Distal Extension Risk After Long Fusion to Lower Instrumented Vertebrae of L4 or L5 in Adult Spinal Deformity: A Multicenter Cohort Study

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INTRODUCTION:

Determining the optimal lower instrumented vertebra (LIV) in adult spinal deformity (ASD) surgery remains controversial, particularly in patients with preserved distal lumbar motion segments. While terminating constructs at L4 or L5 may maintain lumbosacral motion, the long-term durability of these strategies is still uncertain.

METHODS:

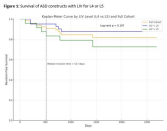
This multicenter retrospective cohort study included patients with ASD who underwent fusion at four or more levels, with LIV at L4 or L5, and minimum two-year follow-up. Patients were categorized based on whether they required distal extension to the pelvis (extension cohort, EC) or not (non-extension cohort, NEC). We compared baseline demographics, alignment parameters, disc integrity, and patient-reported outcomes at key time points, including pre-revision for EC and 2 years for NEC.

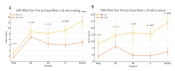
RESULTS:

A total of 65 patients (52 females; mean age 47.9 years; 41 L4, 24 L5 LIVs) were included in the study, with a mean age of 47.9, a mean BMI of 25.3, and an average of 8.7 levels fused. 11 patients (16.9%) had distal extension to the pelvis, with a median time of 517 days postoperatively, showing no difference between L4 and L5 LIV (13.9% vs. 33.3%, p=0.304, Figure 1). The reasons for extension included sagittal malalignment with distal kyphotic change (n=2, patient 1), sagittal malalignment without distal kyphotic change (n=3, patient 2), adjacent segment disease without sagittal malalignment (n=4), and distal failure (screw pullout, pseudarthrosis) (n=2). Baseline demographic and radiographic variables did not differ significantly between groups (Table 1). However, patients who underwent distal extension exhibited greater anterior translation at L5–S1 by 6 weeks post-op (−2.1 mm vs −0.8 mm, p=0.049, Table 3), and by 1 year had significantly higher pelvic tilt (23.6° vs 16.4°, p=0.024, Table 2) and pelvic angle offsets (Figure 2). Early worsening of disability (ODI at 6 months: 47.3 vs 30.3, p=0.047, Figure 3) and a reduction in L5–S1 anterior disc height at final follow-up (10.6 mm vs 15.2 mm, p=0.026, Table 3) were observed in the EC group.

DISCUSSION AND CONCLUSION:

Stopping long fusion at L4 or L5 is associated with an 83.1% extension-free survival rate at two years. The majority of failures occur early and are indicated by subtle changes in distal segment alignment and disc height. The risk for revision may be reduced by avoiding malalignment, reinforcing distal fixation, and spanning any segment with preoperative listhesis exceeding 0.5 mm. Careful patient selection and early radiographic surveillance are warranted to optimize outcomes for constructs ending at L4/L5.





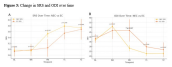


Table 1: Demographic and surgical details of NEC and EC patients

	NEC	EC	p-value
n	54	11	
Age	46.64 (17.02)	54.68 (12.76)	0.097
BMI	25.19 (5.01)	25.94 (1.35)	0.419
Smoker	8 (11.1%)	0 (0%)	0.191
CCI	1.3 (1.45)	0.73 (0.82)	0.332
Gender			0.679
Male	13 (18.1%)	3 (27.3%)	
Female	41 (81.1%)	8 (72.7%)	
Race			0.556
Asian	1 (1.9%)	0 (0%)	
Black	5 (9.3%)	0 (0%)	
Hispanic	2 (3.7%)	0 (0%)	
White	40 (74.1%)	10 (90.9%)	
Other/unknown	6 (11.1%)	1 (9.1%)	
Prior surgery	7 (13%)	3 (27.3%)	0.342
Fusion to lumbar levels	8.58 (0.76)	9.45 (4.43)	0.523
LIV			0.053
L4	37 (68.5%)	4 (36.4%)	
L5	17 (31.5%)	7 (63.6%)	
Follow-up (years)	4.09 (2.39)	4.17 (1.99)	0.768

Table 2: Sagittal alignment parameters at follow-up through 2 years.

	alignment parameter	NEC	EC	p-value
Preop	PI	55.28 (11.46)	58.45 (11.11)	0.393
	PT	19.83 (8.95)	20.27 (7.39)	0.259
	PI	36.89 (10.67)	38.44 (7.27)	0.897
	LL-SS Code	43.11 (15.94)	45.64 (10.23)	0.646
	T1Sl-CA Code	10.72 (17.37)	11.19 (18.12)	0.888
	TA-TLO Code	49.91 (21.17)	56.45 (20.26)	0.563
6 month	SS	32.19 (8.98)	30.82 (12.17)	0.756
	PT	19.53 (5.26)	18.64 (8.82)	0.866
	PI	36.89 (10.67)	38.44 (7.27)	0.897
	LL-SS Code	1.18 (12.41)	14.82 (11.18)	0.724
	T1Sl-CA Code	47.72 (14.82)	45.94 (22.20)	0.527
	TA-TLO Code	49.91 (21.17)	56.45 (20.26)	0.563
6 months	PI	36.41 (9.23)	39.17 (8.95)	0.407
	PT	21.22 (5.54)	26.22 (16.39)	0.477
	LL-SS Code	15.32 (15.94)	46.22 (16.39)	0.477
	T1Sl-CA Code	1.13 (19.65)	6.63 (19.57)	0.720
	TA-TLO Code	38.91 (15.47)	43.27 (24.47)	0.630
1 year	SS	33.45 (10.14)	29.64 (9.21)	0.284
	PT	19.43 (10.14)	23.64 (8.20)	0.004
	PI	31.79 (10.76)	47.74 (17.33)	0.501
	LL-SS Code	13.36 (13.75)	18.09 (11.23)	0.253
	T1Sl-CA Code	34.45 (16.47)	44.45 (20.12)	0.233
	TA-TLO Code	36.93 (11.51)	27.82 (6.44)	0.004
2 year or pre-revision	SS	33.93 (11.51)	34.45 (9.41)	0.888
	PT	19.93 (7.53)	24.09 (5.75)	0.045
	PI	35.71 (11.24)	44.45 (9.41)	0.008
	LL-SS Code	11.36 (12.97)	11.45 (13.58)	0.995
	T1Sl-CA Code	37.14 (16.43)	42.86 (21.38)	0.439

Table 3: Pain of the L4-S1 disc space at follow-up through 2 years

Outcome	mean change	P-value	mean change	P-value	p-to-p comparison	
Preop	4.38 (2.04)	ref	4.82 (1.94)	ref	0.49	0.49
6weeks	4.38 (2.07)	1.000	4.64 (1.96)	0.001	0.49	0.49
6months	4.38 (2.07)	1.000	4.64 (1.96)	0.001	0.49	0.49
1year	4.38 (2.07)	1.000	4.64 (1.96)	0.001	0.49	0.49
2years	4.38 (2.07)	1.000	4.64 (1.96)	0.001	0.49	0.49