Advanced Age is Associated with Increased Subsidence, Sagittal Imbalance, and Late-Onset Neck Pain Following Anterior Cervical Discectomy and Fusion

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INTRODUCTION: Anterior cervical discectomy and fusion (ACDF) is a commonly performed and effective treatment for cervical spine pathology. However, as the average age of patients undergoing spinal fusion increases, the impact of advanced age on outcomes such as subsidence, sagittal imbalance, and long-term neck pain remains unclear. This study aimed to evaluate age-related differences in radiographic alignment, complication rates, and patient-reported outcomes (PROs) following ACDF.

METHODS: A retrospective review of 302 patients undergoing ACDF between 2020 and 2022 at a single academic institution was conducted. Patients were stratified into four age groups: <50, 50–59, 60–69, and ≥70 years. Radiographic alignment was measured preoperatively, immediately postoperatively, and at 2-year follow-up. Outcome variables included C2–C7 sagittal vertical axis (SVA), Cobb angles, range of motion, and T1 slope. PROs were assessed at baseline and follow-up intervals. Multivariate regression analyses were performed to control for demographic and surgical variables.

RESULTS: Older age was associated with significantly higher rates of subsidence (29.6% in 50–59, 24.6% in 60–69, and 42.1% in ≥70 vs. 13.7% in <50; all p<0.05) and longer hospital stays (1.74 days in ≥70 vs. 0.96 in <50; p=0.001). The ≥70 group also experienced a progressive increase in SVA (+0.83 cm; p<0.0001) and a recurrence of neck pain at 1- and 2-year follow-ups. Despite these findings, this group demonstrated the greatest improvement in Brief Resilience Scale scores, reporting the highest resilience at 1 year (p=0.0162).

DISCUSSION AND CONCLUSION: Patients aged ≥70 undergoing ACDF are at increased risk for subsidence, sagittal imbalance, and delayed neck pain, indicating a need for closer postoperative monitoring. Nevertheless, these patients also show notable gains in psychological resilience, underscoring their capacity for recovery. These findings support the importance of age-specific surgical planning to optimize outcomes in elderly ACDF patients.

Table 1. Patient Demographics and Preoperative Characteristics

VARIABLE	AGE < 50 (N=96)	50 ≤ AGE < 60 (N=115)	60 ≤ AGE < 70 (N=71)	70 ≤ AGE (N=20)	P-VAL
DEMOGRAPHICS					
AGE	42.3 (5.95)	54.3 (2.82)	63.5 (2.58)	75.0 (3.31)	**<0.001**
FEMALE	53/96 (55.2%)	57/115 (49.6%)	28/71 (39.4%)	11/20 (55.0%)	0.224
BMI	30.0 (6.03)	30.7 (5.68)	29.7 (6.17)	29.5 (5.64)	0.656
CURRENT SMOKER	21/96 (21.9%)	27/115 (23.5%)	18/71 (25.4%)	2/20 (10.0%)	0.531
FORMER SMOKER	45/96 (46.9%)	55/115 (47.8%)	46/71 (64.8%)	11/20 (55.0%)	0.088
DIABETES	8/96 (8.33%)	9/115 (7.83%)	13/71 (18.3%)	1/20 (5.00%)	0.113
ASA CLASSIFICATION	2.1 (0.43)	2.2 (0.42)	2.4 (0.49)	2.6 (0.51)	**<0.001**
CCI SCORE	0.3 (0.65)	0.5 (0.91)	0.7 (0.87)	1.5 (1.50)	**<0.001**
PREOPERATIVE CHARACTERISTICS					
DURATION OF SYMPTOMS (MONTHS)	20.2 (31.9)	27.7 (44.6)	21.2 (36.5)	13.3 (38.1)	0.402
NECK PAIN	96/96 (100%)	114/115 (99.1%)	70/71 (98.6%)	18/20 (90.0%)	**0.005**
NUMBNESS	83/96 (86.5%)	94/115 (81.7%)	53/71 (74.6%)	14/20 (70.0%)	0.191
PRIOR CERVICAL SURGERY	6/96 (6.25%)	14/115 (12.2%)	6/71 (8.45%)	2/20 (10.0%)	0.520
INDICATION FOR SURGERY					
MYELOPATHY	8/96 (8.33%)	1/115 (87.0%)	3/71 (4.23%)	2/20 (10.0%)	**0.046**
RADICULOPATHY	79/96 (82.3%)	99/115 (86.1%)	55/71 (77.5%)	9/20 (45.0%)	**<0.001**
MYELORADICULOPATHY	9/96 (9.38%)	15/115 (13.0%)	13/71 (18.3%)	9/20 (45.0%)	**0.001**
SEGMENTS OPERATED ON	1.57 (0.61)	1.68 (0.67)	1.87 (0.70)	1.75 (0.72)	**0.036**

Table 2. Perioperative Characteristics and Complication Rates (Age < 50 vs. 50 ≤ Age < 60)

	UNIVARIATE			MULTIVARIATE		
VARIABLE	AGE < 50	50 ≤ AGE < 60	P-VAL	COEFFICIENTS	95% CI	P-VAL
PERIOPERATIVE CHARACTERISTICS				**BETA**		
ESTIMATED BLOOD LOSS (ML)	18.0 (10.2)	29.5 (54.5)	**0.032**	10.693	[-1.162, 22.548]	0.077
TOTAL PROCEDURE TIME (MINUTES)	161.0 (55.1)	160.9 (62.6)	0.987	-6.817	[-23.925, 10.292]	0.433
POSTOPERATIVE LENGTH OF STAY (DAYS)	0.96 (0.67)	1.11 (0.88)	0.291	0.168	[-0.107, 0.443]	0.230
CLINICAL FOLLOW-UP LENGTH (MONTHS)	13.0 (11.1)	14.8 (10.7)	0.204	0.551	[-2.588, 3.690]	0.730
COMPLICATION RATES				**OR**		
IN-HOSPITAL COMPLICATION RATES	0/79 (0%)	5/95 (5.26%)	**0.039**	-	-	-
OUT-OF-HOSPITAL COMPLICATION RATES	5/95 (5.26%)	6/115 (5.22%)	0.988	0.596	[0.095, 3.735]	0.581
DISCHARGE TO REHAB	0/79 (0%)	1/95 (1.05%)	0.360	-	-	-
DYSPHAGIA	1/96 (1.04%)	5/115 (4.35%)	0.150	2.449	[0.228, 26.290]	0.459
ADJACENT SEGMENT DISEASE	6/96 (6.25%)	9/115 (7.83%)	0.657	1.284	[0.419, 3.940]	0.662
ANTERIOR OSTEOPHYTE FORMATION	5/95 (5.26%)	10/115 (8.70%)	0.336	1.614	[0.482, 5.401]	0.437
SUBSIDENCE	13/95 (13.7%)	34/115 (29.6%)	**0.006**	4.365	[1.760, 10.826]	**0.001**
REOPERATION RATE	11/96 (11.5%)	12/115 (10.4%)	0.812	0.643	[0.236, 1.749]	0.387

Table 3. Perioperative Characteristics and Complication Rates (Age < 50 vs. 60 ≤ Age < 70)

	UNIVARIATE			MULTIVARIATE		
VARIABLE	AGE < 50	60 ≤ AGE < 70	P-VAL	COEFFICIENTS	95% CI	P-VAL
PERIOPERATIVE CHARACTERISTICS				**BETA**		
ESTIMATED BLOOD LOSS (ML)	18.0 (10.2)	20.9 (17.4)	0.627	2.28	[-11.758, 16.318]	0.749
TOTAL PROCEDURE TIME (MINUTES)	161.0 (55.1)	161.6 (74.6)	0.961	-14.046	[-34.167, 6.076]	0.170
POSTOPERATIVE LENGTH OF STAY (DAYS)	0.96 (0.67)	1.34 (0.83)	**0.012**	0.379	[0.053, 0.704]	**0.023**
CLINICAL FOLLOW-UP LENGTH (MONTHS)	13.0 (11.1)	10.8 (9.04)	0.168	-3.139	[-6.838, 0.559]	0.096
COMPLICATION RATES				**OR**		
IN-HOSPITAL COMPLICATION RATES	0/79 (0%)	1/61 (1.64%)	0.253	-	-	-
OUT-OF-HOSPITAL COMPLICATION RATES	5/95 (5.26%)	4/71 (5.63%)	0.917	1.294	[0.226, 7.425]	0.772
DISCHARGE TO REHAB	0/79 (0%)	2/61 (3.28%)	0.105	-	-	-
DYSPHAGIA	1/96 (1.04%)	1/71 (1.41%)	0.829	-	-	-
ADJACENT SEGMENT DISEASE	6/96 (6.25%)	4/71 (5.63%)	0.868	0.746	[0.166, 3.350]	0.702
ANTERIOR OSTEOPHYTE FORMATION	5/95 (5.26%)	1/71 (1.41%)	0.188	0.261	[0.027, 2.538]	0.247
SUBSIDENCE	13/95 (13.7%)	17/69 (24.6%)	0.073	3.037	[1.091, 8.455]	**0.033**
REOPERATION RATE	11/96 (11.5%)	6/71 (8.45%)	0.525	0.546	[0.160, 1.858]	0.333