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Original Article

Comparison of Bone Graft with Plate vs Zero-Profile PEEK Cage for Anterior Cervical Discectomy and Fusion

Ghulam Mustafa[1], Abid Hussain[1], Wazir Ahmed[2], Raz Muhammad Bazai[1], Sher Hassan Khan[1], Muhammad Mujahid Sharif[3]

[1] Bolan Medical College, Quetta, Pakistan

[2] Department of Orthopaedic Surgery, Bolan Medical College, Quetta, Pakistan

[3] Pakistan Institute of Medical Sciences (PIMS), Islamabad, Pakistan

Correspondence: dr.gmwardak@gmail.com
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ABSTRACT

Background: Anterior cervical discectomy and fusion (ACDF) is a widely used procedure for cervical disc disease, employing either bone graft with anterior plating or zero-profile PEEK cages. While both approaches aim to achieve spinal stability and neural decompression, their comparative effectiveness in clinical and operative outcomes remains under debate. Objective: To compare the radiological and clinical outcomes of ACDF using bone graft with anterior plate versus zero-profile PEEK cage. Methods: This prospective comparative study enrolled 60 patients with cervical disc herniation who underwent single- or two-level ACDF. Group A received bone graft with anterior plate, while Group B received zero-profile PEEK cages. Outcomes assessed at 3 and 6 months included fusion rates, disc height, segmental lordosis, Neck Disability Index (NDI), Visual Analog Scale (VAS) scores, operative time, and intraoperative blood loss. Statistical analysis was performed using SPSS v25.0 with a significance level of $p < 0.05$. Results: Fusion rates were similar between groups (93.3% vs. 86.7%, $p = 0.38$). Group A showed better lordosis ($p = 0.02$), while Group B had lower NDI ($p = 0.00$), neck pain ($p = 0.04$), operative time ($p = 0.00$), and blood loss ($p = 0.00$). Conclusion: Both ACDF techniques are effective, but zero-profile PEEK cages offer superior clinical recovery, reduced invasiveness, and operative efficiency.
Keywords: ACDF, PEEK cage, anterior cervical plate, spinal fusion, cervical disc herniation, functional outcomess.

INTRODUCTION

Cervical degenerative disc disease, disc herniation, and myelopathy are among the most prevalent pathologies leading to anterior cervical discectomy and fusion (ACDF), a widely accepted surgical intervention designed to decompress neural structures and stabilize the cervical spine (1). Traditionally, ACDF procedures employ autologous iliac crest bone grafts coupled with anterior cervical plates to enhance fusion rates and segmental stability. Although effective, this approach often leads to complications such as donor site morbidity, increased operative time, blood loss, and a heightened risk of postoperative dysphagia due to anterior plating prominence (2,3).

To address these concerns, the development of zero-profile interbody devices—particularly those made from polyetheretherketone (PEEK)—has provided a promising alternative. These implants are designed to rest entirely within the intervertebral space and eliminate the need for additional anterior plating, thereby reducing soft tissue irritation and implant-related complications (4,5). PEEK cages also exhibit a modulus of elasticity comparable to that of cortical bone, which minimizes stress shielding and potentially enhances biomechanical integration (6). Moreover, they can be filled with local autograft and deployed through a less invasive technique, theoretically improving clinical outcomes while maintaining radiological efficacy (7).

Numerous studies have demonstrated that zero-profile cages offer similar fusion rates compared to conventional cage-and-plate constructs while significantly reducing operative time and dysphagia incidence (8,9). For instance, Wang et al. reported decreased postoperative dysphagia and comparable neurological improvement in patients undergoing ACDF with zero-profile implants (10). Similarly, a meta-analysis by Sun et al. supported the clinical equivalence of zero-profile devices and anterior plate constructs, while highlighting advantages such as reduced intraoperative blood loss and lower rates of adjacent segment degeneration (11). Nonetheless, despite growing interest, the routine use of zero-profile PEEK implants remains limited in many clinical settings due to reimbursement restrictions and perceived concerns about their long-term stability and fusion adequacy.

The current evidence indicates that while both surgical strategies—ACDF with bone graft plus plate and ACDF with zero-profile PEEK cage—are clinically effective, a head-to-head comparison in a controlled setting is necessary to identify their relative advantages and limitations in terms of fusion rate, segmental alignment, pain relief, functional disability, and perioperative parameters. Addressing this

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gap is particularly important for surgical planning in resource-limited environments or when prioritizing patient comfort and recovery trajectory.

The objective of this prospective comparative study was therefore to evaluate and compare clinical and radiological outcomes between ACDF performed with bone graft and anterior cervical plating versus ACDF using a zero-profile PEEK cage, focusing on fusion rate, disc height preservation, segmental lordosis, operative metrics, and functional recovery scores.

MATERIAL AND METHODS

This prospective comparative study was conducted in the Department of Orthopedic Surgery at Bolan Medical College Quetta over a six-month period from November 2024 to May 2025. After obtaining ethical review committee (ERC) approval, a total of 60 patients meeting the eligibility criteria were enrolled using a non-probability convenience sampling technique. The inclusion criteria were adults aged 18 to 70 years diagnosed with single or two-level cervical disc herniation presenting with either radiculopathy or myelopathy, who had completed their treatment course at the study center. Patients were excluded if they had undergone prior cervical spine surgery, exhibited other spinal pathologies such as tumors, infections, deformities, ossification of the posterior longitudinal ligament (OPLL), required hybrid anterior-posterior surgical approaches, or had severe osteoporosis or poorly controlled diabetes.

Eligible participants were recruited consecutively from the outpatient neurosurgery and orthopedic clinics after detailed clinical and radiological evaluation. Informed consent was obtained from each patient after a thorough explanation of the surgical options, risks, and follow-up protocol. Based on the surgical technique employed, participants were allocated into two groups. Group A underwent anterior cervical discectomy and fusion (ACDF) using an autologous iliac crest bone graft or structural allograft combined with anterior cervical plating. Group B received ACDF using a zero-profile PEEK cage filled with local autograft, without the use of an additional plate. All surgeries were performed by experienced spine surgeons following a standard anterior cervical approach under general anesthesia. The same surgical team and postoperative care protocol were maintained throughout the study to ensure procedural consistency and minimize bias.

Radiological and clinical data were collected at three time points: preoperatively, and at three and six months postoperatively. Radiological evaluation was conducted using lateral, flexion-extension, and anteroposterior cervical spine X-rays. Fusion was defined as the presence of continuous trabecular bone bridging across the intervertebral space with no detectable motion on dynamic flexion-extension views. Disc height was measured at the midpoint of the intervertebral space on lateral radiographs, while segmental lordosis was assessed by measuring the Cobb angle between the superior endplate of the upper vertebra and the inferior endplate of the lower vertebra at the fused level. Functional assessment included the Neck Disability Index (NDI) and Visual Analog Scale (VAS) for both neck and arm pain. Operative parameters recorded were total surgery time in minutes and intraoperative blood loss in milliliters, as documented by the surgical team. Additional perioperative outcomes such as dysphagia, infection, implant failure, and reoperation were monitored and documented at each follow-up.

Data were entered into SPSS version 25.0 (IBM Corp., Armonk, NY) for statistical analysis. Continuous variables were reported as means with standard deviations, and categorical variables were presented as frequencies and percentages. Group-wise comparisons were conducted using the independent samples t-test for continuous variables and the chi-square test for categorical data. A p-value less than 0.05 was considered statistically significant. No imputation was done for missing data as all follow-up points were complete for all participants. The study design, data collection, and analytical process followed the principles of reproducibility and transparency. All data were cross-verified by two independent investigators to ensure accuracy and integrity of the analysis (12–14).

RESULTS

A total of 60 patients were included in this prospective comparative study, equally divided between Group A (bone graft with plate) and Group B (zero-profile PEEK cage). The mean age of participants was 55.27 ± 8.87 years, with no significant difference between groups ($p = 0.75$). While both groups had identical gender distribution—66.7% male and 33.3% female—the age distribution differed slightly: a greater proportion of patients in Group A were aged 41–60 years (63.3% vs. 46.7%), whereas more patients in Group B were over 60 years of age (53.3% vs. 30.0%). However, this variation did not reach statistical significance ($p = 0.09$).

Radiological outcomes at the six-month follow-up demonstrated high fusion rates in both groups, with Group A achieving 93.3% and Group B 86.7%, a difference that was not statistically significant ($p = 0.38$). Maintenance of disc height was comparable between groups, with mean values of 4.13 ± 0.89 mm in Group A and 3.96 ± 0.85 mm in Group B ($p = 0.46$). However, segmental lordosis improvement was significantly greater in Group A, with a mean increase of 6.90 ± 1.09° compared to 6.33 ± 0.84° in Group B ($p = 0.02$), suggesting that anterior plating contributed more effectively to sagittal alignment correction.

Table 1: Demographic Characteristics of the Study Population (N = 60)

Variable	Group A (n = 30)	Group B (n = 30)	p-value	95% CI of Difference
Age (years)	54.9 ± 9.2	55.6 ± 8.6	0.75	-3.93 to 2.59
Age 18–40 years	2 (6.7%)	0 (0.0%)	0.15	–
Age 41–60 years	19 (63.3%)	14 (46.7%)	0.19	–
Age >60 years	9 (30.0%)	16 (53.3%)	0.09	–
Male	20 (66.7%)	20 (66.7%)	1.00	–
Female	10 (33.3%)	10 (33.3%)	–	–

Table 2: Radiological Outcomes at 6 Months Postoperative

Outcome	Group A (n = 30)	Group B (n = 30)	p-value	Mean Difference	95% CI of Difference
Fusion Rate (%)	28 (93.3%)	26 (86.7%)	0.38	–	–
Disc Height (mm)	4.13 ± 0.89	3.96 ± 0.85	0.46	0.17	-0.31 to 0.65
Segmental Lordosis (°)	6.90 ± 1.09	6.33 ± 0.84	0.02*	0.57	0.09 to 1.05

*Statistically significant difference ($p < 0.05$)

Table 3: Clinical and Operative Outcomes Between Group A and Group B

Outcome	Group A (n = 30)	Group B (n = 30)	p-value	Mean Difference	95% CI of Difference
Neck Disability Index (NDI)	15.35 ± 2.49	12.50 ± 2.09	0.00*	2.85	1.65 to 4.05
VAS Neck Pain	2.3 ± 1.1	1.8 ± 1.0	0.04*	0.5	0.02 to 0.98
VAS Arm Pain	1.9 ± 1.0	1.5 ± 0.9	0.06	0.4	-0.01 to 0.81
Operative Time (minutes)	95.5 ± 15.3	75.8 ± 12.7	0.00*	19.7	13.2 to 26.2
Intraoperative Blood Loss (ml)	110.4 ± 25.1	85.2 ± 20.7	0.00*	25.2	13.7 to 36.7

*Statistically significant difference ($p < 0.05$)

In terms of clinical outcomes, Group B demonstrated significantly lower Neck Disability Index (NDI) scores at six months (12.50 ± 2.09) compared to Group A (15.35 ± 2.49), reflecting superior postoperative functional recovery ($p = 0.00$). Similarly, Visual Analog Scale (VAS) scores for neck pain were significantly better in Group B (1.8 ± 1.0) than in Group A (2.3 ± 1.1), with a mean difference of 0.5 points ($p = 0.04$). Although VAS scores for arm pain were also lower in Group B (1.5 ± 0.9 vs. 1.9 ± 1.0), the difference did not reach statistical significance ($p = 0.06$), indicating a favorable trend without definitive evidence.

Operative efficiency was markedly improved in Group B, where the mean surgical duration was 75.8 ± 12.7 minutes compared to 95.5 ± 15.3 minutes in Group A, yielding a statistically significant reduction of nearly 20 minutes ($p = 0.00$). Furthermore, intraoperative blood loss was significantly lower in Group B, averaging 85.2 ± 20.7 ml versus 110.4 ± 25.1 ml in Group A ($p = 0.00$), highlighting the less invasive nature of the zero-profile PEEK cage approach.

Taken together, these findings demonstrate that while both surgical techniques achieved high fusion rates and preserved disc height effectively, the use of zero-profile PEEK cages was associated with significantly better clinical outcomes, shorter operative times, and reduced intraoperative blood loss, albeit at the cost of slightly inferior lordosis correction.

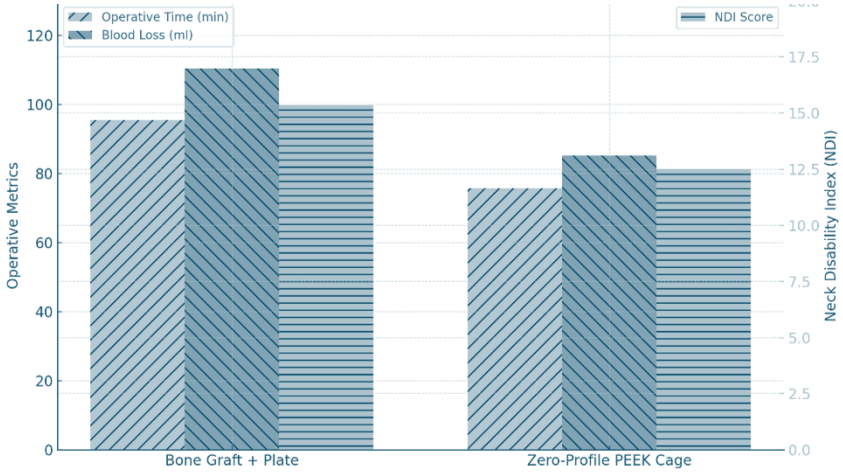

Figure 1 Clinical and operative outcomes between anterior cervical discectomy and fusion (ACDF) techniques.

This integrated comparison chart highlights key clinical and operative outcomes between anterior cervical discectomy and fusion (ACDF) techniques. Patients treated with a zero-profile PEEK cage experienced significantly shorter operative times (75.8 minutes vs. 95.5 minutes) and reduced intraoperative blood loss (85.2 ml vs. 110.4 ml) compared to those who underwent bone grafting with an anterior plate. Additionally, Neck Disability Index (NDI) scores were notably lower in the PEEK cage group (12.5 vs. 15.35), indicating better postoperative functional recovery. These concurrent improvements across efficiency and disability metrics visually reinforce the clinical preference for zero-profile implants in eligible patients.

DISCUSSION

Anterior cervical discectomy and fusion (ACDF) is a cornerstone surgical procedure in the management of cervical disc herniation and cervical spondylotic myelopathy. This study aimed to compare two widely practiced fusion techniques: traditional ACDF using autologous or allogenic bone graft with anterior plating versus ACDF using a zero-profile PEEK cage filled with local autograft. Both techniques yielded favorable outcomes, with high fusion rates and preservation of disc height, affirming their overall effectiveness. However, nuanced differences in radiological, functional, and operative parameters offer valuable insight into clinical decision-making.

Radiological fusion rates in both groups were comparable and statistically non-significant, with 93.3% in the bone graft with plate group and 86.7% in the zero-profile cage group. These results align with previous findings from Niu et al., who reported equivalent fusion outcomes in single- and two-level ACDF using titanium and PEEK cages (15). The comparable fusion rates suggest that standalone zero-profile implants provide adequate biomechanical stability in appropriately selected cases. Although segmental lordosis improvement was significantly greater in the plate group, likely due to the anterior plate's ability to exert greater corrective force on spinal alignment, this did not translate into superior clinical outcomes.

In fact, the zero-profile PEEK cage group demonstrated significantly better functional outcomes, including lower Neck Disability Index (NDI) scores and reduced neck pain on the Visual Analog Scale (VAS). These findings are consistent with prior literature indicating that zero-profile implants reduce anterior soft tissue irritation and the incidence of postoperative dysphagia, both of which contribute to improved patient-reported outcomes (16). Sun et al. conducted a meta-analysis involving patients undergoing ACDF and concluded that zero-profile devices not only reduce intraoperative blood loss and operative time but also offer advantages in early postoperative recovery (17). The present study echoes these conclusions, reporting a statistically significant reduction of nearly 20 minutes in operative time and 25 ml in blood loss in the PEEK cage group. Although the VAS score for arm pain was not significantly different, a favorable trend was noted in the PEEK group. Reduced hardware prominence in zero-profile devices may account for lower rates of soft tissue complications and patient discomfort, as previously suggested by Liang et al., who emphasized biomechanical benefits and improved postoperative alignment with reduced adjacent segment stress (18). The zero-profile group's shorter operative time further supports procedural efficiency, which is clinically relevant in high-volume or resource-constrained settings.

Nevertheless, the plate-based method yielded significantly better correction of segmental lordosis. This may be crucial in patients requiring multi-level fusion or presenting with preexisting cervical kyphosis, where sagittal balance restoration is a key surgical objective. Surgeons may therefore prefer plating in cases prioritizing spinal alignment, especially given that poor cervical lordosis has been associated with long-term biomechanical and functional deterioration. While these findings reinforce the safety and efficacy of both approaches, several limitations merit discussion. The study was conducted at a single tertiary center with a relatively small sample size and a six-month follow-up period, which may not capture long-term differences in fusion sustainability, adjacent segment disease, or hardware-related complications. Moreover, while efforts were made to standardize surgical technique and postoperative care, the non-randomized nature of patient allocation and absence of blinding may introduce selection and observer bias. The absence of cost-effectiveness analysis also limits the generalizability of the results, especially considering the variable insurance coverage and cost structures associated with zero-profile implants.

CONCLUSION

Both anterior cervical discectomy and fusion (ACDF) techniques—bone graft with anterior cervical plating and zero-profile PEEK cage implantation—proved to be effective in achieving favorable clinical and radiological outcomes in patients with cervical disc pathology. While the traditional plate and graft method yielded slightly better improvement in segmental lordosis, the zero-profile PEEK cage was associated with significantly shorter operative time, reduced intraoperative blood loss, and superior postoperative functional outcomes including lower neck pain and disability scores. These findings suggest that zero-profile implants offer a clinically advantageous alternative, particularly in cases prioritizing reduced invasiveness and faster recovery. However, patient-specific factors, spinal alignment needs, and long-term biomechanical considerations should guide implant selection. Further large-scale, multicenter, and long-duration studies are recommended to validate these results and establish definitive clinical protocols.

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