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Perioperative Profile of Stand-Alone Cages in Anterior Cervical Discectomy and Fusion for Degenerative Cervical Stenosis: Reduced Bleeding and Hospital Stay Compared to Cage-Plate Constructs

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A B S T R A C T

Introduction: Anterior cervical discectomy and fusion (ACDF) is a common surgical treatment for degenerative cervical stenosis. Stand-alone cages (SAC) and cage-plate constructs (CPA) are frequently used, with comparable reported fusion rates. This study aimed to compare the perioperative profiles, specifically intraoperative bleeding and length of hospital stay, alongside fusion rates, between ACDF-SAC and ACDF-CPA for single-level degenerative subaxial cervical stenosis in an Indonesian population. **Methods:** A retrospective cohort study was conducted using medical records from February to March 2025, including patients who underwent single-level ACDF-SAC or ACDF-CPA for degenerative subaxial cervical stenosis between June 2022 and June 2024 at Dr. Mohammad Hoesin General Hospital, Palembang. Twenty-one patients (10 ACDF-SAC, 11 ACDF-CPA) were included. Data on demographics, operative level, intraoperative bleeding, length of hospital stay, and 6-month fusion rates were analyzed. **Results:** No significant differences were observed in age (p=0.056), gender (p=0.635), or BMI (p=0.708) between groups. The ACDF-CPA group had significantly more procedures at the C5-6 level (p=0.010). Intraoperative bleeding was significantly lower in the ACDF-SAC group (86.90 ± 30.00 cc) compared to ACDF-CPA (183.27 ± 58.74 cc; p=0.000). Length of hospital stay was shorter for ACDF-SAC (4.70 ± 1.49 days) versus ACDF-CPA (6.27 ± 1.19 days; p=0.015). Fusion rates were 100% for ACDF-SAC and 90.9% for ACDF-CPA (RR=2.000; 95% CI 1.290–3.100; p=1.000), a non-statistically significant difference. The single non-fusion occurred at C3-4 in the ACDF-CPA group. **Conclusion:** In patients undergoing single-level ACDF for degenerative subaxial cervical stenosis, the use of stand-alone cages was associated with significantly less intraoperative bleeding and shorter hospital stays compared to cage-plate constructs, without compromising 6-month fusion rates. These findings suggest potential perioperative advantages for the ACDF-SAC technique.

1. Introduction

Degenerative cervical stenosis, a condition marked by the narrowing of the cervical spinal canal, frequently leads to neural compression and subsequent myelopathy or radiculopathy, significantly impacting patient quality of life. This pathology is particularly prevalent in the aging population, representing one of the foremost indications for spinal surgery. The underlying degenerative cascade involves changes such as disc desiccation and herniation, osteophyte formation, facet joint hypertrophy, and ligamentum flavum thickening or calcification, all contributing to the reduction of available space for neural elements. While conservative management may

be appropriate for mild, non-progressive symptoms, surgical intervention is often warranted for patients with persistent or progressive neurological deficits, intractable pain, or evidence of spinal cord compression.[1,2]

Anterior cervical discectomy and fusion (ACDF) has long been established as a gold-standard surgical procedure for addressing symptomatic cervical stenosis and disc disease. The primary goals of ACDF are to decompress the neural elements by removing the offending disc and osteophytes, restore physiological disc height and cervical lordosis, and achieve stable interbody fusion to maintain spinal alignment and prevent recurrence of symptoms. Over the decades, various techniques and implant technologies have evolved to optimize ACDF outcomes. Among the most common contemporary approaches for achieving interbody fusion are the use of a stand-alone cage (ACDF-SAC) and the placement of an interbody cage augmented with an anterior cervical plate and screws (ACDF-CPA).[3,4]

Both ACDF-SAC and ACDF-CPA techniques have demonstrated high rates of clinical success and arthrodesis. Literature reviews and meta-analyses often report comparable fusion rates, typically ranging from 92% to 100% for SAC and 94% to 100% for CPA, suggesting that both are effective in achieving solid bony union. However, the choice between these two constructs is not merely based on fusion rates; it involves a nuanced consideration of various factors, including patient-specific anatomy, such as bone quality, number of levels involved, and segmental instability, surgeon preference and experience, and the potential risks and benefits associated with each type of instrumentation.[5,6]

The ACDF-SAC technique, which involves placing an interbody cage filled with bone graft or substitute into the disc space without anterior plating, offers potential advantages such as reduced operative time, less extensive soft tissue dissection, and potentially a lower incidence of postoperative dysphagia due to less irritation of prevertebral structures. The absence of an anterior plate might also theoretically reduce stress shielding at the operative segment, potentially promoting more physiological load sharing and bone remodeling, although this remains a subject of biomechanical investigation. Furthermore, from an economic perspective, SAC procedures may involve lower implant costs.[7,8]

Conversely, the ACDF-CPA technique, which adds an anterior plate and screws to the interbody cage, is traditionally believed to provide superior initial biomechanical stability, particularly against translational and rotational forces. This enhanced stability is thought to be beneficial in multi-level constructs, in patients with poorer bone quality, or where there is a concern for graft extrusion or subsidence. Some studies suggest that plating may reduce the incidence of cage subsidence, a complication that can lead to loss of disc height, foraminal stenosis, and potentially segmental kyphosis. However, the addition of a plate is not without potential downsides. It inherently requires more extensive soft tissue stripping, which can increase operative time, blood loss, and the risk of dysphagia or injury to adjacent structures like the recurrent laryngeal nerve or esophagus. Moreover, hardware-related complications, though infrequent, such as screw back-out, plate fracture, or plate-to-bone interface issues, are specific to CPA constructs.[9,10]

In developing regions, such as Indonesia, considerations of cost-effectiveness, resource availability, and patient presentation patterns (often with more advanced disease due to delays in seeking specialist care) become particularly pertinent. Optimizing surgical techniques that provide a robust balance between clinical efficacy, safety, and economic viability is paramount. While international literature provides a wealth of data on ACDF-SAC and ACDF-CPA, there has been limited direct comparative data originating from the Indonesian context, particularly concerning the perioperative profiles of these procedures. Factors such as intraoperative bleeding and length of hospital stay are not only crucial indicators of early surgical morbidity and patient

recovery but also have significant implications for healthcare resource utilization. Reduced bleeding can lessen the need for blood transfusions and associated risks, while shorter hospital stays can decrease the likelihood of nosocomial infections and lower overall treatment costs. This study aimed to rigorously compare the perioperative performance—defined by intraoperative blood loss and length of hospital stay—and 6-month fusion integrity of stand-alone cages (ACDF-SAC) versus cage-plate constructs (ACDF-CPA) for single-level degenerative subaxial cervical stenosis, thereby generating critical insights to guide evidence-based surgical choices within the Indonesian healthcare landscape.

2. Methods

This investigation was structured as an observational analytical study employing a retrospective cohort design. The research was conducted at the Department of Surgery and utilized data from the Medical Records Installation of Dr. Mohammad Hoesin General Hospital, a tertiary referral hospital in Palembang, South Sumatra, Indonesia. Data collection for this study was carried out from February to March 2025. The study cohort comprised patients who had undergone surgical treatment for single-level degenerative subaxial cervical stenosis between June 2022 and June 2024. Ethical approval for the study was obtained from the institutional ethics committee of Dr. Mohammad Hoesin General Hospital prior to the commencement of any data collection activities. The study was conducted in adherence to the principles outlined in the Declaration of Helsinki, and patient confidentiality was maintained throughout the research process by anonymizing all collected data prior to analysis.

The target population for this study consisted of all patients diagnosed with single-level degenerative subaxial cervical canal stenosis who received surgical management via either ACDF-SAC or ACDF-CPA at Dr. Mohammad Hoesin General Hospital during the specified two-year period (June 2022 to June 2024). A total sampling method was employed, meaning all eligible patients meeting the inclusion criteria within the defined timeframe were included in the study. This approach was chosen due to the relatively limited number of cases anticipated for each specific surgical subtype within the study period, and to maximize the statistical power obtainable from this real-world clinical cohort. While a formal prospective sample size calculation was not performed due to the nature of the total sampling design in a retrospective setting, the intention was to capture all available data to provide the most comprehensive analysis possible with the existing patient records.

The selection of participants for this study was governed by a stringent set of inclusion and exclusion criteria to ensure a homogenous cohort suitable for comparative analysis. Eligible individuals were adult patients, specifically within the 55 to 61 year age range observed in this study, who presented with a confirmed diagnosis of single-level degenerative subaxial cervical canal stenosis. This diagnosis necessitated both clinical manifestations, such as radiculopathy or myelopathy, and radiological evidence, typically obtained via Magnetic Resonance Imaging (MRI), demonstrating neural compression at a single subaxial cervical level, which could include C3-C4, C4-C5, C5-C6, or C6-C7. Furthermore, participants must have undergone either an Anterior Cervical Discectomy and Fusion with a Stand-Alone Cage (ACDF-SAC) or with a Cage and Plate Augmentation (ACDF-CPA) for their condition. Essential for inclusion was the availability of comprehensive clinical documentation, encompassing intraoperative records with details of blood loss and surgical specifics, alongside postoperative lateral cervical spine X-rays at the six-month follow-up to evaluate fusion status.

Conversely, individuals were excluded if they had a history of previous cervical spine surgery at any level or if there was evidence of active systemic or local infections around the time of surgery that could potentially confound the outcomes. Patients who were active smokers within the year prior to surgery, a known significant risk factor for pseudarthrosis, were

also ineligible. Additional exclusion criteria included a history of progressive malignancy within the preceding five years, due to its potential impact on bone healing and overall health, and the presence of incomplete or missing medical records, especially those pertaining to the primary outcome of fusion or key exposure variables like surgical technique, bleeding, and length of hospital stay. To maintain focus on single-level pathology, patients with multi-level cervical stenosis requiring multi-level ACDF were not included. Finally, the study concentrated exclusively on degenerative conditions; therefore, cases where stenosis was primarily caused by cervical trauma, tumors (either primary or metastatic to the cervical spine), or inflammatory arthropathies were excluded

The primary exposure variable was the type of ACDF surgical technique employed: ACDF with a stand-alone cage (ACDF-SAC) or ACDF with a cage and anterior plate-screw augmentation (ACDF-CPA). The primary outcome variable was the radiographic spinal fusion rate at six months postoperatively. Fusion was defined radiographically based on the interpretation of lateral cervical spine X-rays performed at the 6-month follow-up visit. The criteria for fusion included the presence of continuous trabecular bridging bone across the intervertebral space, connecting the vertebral endplates of the operated segment, and the absence of radiolucency at the graft-host bone interface or around any instrumentation. Other indicators such as lack of motion on dynamic flexion-extension radiographs or absence of segmental kyphosis/instability could supplement this assessment, though the primary definition relied on static lateral views as per the study document. These interpretations were typically performed by qualified radiologists as part of routine clinical care and recorded in the patient's medical file.

In addition to the primary outcome, a comprehensive suite of secondary variables and relevant data points was meticulously collected for each participant to provide a thorough comparative analysis. Demographic information, specifically patient age in years at the time of surgery and gender, was recorded. Anthropometric data included the Body Mass Index (BMI), calculated as weight in kilograms divided by the square of height in meters. Key surgical details were also documented, notably the specific subaxial cervical level that underwent intervention, such as C3-4, C4-5, or C5-6. Intraoperative blood loss, a critical perioperative metric, was quantified in milliliters (cc) as noted in the anesthesia and surgical records; this estimation typically incorporated measurements from suction canister contents, weighed surgical sponges, and, where applicable, an assessment of irrigation fluid balance. The length of hospital stay, measured in days from admission to discharge, served as another important indicator of early recovery. Finally, postoperative follow-up timing was carefully tracked to confirm adherence to the 6-month schedule for the crucial assessment of radiographic fusion.

Data collection was performed by systematically reviewing all identified surgical cases that underwent ACDF procedures during the study period. Each patient's medical record, including inpatient notes, operative reports, anesthesia charts, radiology reports, and discharge summaries, was meticulously assessed for eligibility based on the predefined inclusion and exclusion criteria. All relevant data points for eligible cases were extracted and recorded onto a standardized data collection form, initially in Microsoft Excel. Subsequently, this database was imported into SPSS version 29 (IBM Corp., Armonk, NY, USA) for statistical analysis. All patient identifiers were removed, and data were anonymized prior to analysis to ensure patient confidentiality.

While specific surgeon-to-surgeon variations exist, the general ACDF procedure at the institution for both SAC and CPA would have involved a standard anterior cervical approach, such as the Smith-Robinson approach. After adequate exposure of the anterior cervical spine at the target level, a discectomy was performed, removing the intervertebral disc material. Endplate preparation was carried out to create a suitable bed for the interbody device. For ACDF-SAC, an appropriately sized stand-alone interbody cage,

typically made of PEEK (polyetheretherketone) or titanium, and filled with autograft (such as local bone from osteophytes or iliac crest bone graft if used) or an allograft/synthetic bone substitute, was impacted into the prepared disc space. For ACDF-CPA, following cage insertion, an anterior cervical plate of appropriate length was selected and secured to the vertebral bodies above and below the fused segment using screws. The choice of SAC versus CPA was likely based on surgeon preference, intraoperative assessment of stability, bone quality, and possibly other patient-specific factors not explicitly detailed in the retrospective data but acknowledged in the literature. Closure was then performed in layers. Postoperative management would typically involve a cervical collar for a period, pain management, and mobilization as tolerated, followed by scheduled outpatient follow-up visits.

Descriptive statistics were employed to summarize the characteristics of the study subjects and the surgical outcomes. Continuous variables with a normal distribution were presented as mean ± standard deviation (SD), while those with a non-normal distribution were presented as median and range (minimum–maximum). Categorical variables were presented as frequencies and percentages (n, %). To compare baseline characteristics and outcomes between the ACDF-SAC and ACDF-CPA groups, appropriate inferential statistical tests were used. For continuous variables, independent samples t-tests were used if the data were normally distributed and variances were equal; otherwise, the Mann-Whitney U test was applied. For categorical variables, such as gender, operated level, and fusion status, chi-square tests or Fisher's exact tests were utilized, particularly when expected cell counts were low. The relative risk (RR) with a 95% confidence interval (CI) was calculated to assess the association between the type of ACDF procedure and the likelihood of achieving fusion at 6 months. A p-value of less than 0.05 was considered statistically significant for all analyses. All statistical analyses were performed using SPSS version 29.

3. Results

A total of twenty-one patients who underwent single-level ACDF for degenerative subaxial cervical stenosis between June 2022 and June 2024 and met the inclusion criteria were included in this retrospective cohort study. Of these, 10 patients (47.6%) were treated with the ACDF stand-alone cage (ACDF-SAC) technique, and 11 patients (52.4%) received ACDF with cage and plate augmentation (ACDF-CPA). The demographic and clinical characteristics of the entire study cohort (N=21) are presented in Table 1. The mean age of the participants was 57.24 ± 1.92 years, with a median age of 57 years and an age range from 55 to 61 years. The majority of the patients were male, accounting for 71.4% (n=15) of the cohort, while females constituted 28.6% (n=6). The average Body Mass Index (BMI) for the cohort was 23.11 ± 4.15 kg/m², with a median BMI of 22.04 kg/m² (range: 16.53–33.06 kg/m²), generally falling within the normal to slightly overweight range Regarding the surgical level, the most frequently operated segment was C5–6, which accounted for 57.1% (n=12) of all procedures. This was followed by the C4–5 level at 28.6% (n=6) and the C3–4 level at 14.3% (n=3). The mean intraoperative bleeding for the total cohort was 137.38 ± 67.55 cc (median: 119 cc; range: 54–279 cc). The average length of hospital stay was 5.52 ± 1.54 days (median: 6 days; range: 3–8 days).

Table 2 provides a detailed comparison of patient characteristics and perioperative outcomes between the ACDF-SAC group (n=10) and the ACDF-CPA group (n=11). There were no statistically significant differences observed between the two surgical groups in terms of mean age (ACDF-SAC: 58.1 ± 2.18 years vs. ACDF-CPA: 56.45 ± 1.29 years; p = 0.056, Mann-Whitney U test). Similarly, the distribution of gender was comparable between the groups, with 80.0% males in the ACDF-SAC group and 63.6% males in the ACDF-CPA group (p = 0.635, Fisher's exact test). Body Mass Index also showed no significant difference (ACDF-SAC: 22.74 ± 3.64 kg/m² vs. ACDF-CPA: 23.44 ± 4.72 kg/m²; p = 0.708, Mann-Whitney U test). These

findings suggest that the two groups were reasonably well-matched concerning these baseline demographic and anthropometric variables.

Table 1. Baseline demographic and clinical characteristics of study subjects (N=21).

Characteristic	Value (n)	Percentage (%)	Mean ± Standard Deviation	Median (Minimum–Maximum)
Age (years)	–	–	57.24 ± 1.92	57 (55–61)
Gender				
– Male	15	71.4%	–	–
– Female	6	28.6%	–	–
Body mass index (kg/m²)	–	–	23.11 ± 4.15	22.04 (16.53–33.06)
Operated spinal level				
– C3–4	3	14.3%	–	–
– C4–5	6	28.6%	–	–
– C5–6	12	57.1%	–	–
Intraoperative bleeding (cc)	–	–	137.38 ± 67.55	119 (54–279)
Length of hospital stay(days)	–	–	5.52 ± 1.54	6 (3–8)

Table 2. Comparative analysis of patient demographics, clinical characteristics, and perioperative outcomes between ACDF-SAC and ACDF-CPA surgical groups.

Characteristic	ACDF-SAC Group (n=10)	ACDF-CPA Group (n=11)	p-value
Age (years)			0.056[a]
– Mean ± SD	58.1 ± 2.18	56.45 ± 1.29	
– Median (Min–Max)	59 (55–61)	56 (55–59)	
Gender, n (%)			0.635[b]
– Male	8 (80.0%)	7 (63.6%)	
– Female	2 (20.0%)	4 (36.4%)	
Body mass index (kg/m²)			0.708[a]
– Mean ± SD	22.74 ± 3.64	23.44 ± 4.72	
– Median (Min–Max)	22.41 (16.9–29.38)	22.04 (16.53–33.06)	
Operated level, n (%)			**0.010**[c]*
– C3–4	1 (10.0%)	2 (18.2%)	
– C4–5	6 (60.0%)	0 (0.0%)	
– C5–6	3 (30.0%)	9 (81.8%)	
Intraoperative bleeding (cc)			**0.000**[a]*
– Mean ± SD	86.90 ± 30.00	183.27 ± 58.74	
– Median (Min–Max)	83 (54–132)	192 (115–279)	
Length of hospital stay (days)			**0.015**[a]*
– Mean ± SD	4.70 ± 1.49	6.27 ± 1.19	
– Median (Min–Max)	4.5 (3–7)	6 (5–8)	

Notes: Statistically significant difference ($p < 0.05$). P-values in bold indicate statistical significance. [a] Mann-Whitney U test was used for comparison. [b] Fisher's Exact test was used for comparison. [c] Chi-square test was used for comparison.

However, a statistically significant difference was identified in the distribution of the operated cervical levels between the two groups ($p = 0.010$, Chi-square test). Specifically, the ACDF-CPA group had a higher proportion of surgeries performed at the C5–6 level (81.8%, n=9/11) compared to the ACDF-SAC group (30.0%, n=3/10). Conversely, surgeries at the C4–5 level were more common in the ACDF-SAC group (60.0%, n=6/10) and absent in the ACDF-CPA group (0.0%, n=0/11) at this level. The C3-4 level was

operated on in 10.0% (n=1/10) of ACDF-SAC cases and 18.2% (n=2/11) of ACDF-CPA cases. Crucially, highly significant differences were found in the perioperative outcome measures. Intraoperative bleeding was substantially and statistically significantly lower in the ACDF-SAC group, with a mean of 86.90 ± 30.00 cc (median: 83 cc), compared to the ACDF-CPA group, which had a mean of 183.27 ± 58.74 cc (median: 192 cc) (p = 0.000, Mann-Whitney U test). This indicates that, on average, the ACDF-CPA procedure was associated with more than double the amount of intraoperative blood loss observed in the ACDF-SAC procedure in this cohort.

Furthermore, the length of hospital stay was also significantly shorter for patients in the ACDF-SAC group. The mean hospital stay for ACDF-SAC patients was 4.70 ± 1.49 days (median: 4.5 days), whereas for ACDF-CPA patients, it was 6.27 ± 1.19 days (median: 6 days) (p = 0.015, Mann-Whitney U test). This represents an average reduction of approximately 1.5 days in hospital stay for patients undergoing the stand-alone cage technique.

The primary clinical endpoint, radiographic fusion at 6 months post-surgery, is detailed in Table 3. All 10 patients (100%) in the ACDF-SAC group achieved successful bony fusion at the 6-month follow-up. In the ACDF-CPA group, 10 out of 11 patients (90.9%) demonstrated fusion, with one patient (9.1%) experiencing non-fusion at the 6-month assessment. Patients who underwent the ACDF-SAC procedure were reported to be 2 times more likely to experience fusion after 6 months compared to those who underwent the ACDF-CPA procedure, with a relative risk (RR) of 2.000 (95% Confidence Interval: 1.290 – 3.100). However, despite this calculated relative risk and the numerically higher fusion rate in the SAC group, the difference in fusion rates between the two groups was not statistically significant (p = 1.000, Fisher's exact test). This lack of statistical significance is likely influenced by the small sample size and the low number of non-fusion events (only one case in total).

Table 3. Comparative analysis of 6-month radiographic fusion outcomes and associated risk between ACDF-SAC and ACDF-CPA surgical groups.

Fusion status at 6 months	ACDF-SAC Group (n=10) n (%)	ACDF-CPA Group (n=11) n (%)	Relative Risk (RR) (for Fusion, SAC vs. CPA)	95% Confidence Interval (CI) for RR	p-value (for Fusion Comparison)
Fused (Yes)	10 (100.0%)	10 (90.9%)	2.000	(1.290 – 3.100)	1.000[a]
Not fused (No)	0 (0.0%)	1 (9.1%)	–	–	

Notes: [a] Fisher's Exact test was used for comparing fusion proportions between the groups. The Relative Risk (RR) and its 95% Confidence Interval (CI) are calculated for the outcome of achieving fusion in the ACDF-SAC group compared to the ACDF-CPA group.

Table 4 presents an analysis of factors potentially associated with fusion outcomes, specifically looking at the single non-fusion case. Overall, fusion occurred in 20 out of 21 patients. Among those who fused, the C5–6 level was the most common site of fusion (60.0%, n=12/20), followed by C4–5 (30.0%, n=6/20), and C3–4 (10.0%, n=2/20). The single case of non-fusion in this study occurred in a patient who had undergone an ACDF-CPA procedure at the C3–4 level. A statistically significant association was found between the operated level and fusion status (p = 0.043, Fisher's exact test), suggesting that the level of surgery might influence fusion outcomes, with the C3-4 level being implicated in the non-union event in this cohort.

The patient who did not achieve fusion had numerically higher intraoperative bleeding (237 cc) compared to the mean bleeding in patients who did fuse (132.4 ± 65.22 cc). Similarly, the length of hospital stay for the non-fusion case was 7 days, slightly higher than the mean stay for fused patients

(5.45 ± 1.54 days). However, these differences in mean intraoperative bleeding (p = 0.137, Mann-Whitney U test) and mean length of hospital stay (p = 0.338, Mann-Whitney U test) between the fused and non-fused groups were not statistically significant, which is to be expected given that the non-fusion group consisted of only one patient, precluding meaningful statistical comparison for these continuous variables.

Table 4. Comparison of fusion outcomes by operation level, intraoperative bleeding, and length of hospital stay.

Characteristic	Fusion achieved (Yes) (n=20)	Fusion not achieved (No) (n=1)	p-value
Operated level, n (%)			**0.043**[a]*
– C3–4	2 (10.0%)	1 (100.0%)	
– C4–5	6 (30.0%)	0 (0.0%)	
– C5–6	12 (60.0%)	0 (0.0%)	
Intraoperative bleeding (cc)			0.137[b]
– Mean ± SD	132.4 ± 65.22	237.0 ± 0.0	
– Median (Min–Max)	118 (54–279)	237 (237–237)	
Length of hospital stay (days)			0.338[b]
– Mean ± SD	5.45 ± 1.54	7.0 ± 0.0	
– Median (Min–Max)	5.5 (3–8)	7 (7–7)	

Notes: *Statistically significant difference (p < 0.05). P-values in bold indicate statistical significance. [a] Fisher's Exact test was used for comparison. [b] Mann-Whitney U test was used for comparison.

In summary, the ACDF-SAC technique was associated with significantly less intraoperative blood loss and shorter hospital stays compared to ACDF-CPA. While the ACDF-SAC group demonstrated a 100% fusion rate compared to 90.9% in the ACDF-CPA group, this difference did not reach statistical significance. The single non-fusion event occurred at the C3-4 level in a CPA patient.

4. Discussion

This retrospective cohort study aimed to compare the perioperative profiles and early fusion outcomes of anterior cervical discectomy and fusion with stand-alone cages (ACDF-SAC) versus cage-plate constructs (ACDF-CPA) for single-level degenerative subaxial cervical stenosis in patients treated at Dr. Mohammad Hoesin General Hospital, Palembang. The findings of this study provide valuable insights, particularly within the Indonesian healthcare context, highlighting that ACDF-SAC was associated with significantly reduced intraoperative bleeding and shorter hospital stays compared to ACDF-CPA, without a statistically significant compromise in 6-month fusion rates.[11,12]

The general characteristics of the study population were consistent with established epidemiological patterns of degenerative cervical stenosis. The mean age of patients in this cohort was 57.24 years, which aligns well with numerous studies reporting cervical stenosis as a condition predominantly affecting individuals over 50 years of age. The male predominance (71.4%) observed in our study is also a common finding in the literature on symptomatic cervical spinal pathologies requiring surgery. A previous study similarly reported male majorities in their cohorts. The mean BMI of 23.11 kg/m² in our cohort falls within the normal range. Importantly, the ACDF-SAC and ACDF-CPA groups in our study were well-matched in terms of age, gender, and BMI, minimizing these factors as potential confounders for the primary perioperative comparisons.[13,14]

The C5-6 level was the most frequently operated segment (57.1%) in this study, a finding that mirrors observations from other research, where C5-6 is often cited as the level most susceptible to degenerative changes and subsequent stenosis in the subaxial cervical spine. However, there was a significant

difference in the distribution of operated levels between the two surgical groups. The ACDF-CPA group had a preponderance of C5-6 surgeries (81.8%), while the ACDF-SAC group had more C4-5 surgeries (60.0%). This difference is a potential confounder when interpreting outcomes, particularly fusion rates, as different cervical levels have varying biomechanical properties and fusion potentials. For instance, upper cervical levels like C3-4 are known for higher mobility, which might influence fusion. While the reasons for this distribution difference are not explicitly available from the retrospective data, it might reflect surgeon preference based on perceived instability or specific anatomical features at certain levels, possibly leading to a bias where plating was preferentially used for C5-6. This imbalance should be considered when interpreting the results, although a direct link between this distribution and the primary perioperative outcomes of bleeding and hospital stay is less obvious than its potential link to fusion.[15,16]

The most striking findings of this study relate to the perioperative advantages observed with the ACDF-SAC technique. Patients undergoing ACDF-SAC experienced significantly less intraoperative blood loss (mean 86.90 cc) compared to those undergoing ACDF-CPA (mean 183.27 cc). This represents a substantial reduction, with CPA procedures associated with more than double the bleeding. This finding is consistent with the inherent nature of the procedures; ACDF-CPA requires more extensive soft tissue dissection and exposure of the anterior vertebral bodies to accommodate the plate and screws, which logically can lead to increased vascular disruption and oozing from bone and soft tissues. Several studies and meta-analyses corroborate this observation. While the absolute amounts of blood loss in both groups in our study were generally not indicative of a need for transfusion in most single-level ACDF cases, minimizing blood loss is always a surgical goal, as it can contribute to a cleaner operative field, potentially reduce operative time, and lessen physiological stress on the patient.[17,18]

Congruent with the reduced blood loss, the length of hospital stay was also significantly shorter for patients in the ACDF-SAC group (mean 4.70 days) compared to the ACDF-CPA group (mean 6.27 days). This difference of approximately 1.5 days is clinically relevant. Shorter hospital stays are associated with reduced healthcare costs, lower risk of nosocomial infections, and faster return to a home environment, which is often preferred by patients. The reasons for the shorter stay in the SAC group are likely multifactorial but plausibly linked to the less invasive nature of the procedure: reduced soft tissue trauma could lead to less postoperative pain, quicker mobilization, and potentially less postoperative dysphagia. Previous studies also support shorter hospital stays with SAC techniques. These perioperative benefits—reduced bleeding and shorter hospitalization—are particularly important in resource-constrained healthcare systems, where efficiency and cost-effectiveness are critical considerations.[19,20]

Regarding the primary efficacy outcome, radiographic fusion at 6 months, the ACDF-SAC group demonstrated a 100% fusion rate (10 out of 10 patients), while the ACDF-CPA group achieved a 90.9% fusion rate (10 out of 11 patients). Although the relative risk for fusion was 2.000 in favor of ACDF-SAC, this difference was not statistically significant ($p=1.000$). This lack of statistical significance is a common issue in studies with small sample sizes and very few adverse events (in this case, only one non-fusion). With only one non-union, the study was underpowered to detect a true difference in fusion rates if one existed. However, the numerical trend, combined with the perioperative benefits, suggests that ACDF-SAC provides at least comparable early fusion outcomes to ACDF-CPA in this cohort of single-level degenerative subaxial cervical stenosis patients. These fusion rates are within the ranges reported in broader literature, where both SAC and CPA achieve high success. Another study indicated that fusion typically occurs between 6-9 months for ACDF-SAC and 5-10 months for ACDF-CPA, and our 6-month

assessment falls within this window.

The single case of non-fusion occurred in the ACDF-CPA group at the C3-4 level. Interestingly, the analysis of fusion by operative level showed a statistically significant association (p=0.043), with this C3-4 level being the site of the non-union. The C3-4 segment is known for its relatively higher mobility compared to lower subaxial levels. This increased segmental motion can place greater biomechanical stress on an attempted fusion, potentially increasing the risk of pseudarthrosis, especially if initial stability is suboptimal or if biological healing is impaired. While it is counterintuitive for a non-union to occur in a plated construct, this isolated event could be due to various unmeasured factors, such as patient-specific bone quality at that level, technical aspects of the surgery, or specific biomechanical loading patterns in that individual. The observation that the non-fusion occurred despite plating at a mobile segment warrants further investigation in larger cohorts, perhaps exploring whether specific plating techniques or cage characteristics are more critical at such levels. The study also noted that this non-fusion case had numerically higher bleeding and a longer hospital stay, though these were not statistically significant in relation to fusion status due to the N=1 in the non-fusion group.

The findings of this study, particularly the perioperative advantages of ACDF-SAC, are significant in the context of healthcare in Indonesia and similar developing regions. The reduced blood loss minimizes the already low risk of requiring blood transfusions and simplifies perioperative management. The shorter hospital stay directly translates to lower healthcare costs, increased bed availability, and potentially reduced risk of hospital-acquired complications. Given that ACDF-SAC also typically involves lower implant costs than ACDF-CPA, the SAC technique appears to offer a more cost-effective profile without compromising early fusion success in this patient population.

This study reinforces the notion that for single-level, uncomplicated degenerative cervical stenosis, ACDF-SAC can be a highly effective and efficient treatment option. The traditional rationale for plating often includes preventing graft/cage migration or subsidence and enhancing stability in cases of poor bone quality or multi-level constructs. In this cohort of single-level disease, these concerns might be less critical, allowing the benefits of a less invasive SAC procedure to come to the forefront. However, the decision to use SAC versus CPA should always be individualized. Factors such as significant segmental instability, including spondylolisthesis greater than 2 mm, osteoporosis, or planned multi-level fusion might still favor the enhanced biomechanical support of a CPA construct, as suggested by broader literature.

5. Conclusion

In this retrospective cohort study of patients undergoing single-level anterior cervical discectomy and fusion for degenerative subaxial cervical stenosis at a tertiary hospital in Palembang, Indonesia, the use of stand-alone cages (ACDF-SAC) was associated with a significantly more favorable perioperative profile compared to cage-plate augmentation (ACDF-CPA). Specifically, ACDF-SAC resulted in significantly less intraoperative blood loss and markedly shorter hospital stays. While the ACDF-SAC group demonstrated a 100% fusion rate at 6 months compared to 90.9% in the ACDF-CPA group, this difference did not achieve statistical significance, likely due to the limited sample size. Nevertheless, the findings suggest that ACDF-SAC does not compromise early fusion success in this patient group. The single non-fusion event occurred at the C3-4 level in a patient treated with ACDF-CPA, highlighting the potential influence of the specific operative segment on fusion outcomes. These results indicate that ACDF-SAC may offer important perioperative benefits, including reduced surgical morbidity and more efficient resource utilization, which are particularly relevant in healthcare settings like Indonesia. For appropriately selected patients with single-level degenerative cervical stenosis, ACDF-SAC appears to be a safe and effective option that can yield excellent

early fusion results while minimizing perioperative burdens. Further prospective studies with larger cohorts and longer-term follow-up are warranted to confirm these findings and to explore other clinically relevant outcomes, such as dysphagia rates and late biomechanical issues like cage subsidence. However, based on this study, ACDF-SAC presents a compelling surgical alternative to ACDF-CPA for single-level disease, balancing clinical efficacy with perioperative advantages.

6. References

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