Thesis

Prospective Comparative Study of Stand-Alone versus Zero-Profile Anchored Cages in Single-Level ACDF: Radiological and Clinical Outcomes

Niharika Virkar[1],
Chetan Pradhan[1],
Atul Patil[1],
Chetan Puram[1],
Darshan Sonawane[1],
Ashok Shyam[1],
Parag Sancheti[1]

[1]Department of Orthopaedics, Sancheti Institute of Orthopaedics and Rehabilitation, Pune, Maharashtra, India.

Address of Correspondence
Dr. Niharika Virkar
Department of Orthopaedics, Sancheti Institute of Orthopaedics and Rehabilitation, Pune, Maharashtra, India.
E-mail: niharikavirkar@yahoo.in

Abstract

Background: Anterior cervical discectomy and fusion (ACDF) is a well-established surgery for symptomatic cervical disc disease. Interbody devices—stand-alone PEEK cages and zero-profile anchored PEEK cages—restore disc height, decompress neural elements and promote fusion. This study compares clinical and radiological outcomes after single-level ACDF using these two implant types.

Methods: In a retro-prospective cohort from September 2019 to September 2021, sixty-two patients with single-level degenerative cervical pathology underwent ACDF with either a stand-alone PEEK cage (n=31) or an anchored zero-profile PEEK cage (n=31). Clinical assessments included VAS, Neck Disability Index and modified JOA scores. Radiographic evaluation recorded segmental and global lordosis, fused segment height, disc heights and subsidence (>2 mm). Follow-up was immediate, 3, 6, 12 and 24 months.

Results: Both groups experienced significant clinical improvement in pain and function at final follow-up, with comparable gains in VAS, NDI and mJOA. Radiographically, anchored cages showed lower subsidence rates and better maintenance of segmental height and lordosis. Dysphagia was mostly mild and transient.

Conclusion: Single-level ACDF produces reliable clinical improvement with both implant types. Anchored zero-profile cages may better preserve radiographic alignment and reduce subsidence without compromising early clinical outcomes and patient satisfaction postoperatively.

Keywords: ACDF, PEEK cage, Zero-profile, Subsidence, Dysphagia, Fusion

Introduction

Anterior cervical discectomy and fusion (ACDF) is an established operation for symptomatic degenerative cervical disease and compressive myelopathy, with early foundational descriptions that laid the groundwork for modern anterior approaches. Classic anterior techniques have demonstrated consistent decompression and symptom relief. [1, 2] The anterior route permits direct disc removal and placement of structural graft or spacer to restore disc height, maintain foraminal dimensions and promote arthrodesis. [3, 4] Historically, autologous iliac crest graft provided reliable fusion but carried donor-site morbidity that motivated the search for alternative materials and constructs. [5, 6] Interbody cage technology progressed from early metallic cages to the more recently favoured PEEK spacers, chosen for radiolucency and a modulus closer to bone, which may reduce stress shielding and facilitate radiographic fusion assessment. [7, 8]

Plated constructs showed early advantages in immediate stability and fusion rates in some series, but the anterior plate has also been implicated in higher rates of early postoperative


Dr. Niharika Virkar


Dr. Chetan Pradhan


Dr. Atul Patil


Dr. Chetan Puram


Dr. Darshan Sonawane


Dr. Ashok Shyam


Dr. Parag Sancheti

DOI: https://doi.org/10.13107/jmt.2025.v11.i01.242

dysphagia and anterior soft-tissue irritation. [9, 10] This trade-off inspired low-profile and zero-profile anchored devices designed to provide fixation while reducing anterior profile and soft-tissue contact. [11, 12] The literature contains mixed findings on whether the choice of implant significantly alters long-term clinical outcomes despite radiographic differences such as subsidence and segmental alignment. [13, 14] Factors intrinsic to surgery — including endplate preservation, cage sizing and avoidance of over-distraction — remain central to reducing subsidence irrespective of implant design. [15, 16] Given continued debate about the relative radiographic behaviour of stand-alone versus anchored constructs and the clinical significance of those differences, focused comparative studies are needed. [17-20]

Aims and objectives

1. To evaluate, quantify and compare radiographic parameters of single-level ACDF treated with a stand-alone PEEK cage versus an anchored (zero-profile) PEEK cage.
2. To assess and compare clinical outcomes and functional recovery (VAS, NDI, mJOA) between the two groups.
3. To determine the incidence of complications including subsidence, dysphagia and absence of radiographic fusion and to analyse their relationship with implant type and level of fusion.
4. To provide practical recommendations on implant selection and technique to minimise adverse radiographic events while optimizing patient-reported results.

Review of literature

Seminal clinical reports established ACDF as a reliable method for decompression and fusion in cervical degenerative disease, demonstrating early and sustained symptomatic improvement across varied patient cohorts. [1][2] Over decades researchers compared autograft, allograft and synthetic cages; while fusion rates tended to be comparable, each choice carried differing profiles for complications and radiographic visibility. [3][4] Titanium cages were introduced early but concerns about imaging artefact and stress shielding encouraged wider adoption of PEEK devices, both for radiographic assessment and for mechanical compatibility with bone. [5][6] Comparative series examining plated versus plate-less constructs found that anterior plating may better preserve immediate sagittal alignment in some circumstances but can increase anterior soft tissue contact and early dysphagia. [7][8] Zero-profile anchored spacers were developed to couple fixation with a lower anterior profile, with multiple retrospective and prospective series reporting reduced early dysphagia compared with traditional plate-and-cage constructs while maintaining satisfactory fusion rates. [9][10] Subsidence remains variably reported across studies — a product of inconsistent definitions, surgical technique, implant geometry and patient bone quality. [11][12] Some authors conceptualise modest subsidence as benign settling that does not impair patient outcomes, whereas others report a threshold beyond which subsidence produces segmental kyphosis and potential clinical sequelae. [13, 14] Meta-analyses and systematic reviews suggest implant choice influences radiographic parameters and perioperative morbidity but that patient-reported outcomes are often similar across contemporary devices when appropriate technique is used. [15, 16] The literature therefore supports a nuanced approach: implant selection should be informed by the balance between radiographic preservation and soft-tissue morbidity, while meticulous surgical technique remains the most reproducible determinant of favourable outcomes. [17-20]

Materials and methods

Study design: Retro-prospective, non-randomised cohort study at a tertiary centre. Ethics approval and informed consent were obtained.

Study period and sample: September 2019 to September 2021. Sixty-two consecutive patients fulfilling inclusion criteria were enrolled. Inclusion criteria comprised symptomatic cervical radiculopathy refractory to 4–6 weeks of conservative management, progressive neurological deficit, Nurick grade ≥2, or single-level cervical myelopathy. Exclusion criteria included active spinal infection, inflammatory spondyloarthropathy, traumatic or pathological fractures, cervical spinal tumours, developmental canal stenosis, and ossification of the posterior longitudinal ligament, prior cervical surgery, C7–T1 pathology and congenital block vertebrae. Patients were allocated to two groups: Group A (stand-alone PEEK cage) and Group B (anchored zero-profile PEEK cage), each containing thirty-one patients.

Clinical assessment: Baseline and follow-up evaluations included VAS for neck and arm pain, Neck Disability Index (NDI) and modified Japanese Orthopaedic Association (mJOA) score. Neurological examination and patient-reported outcomes were recorded preoperatively and at scheduled postoperative intervals.

Radiographic assessment: Standard AP, lateral and flexion–extension radiographs and preoperative MRI were used. Radiographic parameters measured included global cervical lordosis (C2–C7), segmental lordosis at the fused level, fused segment height, anterior and posterior disc heights, anterior cage distance and adjacent disc heights. Subsidence was defined as a decrease >2 mm in anterior or posterior disc height. Fusion was judged by bridging trabeculae, absence of motion on dynamic views and implant stability.

Surgical technique and follow-up: Standard anterior Smith-Robinson exposure was used. In the stand-alone group a PEEK cage packed with demineralised bone matrix was inserted; in the anchored group a zero-profile PEEK cage with integrated fixation screws was used. Patients were followed at immediate post-op, 3, 6, 12 and 24 months. Data collection included

operative time, blood loss, perioperative complications including dysphagia (Bazaz score), and radiographic outcomes. Statistical analysis used appropriate comparative tests with $p<0.05$ considered significant.

Results

Sixty-two patients were included: forty-seven men and fifteen women, mean age 47.82 years. The most frequently treated level was C5–6 (43.5%). Each implant group contained thirty-one patients. Operative time predominantly ranged from 120 to 180 minutes; blood loss was generally minimal across the cohort. Both groups demonstrated significant improvement from baseline in VAS, mJOA and NDI scores at final follow-up with comparable magnitudes of change between groups. Immediate postoperative radiographs documented restored segmental height and increased segmental lordosis in most patients; over time there was a tendency for some reduction in segmental lordosis compared with the immediate postoperative measurements. Subsidence, defined as >2 mm decrease in anterior or posterior disc height, occurred in six patients overall (9.6% of cohort): two in the anchored group and four in the stand-alone group. Fusion as judged radiographically by bridging trabeculae and lack of motion on dynamic views was achieved in the majority of patients by 6–12 months. Dysphagia was reported in several patients but was predominantly mild and transient; severe persistent dysphagia was uncommon. There were no implant migrations or major neurological complications recorded in this series.

Discussion

This study demonstrates that single-level ACDF reliably improves pain, neurological status and function whether performed with a stand-alone PEEK cage or an anchored zero-profile PEEK cage. Both implant groups showed comparable and significant clinical improvement, which aligns with prior literature indicating that modern interbody constructs produce consistent symptomatic relief when appropriate decompression and alignment are achieved. [15] Radiographically, anchored cages in this cohort showed a lower incidence of subsidence and a better capacity to maintain segmental height and lordosis over time. [16] Although modest subsidence has been described as part of implant settling and may not always impair clinical outcomes, our observations and other reports caution that pronounced subsidence and consequent local kyphosis can adversely influence mechanical loading of adjacent segments and potentially affect long-term function. [17]

The lower subsidence observed with anchored devices may relate to immediate fixation through anchoring screws that distribute load and reduce micromotion, together with preservation of the subchondral endplate during insertion. [18] Technique remains critical: endplate preservation, avoidance of overdistraction and appropriate cage sizing are key modifiable factors to reduce subsidence risk. [19] Dysphagia rates were low and predominantly mild in both groups, supporting the premise that zero-profile low-profile fixation mitigates anterior soft-tissue irritation while not compromising stability. [20] It is important to note that differences in radiographic behaviour may not translate to early differences in patient-reported outcomes; longer follow-up will determine whether improved radiographic preservation confers sustained clinical benefits or reduces adjacent segment degeneration.

Limitations of this study include its non-randomised design, the modest sample size and follow-up limited to the early mid-term. Nevertheless, the findings support considering anchored zero-profile constructs when radiographic maintenance of segmental height and minimising subsidence are priorities, while recognising that both constructs deliver meaningful clinical improvement when surgery is performed thoughtfully.

Conclusion

Single-level anterior cervical discectomy and fusion reliably reduces pain and improves neurological function. Both stand-alone PEEK cages and anchored zero-profile PEEK cages produced significant and comparable improvements in VAS, NDI and mJOA scores. Radiographically, anchored cages displayed lower subsidence rates and better maintenance of fused segment height and segmental lordosis in this series. Clinical outcomes, however, were similar between implant types during the follow-up period reported. Surgical technique that preserves endplate integrity, avoids over distraction and ensures correct cage sizing is essential to minimise subsidence and maintain alignment. Anchored constructs may offer a radiographic advantage without negatively affecting early clinical recovery. Longer-term follow-up and larger, ideally randomized studies would clarify whether the radiographic benefits translate to sustained clinical advantage or reduced adjacent segment disease.

References

1. Aronson N, Filtzer DL, Bagan M. Anterior cervical fusion by the smith-robinson approach. J Neurosurg. 1968; 29(4):396-404. doi:10.3171/jns.1968.29.4.0397

2. S M, FP G, AA S, et al. National trends in anterior cervical fusion procedures. Spine (Phila Pa 1976). 2010; 35(15):1454-1459. doi:10.1097/BRS.0B013E3181BEF3CB

3. M P, J S, N G, et al. Anterior discectomy and fusion for the management of neck pain. Spine (Phila Pa 1976). 1999; 24(21):2224-2228. doi:10.1097/00007632-199911010-00009

4. Eck JC, Humphreys SC, Hodges SD, Levi P. A comparison of outcomes of anterior cervical discectomy and fusion in patients with and without radicular symptoms. J Surg Orthop Adv. 2006; 15(1):24-26.

5. Chong E, Pelletier MH, Mobbs RJ, Walsh WR. The design evolution of interbody cages in anterior cervical discectomy

and fusion: A systematic review Orthopedics and biomechanics. BMC Musculoskelet Disord. 2015; 16(1):1-11. doi:10.1186/s12891-015-0546-x
6. Xiao SW, Liang Z De, Wei W, Ning JP. Zero-profile anchored cage reduces risk of postoperative dysphagia compared with cage with plate fixation after anterior cervical discectomy and fusion. Eur Spine J. 2017; 26(4):975-984. doi:10.1007/s00586-016-4914-5
7. A F-B, JK H, B O, et al. Swallowing and speech dysfunction in patients undergoing anterior cervical discectomy and fusion: a prospective, objective preoperative and postoperative assessment. J Spinal Disord Tech. 2002; 15(5):362-368. doi:10.1097/00024720-200210000-00004
8. H T, M N, ER L, et al. Dysphonia and dysphagia after anterior cervical decompression. J Neurosurg Spine. 2007; 7(2):124-130. doi:10.3171/SPI-07/08/124
9. M Q, H C, Y L, Y Z, L L, W Y. The use of a zero-profile device compared with an anterior plate and cage in the treatment of patients with symptomatic cervical spondylosis: A preliminary clinical investigation. Bone Joint J. 2013; 95-B (4):543-547. doi:10.1302/0301-620X.95B4.30992
10. Hofstetter CP, Kesavabhotla K, Boockvar JA. Zero-profile anchored spacer reduces rate of dysphagia compared with ACDF with anterior plating. J Spinal Disord Tech. 2015; 28(5):E284-E290. doi:10.1097/BSD.0b013e31828873ed
11. JS S, DG A, SD D, et al. Donor site morbidity after anterior iliac crest bone harvest for single-level anterior cervical discectomy and fusion. Spine (Phila Pa 1976). 2003; 28(2):134-139. doi:10.1097/00007632-200301150-00008
12. Wang ZD, Zhu RF, Yang HL, et al. Zero-profile implant (Zero-p) versus plate cage benezech implant (PCB) in the treatment of single-level cervical spondylotic myelopathy. BMC Musculoskelet Disord. 2015; 16(1):1-7. doi:10.1186/s12891-015-0746-4
13. RB C. The anterior approach for removal of ruptured cervical disks. J Neurosurg. 1958; 15(6):602-617. doi:10.3171/JNS.1958.15.6.0602
14. SMITH GW, ROBINSON RA. The treatment of certain cervical-spine disorders by anterior removal of the intervertebral disc and interbody fusion. J Bone Joint Surg Am. 1958; 40-A (3):607-624.
15. Shedid D, Benzel EC. Cervical spondylosis anatomy: pathophysiology and biomechanics. Neurosurgery. 2007; 60(1 Suppl 1):S7-13. doi:10.1227/01.NEU.0000215430.86569.C4
16. Frost BA, Camarero-Espinosa S, Foster EJ. Materials for the Spine: Anatomy, Problems, and Solutions. Mater (Basel, Switzerland). 2019; 12(2). doi:10.3390/ma12020253
17. Fakhoury J, Dowling TJ. Cervical Degenerative Disc Disease. StatPearls. August 2021. Accessed November 3, 2021.
18. Connell MD, Wiesel SW. Natural history and pathogenesis of cervical disk disease. Orthop Clin North Am. 1992; 23(3):369-380.
19. Okada E, Matsumoto M, Ichihara D, et al. aging of the cervical spine in healthy volunteers: a 10-year longitudinal magnetic resonance imaging study. Spine (Phila Pa 1976). 2009; 34(7):706-712. doi:10.1097/BRS.0b013e31819c2003
20. Nordin M, Carragee EJ, Hogg-Johnson S, et al. Assessment of neck pain and its associated disorders: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Spine (Phila Pa 1976). 2008; 33(4 Suppl):S101-22. doi:10.1097/BRS.0b013e3181644ae8

Conflict of Interest: Nil

Source of Support: None

Institute Where Research was Conducted: Department of Orthopaedics, Sancheti Institute of Orthopaedics and Rehabilitation, Shivajinagar, Pune, Maharashtra, India.
University Affiliation: MUHS, Nashik, Maharashtra, India.
Year of Acceptance of Thesis: 2022

How to Cite this Article: Virkar N, Pradhan C, Patil A, Puram C, Sonawane D, Shyam A, Sancheti P. Prospective Comparative Study of Stand-Alone versus Zero-Profile Anchored Cages in Single-Level ACDF: Radiological and Clinical Outcomes | Journal of Medical Thesis | 2025 January-June; 11(1): 21-24.