant; fusion rate; sagittal alignment; postoperative dysphagia.*

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INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) is a widely practiced surgical technique designed to alleviate spinal cord or nerve root compression in the cervical spine, most commonly resulting from degenerative disc disease, herniated disc, or cervical spondylosis [1]. The procedure entails removal of the diseased disc followed by fusion of the adjacent vertebrae to restore spinal alignment and ensure long-term stability. In recent years, the use of integrated anchor fixation systems—commonly referred to as zero-profile or stand-alone interbody devices—has emerged as a significant advancement. These systems are intended to enhance clinical outcomes while reducing postoperative complications frequently associated with traditional plate-and-screw constructs [2]. Cervical degenerative disc disease (CDDD) remains a highly prevalent condition, contributing substantially to chronic neck pain, radiculopathy, and myelopathy, thereby imposing a considerable burden on quality of life [3]. Globally, the number of individuals affected by neck pain is estimated at 288.7 million, underscoring the magnitude of this condition [4]. In Bangladesh, cervical disc disease has become a growing public health concern, driven by factors such as increased life expectancy, sedentary lifestyle, and under-recognition of musculoskeletal disorders. Recent hospital-based data highlight a rising incidence of CDDD, particularly among the urban population aged 40–60 years [5]. Traditionally, ACDF using anterior cervical plates and interbody cages has been the mainstay of surgical intervention for symptomatic cervical disc herniation and spondylosis. While effective, anterior plate systems are associated with hardware-related complications such as dysphagia, implant migration, and adjacent segment degeneration [6]. To address these limitations, integrated anchor fixation devices have been developed, offering a zero-profile design that sits entirely within the disc space. These

devices are believed to reduce esophageal irritation, operative time, and the risk of soft-tissue complications without compromising spinal stability or fusion rates [7]. The shift towards integrated interbody systems in ACDF is supported by biomechanical studies and initial clinical trials demonstrating comparable or improved fusion outcomes, reduced rates of postoperative dysphagia, and better preservation of adjacent segment integrity [8]. However, most of these studies originate from Western populations with varying clinical practices and healthcare infrastructure, limiting their generalizability. In developing countries like Bangladesh, there is a lack of comprehensive data evaluating the safety, efficacy, and radiographic outcomes of integrated anchor fixation systems in ACDF [9]. Moreover, local experience and long-term follow-up studies are scarce, creating a gap in evidence-based decision-making in spinal surgery [10]. Given the growing interest in minimally invasive and anatomically favorable spinal implants, there is a need for high-quality, center-specific evidence to validate the clinical and radiological outcomes of such novel interventions [11]. This study was therefore conducted to assess the clinical efficacy, radiographic fusion success, and complication rates associated with anterior cervical discectomy and fusion using integrated anchor fixation devices in a single tertiary care center in Bangladesh [12]. The aim of this study is to evaluate the clinical and radiographic outcomes of ACDF using integrated anchor fixation devices in patients with cervical disc pathology.

METHODS & MATERIALS

This prospective observational study was conducted at the Department of Orthopedic Surgery, Bangladesh Medical, Dhaka, Bangladesh from January 2023 to December 2024. Written informed consent was obtained from all participants. A total of 60 consecutive patients who underwent anterior cervical discectomy and fusion (ACDF) using an integrated anchor fixation cage system were included.

Inclusion and Exclusion criteria

Inclusion criteria were:

- Age between 18 and 75 years
- Clinical and radiological confirmation of cervical DDD
- Failure of conservative management for at least 6 weeks

Exclusion criteria included**:**

- Active infection or spinal tumors.
- Previous cervical spine surgery.
- Severe osteoporosis (T-score < –2.5).
- Traumatic cervical spine injury.
- Other spinal pathologies such as neoplastic or infectious processes.

Preoperative Assessment and Data Collection

Baseline demographic and clinical data, including age, sex, body mass index (BMI), comorbidities (e.g., hypertension, diabetes, smoking status), and symptom duration, were recorded. Perioperative variables included operative level(s), surgery duration, intraoperative blood loss, and length of hospital stay. All clinical assessments were completed by independent assessors blinded to radiological findings.

Surgical Procedure

All operations were performed under general anesthesia with the patient supine and the neck in slight extension. A standard left-sided Smith–Robinson approach exposed the cervical disc space. After discectomy and neural decompression, endplates were prepared carefully to remove cartilage while preserving subchondral bone. An appropriately sized polyetheretherketone (PEEK) cage with self-locking screw anchors was packed with autologous cancellous bone graft or synthetic substitute and inserted centrally under fluoroscopic guidance. Self-locking anchors were advanced into the superior and inferior vertebral bodies for immediate anterior column stability without plating. Final implant position and segmental alignment were confirmed fluoroscopically before layered wound closure over a suction drain.

Postoperative Management and Follow-Up

Patients were mobilized on postoperative day 1 wearing a soft cervical collar for 4–6 weeks. Follow-up visits were scheduled at 1, 3, 6, and 12 months. At each visit, clinical assessments and radiographs were obtained; the primary endpoints were evaluated at the 12-month follow-up.

Outcome Measures

- **Clinical**: Neck and arm pain were graded on a 0–10 Visual Analog Scale (VAS). Functional disability was measured by the Neck Disability Index (NDI, %), and health-related quality of life by the Short Form-36 Health Survey (SF-36), yielding Physical (PCS) and Mental (MCS) Component Summary scores. All clinical data were collected preoperatively and at 12 months by evaluators blinded to radiographic results.
- **Radiographic**: Lateral neutral, flexion, and extension cervical spine radiographs were obtained preoperatively, immediately postoperatively, and at 12 months. Measured parameters included segmental lordosis (Cobb angle at the fused level), global cervical lordosis (C2–C7), and intervertebral disc height at the midpoint of anterior and posterior margins. Subsidence was defined as a decrease in disc height >2 mm from immediate postoperative imaging. Fusion was confirmed by <2° angular motion on dynamic radiographs combined with visible trabecular continuity across the device. Two independent spine surgeons performed all measurements; disagreements were resolved by consensus.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR) depending on data distribution. Paired t-tests or Wilcoxon signed-rank tests were utilized to compare preoperative and postoperative clinical and radiological outcomes. Independent t-tests or Chi-square/Fisher's exact tests were applied to assess differences between single-level and two-level ACDF groups. A p-value < 0.05 was considered statistically significant.

RESULT

A total of 60 patients were included in the study, with a mean age of 52.4±9.1 years. Males predominated (58.3%), and the mean BMI was 26.3±3.7 kg/m^2. Hypertension was the most frequent comorbidity (41.7%), followed by heart disease (23.3%), hyperlipidemia (16.7%), and diabetes mellitus (13.3%). A history of smoking prior to surgery was reported by 15% of patients. The median duration of symptoms was 8 months (IQR 4–14). The most commonly operated level was C5–C6 (43.3%), followed by C6–C7 (38.3%). Single-level ACDF accounted for the majority of procedures (75%), with operative time averaging 85.2±14.6 minutes and mean blood loss 64.1±21.3 ml. The mean length of hospital stay was 2.8±1.1 days (*Table I*).

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Table – I: Baseline Demographic and Perioperative Characteristics of the study population (*n*=60)

Variable	Frequency (n)	Percentage (%)
Age (years)		
Mean ± SD	52.4 ± 9.1	
Gender		
Male	35	58.33
Female	25	41.67
BMI (kg/m^2)		
Mean ± SD	26.3 ± 3.7	
Comorbidities		
Hypertension	25	41.67
Hyperlipidemia	10	16.67
Diabetes mellitus	8	13.33
Heart disease (CAD, prior MI)	14	23.33
Smoking prior to surgery	9	15.00
Duration of symptoms (months)		
median (IQR)	8 (4–14)	
Operated level		
C4–C5	8	13.33
C5–C6	26	43.33
C6–C7	23	38.33
Multilevel	4	6.67
Number of levels operated		
1-level	45	75.00
2-level	12	20.00
3-level	3	5.00
Operative time (min)		
Mean ± SD	85.2 ± 14.6	
Blood loss (ml)		
Mean ± SD	64.1 ± 21.3	
Hospital stay (days)		
Mean ± SD	2.8 ± 1.1	

At 12 months postoperatively, patients demonstrated marked improvement across all clinical parameters. VAS Neck scores decreased from 7.9±1.2 to 2.3±1.1 (p<0.001), and VAS Arm scores from 7.3±1.3 to 1.9±1.2 (p<0.001). NDI improved significantly from 53.2±8.6% to 16.1±6.3% (p<0.001). Quality of life, measured by SF-36, showed significant gains, with PCS increasing from 35.4±5.9 to 52.6±6.1 and MCS from 38.6±6.8 to 54.8±5.7 (both p<0.001) *Table II*.

Table – II: Comparison of preoperative and 12-month postoperative clinical outcomes following ACDF with integrated fixation

Outcome Measure	Preoperative	12 Months Post-op	Mean Difference	p-value†
VAS Neck (0–10)	7.9 ± 1.2	2.3 ± 1.1	-5.6	<0.001
VAS Arm (0–10)	7.3 ± 1.3	1.9 ± 1.2	-5.4	<0.001
NDI (%)	53.2 ± 8.6	16.1 ± 6.3	-37.1	<0.001
SF-36 PCS	35.4 ± 5.9	52.6 ± 6.1	17.2	<0.001
SF-36 MCS	38.6 ± 6.8	54.8 ± 5.7	16.2	<0.001

Table III presented that segmental lordosis increased from 2.1±3.1° preoperatively to 6.0±2.4° at 12 months (p<0.001). C2–C7 global lordosis improved from 11.2±5.6° to 17.1±5.5° (p<0.001). Intervertebral disc height rose from 4.3±0.8 mm to 6.3±0.8 mm at 12 months (p<0.001). Cage subsidence >2 mm was noted in 8.3% of patients at 12 months (p=0.016).

Table – III: Radiographic outcomes

Radiographic Parameter	Preoperative	Immediate Postoperative	12-Month Follow-up	p-value‡
Segmental Lordosis (°)	2.1 ± 3.1	6.4 ± 2.5	6.0 ± 2.4	<0.001
C2–C7 Global Lordosis (°)	11.2 ± 5.6	17.5 ± 5.3	17.1 ± 5.5	<0.001
Intervertebral Disc Height (mm)	4.3 ± 0.8	6.6 ± 0.7	6.3 ± 0.8	<0.001
Cage Subsidence (>2 mm), n (%)	0 (0.00)	0 (0.00)	5(8.33)	0.016†

Table IV showed that at final follow-up, successful radiographic fusion was achieved in 95% of patients, while pseudarthrosis was observed in 5%. Subsidence occurred in 6.7%. Dysphagia was common in the early postoperative period (11.7% at 1 month), but only one patient (1.7%) reported persistence beyond 3 months. Transient hoarseness occurred in 3.3%, superficial infection in 1.7%, and reoperation was required in 1.7%. No implant-related complications were reported.

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Table – IV: Radiological fusion status and postoperative complications at final follow-up (12 Months, *n* = 60)

Parameter	Frequency (n)	Percentage (%)
Successful Radiographic Fusion	57	95.00
Pseudarthrosis (non-union)	3	5.00
Subsidence (>2 mm)	4	6.67
Dysphagia at 1 month	7	11.67
Persistent Dysphagia (>3 months)	1	1.67
Hoarseness (transient)	2	3.33
Superficial Infection	1	1.67
Implant-related Complication	0	0.00
Reoperation	1	1.67

Subgroup analysis revealed no significant difference between single- and two-level ACDF regarding VAS improvement, NDI reduction, or SF-36 outcomes (all p>0.05). However, disc height gain was significantly higher in the single-level group (2.2±0.4 mm vs. 1.8±0.5 mm, p=0.019). Fusion rates were also superior in single-level cases (97.8% vs. 83.3%, p=0.045). Early postoperative dysphagia was more frequent in two-level procedures (33.3% vs. 6.7%, p=0.023). Other complications, including subsidence and reoperation, were not statistically different between groups (*Table V*).

Table – V: Comparison of clinical and radiological outcomes between single-level and two-level ACDF with integrated fixation

Outcome Measure	1-Level ACDF (n = 45)	2-Level ACDF (n = 12)	p-value§
VAS Neck Improvement (0–10)	5.6 ± 1.2	5.2 ± 1.3	0.312
VAS Arm Improvement (0–10)	5.3 ± 1.3	4.9 ± 1.5	0.288
NDI Improvement (%)	35.9 ± 6.3	34.1 ± 7.0	0.281
SF-36 PCS Change	+17.0 ± 5.0	+15.4 ± 5.2	0.268
Segmental Lordosis Gain (°)	4.0 ± 1.9	3.4 ± 1.8	0.225
Disc Height Gain (mm)	2.2 ± 0.4	1.8 ± 0.5	0.019*
Fusion Rate at 12 Months (%)	44 (97.78)	10 (83.33)	0.045*
Dysphagia at 1 Month (%)	3 (6.67)	4 (33.33)	0.023*
Implant Subsidence >2 mm (%)	2 (4.44)	2 (16.67)	0.147
Reoperation Required (%)	0 (0.00)	1 (8.33)	0.135

DISCUSSION

Anterior cervical discectomy and fusion (ACDF) remains the gold standard surgical approach for treating symptomatic cervical degenerative disc disease unresponsive to conservative management [13-15]. Over recent years, the evolution of interbody devices—particularly those with integrated anchor fixation—has sought to minimize complications associated with traditional anterior plating, such as postoperative dysphagia, hardware prominence, and soft tissue irritation, while maintaining or improving clinical and radiographic outcomes [14-16]. In this context, the present study provides valuable evidence supporting the efficacy and safety of integrated anchor fixation devices over a 12-month follow-up period in a real-world, single-centre setting. In the present study, the mean age was 52.4 years, and 58.3% of patients were male, consistent with demographic patterns reported in prior studies involving zero-profile systems. Shi et al. (2016) documented a similar age range (52–56 years) and a male predominance of 57% [17], while Xiao et al. (2017) reported comparable findings, with mean ages of 50–55 years and male proportions of 50–60% [18]. Comorbidities such as hypertension (41.7%), diabetes mellitus (13.3%), and ischemic heart disease (23.3%) were frequently observed, reflecting the age-related nature of cervical spine degeneration [19]. Most patients experienced radiculopathy or myelopathy for a median of 8 months, with C5–C6 and C6–C7 being the most affected levels—consistent with their high mobility and mechanical loading [20]. Alhashash et al. (2021) similarly reported predominant involvement at these segments [21]. Significant improvement was observed in all clinical outcome measures at 12 months postoperatively (Table 2). The reduction in neck and arm pain, as measured by VAS, and the functional recovery assessed by NDI, were both statistically and clinically significant ($p < 0.001$). The decrease in NDI from 53.2% to 16.1% (mean difference: −37.1%) represents a notable enhancement in functional independence. Comparable clinical improvements have been previously reported with integrated anchor fixation systems. Njoku et al. (2014) observed significant reductions in VAS scores for neck and arm pain, from median values of 6 and 2 to 0, respectively, alongside a marked decline in NDI from approximately 56% to 20% at final follow-up ($p < 0.001$) [16]. Similarly, Scholz et al. (2020), in a randomized controlled trial, demonstrated a decrease in NDI from 55% to 18.5% and VAS from 6.3 to 1.1 at 12 months ($p < 0.001$) [21,22]. Barbagallo et al. (2013) also reported sustained improvements in arm pain and functional outcomes over four years using a zero-profile cage-plate construct, with fusion rates exceeding 90% and minimal postoperative complications [23]. Moreover, health-related quality of life, as measured by the SF-36 Physical and Mental Component Scores, improved significantly, further confirming the broad patient benefit conferred by the integrated system. These outcomes align with the prospective multicenter findings of Lonjon et al. (2019), who reported marked postoperative gains in both SF-36 domains at two-year follow-up using a similar zero-profile anchored cage system. Radiographic analysis (Table 3) in the present study demonstrates that integrated anchor fixation effectively restores and maintains sagittal cervical alignment and disc height. Segmental lordosis significantly increased from 2.1° preoperatively to 6.0° postoperatively, while global C2–C7 lordosis improved from 11.2° to 17.1° (both $p < 0.001$), with these corrections sustained at 12 months. These findings align with Noh et al. (2018), who reported a postoperative increase in global lordosis from 12.4° to 17.4° (Δ +5.0°, $p < 0.001$) and segmental alignment improvement from 5.8° to 6.1° (Δ +0.3°, $p < 0.05$) using the Perfect-C system [25]. Similarly, Liu et al. (2016) observed segmental and global lordosis gains of approximately 3–5° and 5–8°, respectively, with the ROI-C zero-

profile device [7]. Disc height increased by an average of 2 mm postoperatively, with a slight reduction at 12 months likely due to cage settling. Cage subsidence >2 mm occurred in 8.3% of patients, consistent with Njoku et al.'s (2014) report of modest postoperative settling [16]. These results underscore the capacity of integrated interbody devices to enhance cervical sagittal balance effectively. The fusion rate in our cohort was 95% at 12 months (Table 4), consistent with rates reported in contemporary studies utilizing integrated or zero-profile devices [24]. Notably, no implant-related mechanical failures occurred, and only one patient required reoperation. The incidence of postoperative dysphagia at one month was 11.7%, with a single case persisting beyond three months, supporting the hypothesis that zero-profile implants reduce anterior soft tissue irritation [26]. Other complications, such as transient hoarseness and superficial infections, were rare and self-limiting. When clinical and radiographic outcomes were stratified by surgical level (Table 5), single-level ACDF showed slightly superior results. Although improvements in VAS, NDI, and SF-36 scores were comparable between groups, disc height gain was significantly greater in the single-level group (2.2 mm vs. 1.8 mm, p = 0.019), as was fusion rate (97.8% vs. 83.3%, p = 0.045). Dysphagia at one month was more frequent in the two-level group (33.3% vs. 6.7%, p = 0.023), consistent with prior findings [27]. Operative time (85.2 minutes), blood loss (64.1 ml), and hospital stay (2.8 days) were favorable compared to benchmarks [23].

LIMITATIONS

This study is limited by its retrospective, single-centre design and relatively small sample size, which may reduce the generalizability of the findings. Additionally, the follow-up period of 12 months, although adequate for assessing fusion and early complications, does not capture long-term outcomes such as adjacent segment degeneration or late-onset hardware issues. The lack of a control group using traditional plating also limits direct comparison of the clinical and radiological advantages of integrated anchor fixation.

CONCLUSION & RECOMMENDATIONS

Anterior cervical discectomy and fusion (ACDF) with integrated anchor fixation demonstrated excellent clinical and radiographic outcomes in patients with cervical degenerative disc disease. Significant improvements in pain, function, and quality of life were achieved, alongside high fusion rates and favorable alignment restoration. The device's low complication profile—particularly reduced dysphagia and absence of implant-related failures—underscores its value, especially in single-level procedures. While two-level cases showed acceptable results, slightly reduced fusion rates and increased dysphagia suggest the need for judicious surgical planning. These findings support the broader adoption of integrated systems as a safe and effective alternative to traditional anterior plating.

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CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee.

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