Impact of Preoperative Sagittal Imbalance on Long-Term Postoperative Outcomes following Minimally Invasive Laminectomy

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INTRODUCTION:

Previous studies have demonstrated that postoperative sagittal alignment may be associated with patient reported outcomes following open lumbar decompression procedures. However, it is currently unknown whether preoperative sagittal imbalance impacts clinical outcomes of decompression only surgery among patients presenting with neurogenic claudication symptoms only when surgery is done utilizing minimally invasive surgery (MIS) techniques. The purpose of this study was to evaluate the impact of preoperative pelvic incidence – lumbar lordosis (PI-LL) imbalance on patient-reported outcomes after MIS laminectomy for the treatment of neurogenic claudication symptoms.

METHODS:

Adult patients undergoing MIS laminectomy for degenerative lumbar spinal stenosis were included. Radiographs were taken prior to surgical treatment and assessed for sagittal alignment parameters. Patients were then grouped based on the preoperative PI-LL (balanced vs. unbalanced). Changes in PROMs were compared between unbalanced PI-LL and balanced PI-LL groups. Minimal clinically important difference (MCID) for Oswestry Disability Index (ODI) was also assessed.

RESULTS:

Fifty-two patients were included. The mean follow up was 17 months. Seventeen patients (32.7%) had unbalanced age-adjusted preoperative PI-LL. There was no significant difference in any PROMs between unbalanced and balanced PI-LL groups preoperatively or at final follow up. Compared to those with unbalanced PI-LL, patients with balanced PI-LL were shown to have no added benefit in achieving MCID for ODI at long-term follow up and no added benefit in the time to achieving MCID.

DISCUSSION AND CONCLUSION:

The inclusion of spinopelvic sagittal parameters in the surgical decision making for degenerative spinal disease has been suggested to be crucial for optimizing clinical outcome. Proper spinopelvic sagittal alignment creates balanced loading on bony structures, muscles, and ligaments of the spine, allowing for minimal expenditure of power during ambulation. Previous studies on adult spinal deformity have reported the association between postoperative alignment and improved patient outcomes. However, there is a paucity of research evaluating the importance of preoperative sagittal alignment on clinical outcomes after minimally invasive spine surgery for patients presenting only with neurogenic claudication symptoms due to degenerative spine disorders.

To evaluate the association between preoperative sagittal alignment and clinical outcomes, patients were stratified into balanced PI-LL and unbalanced PI-LL groups. PI-LL is a measure of spinopelvic sagittal alignment, with greater mismatch between PI and LL likely predisposing to degenerative processes. Preoperative pelvic retroversion and higher PI-LL can be indicative of reaching the compensation limit, ultimately leading to structural sagittal malalignment. Therefore, preoperative PI-LL has also been shown to be a useful marker for distinguishing between reversible and irreversible sagittal malalignment.

Our findings demonstrate that patients with both unbalanced and balanced preoperative PI-LL experience statistically significant improvements in clinical outcomes following MIS laminectomy without fusion. The unbalanced PI-LL group had significant improvements in ODI, VAS leg, and PROMIS, while the balanced PI-LL group had significant changes in ODI, VAS back, VAS leg, SF12 PCS, and PROMIS. Thus, patients with unbalanced PI-LL may be less likely to experience improvement in back pain following MIS laminectomy. However, there was no statistically significant difference in any of the PROMs between unbalanced and balanced PI-LL groups preoperatively or at long-term follow up. This suggests that among patients undergoing MIS laminectomy, preoperative sagittal balance is not a prerequisite for overall positive clinical outcomes, and unbalanced patients may still benefit significantly from surgical intervention. The statistical similarity in outcome measures between the two groups suggests that preoperative sagittal alignment may not appreciably influence the long-term clinical outcome following MIS laminectomy and that the importance of preoperative sagittal alignment for this patient population may be overestimated in current literature.

Table 1: Demographics

	Frequency	Percentage
Age, in years		
40-49	3	5.8%
50-59	10	19.2%
60-69	11	21.2%
70-79	17	32.7%
80-89	11	21.2%
Gender		
Female	19	36.5%
Male	33	63.5%
Body Mass Index		
Normal	15	28.90%
Overweight	32	61.50%
Obese	5	9.60%
Laminectomy Levels		
Single level	37	71.20%
Multi-level	16	28.80%
Laminectomy Levels		
L2/3	3	5.80%
L3/4	16	30.80%
L4/5	38	73.10%
L5/S1	14	26.90%

Table 2: Preoperative Sagittal Alignment

	Frequency	Percentage
PI-LL		
Unbalanced	17	32.70%
Balanced (Age-adjusted)	45	67.30%
Pelvic Tilt		
Unbalanced	13	25.00%
Balanced (Age-adjusted)	39	75.00%
Sagittal Vertebral Axis		
Unbalanced	3	8.10%
Balanced (Age-adjusted)	34	91.90%

PI = pelvic incidence, LL = lumbar lordosis

Table 3: Changes in patient reported outcome measures between Unbalanced PI-LL and Balanced PI-LL groups

		Unbalanced PI-LL (n = 17)	Balanced PI-LL, Age-Adjusted (n = 45)	P-value (Unbalanced vs Balanced)
ODI	Preoperative	39.5	31.9	0.25
	LTFU	17.4	19.9	0.64
	P-value (Preop vs LTFU)	**<0.01***	**<0.01***	
VAS Back	Preoperative	4.7	4.2	0.67
	LTFU	2.4	2.3	0.95
	P-value (Preop vs LTFU)	0.10	**0.01***	
VAS Leg	Preoperative	6.9	5.8	0.20
	LTFU	2.6	2.8	0.81
	P-value (Preop vs LTFU)	**<0.01***	**<0.01***	
SF12 PCS	Preoperative	34.5	34.1	0.88
	LTFU	41.2	41.7	0.89
	P-value (Preop vs LTFU)	0.06	**<0.01***	
SF12 MCS	Preoperative	49.0	51.3	0.59
	LTFU	55.5	55.4	0.98
	P-value (Preop vs LTFU)	0.09	0.24	
PROMIS	Preoperative	34.5	34.7	0.96
	LTFU	45.7	42.1	0.19
	P-value (Preop vs LTFU)	**0.02***	**<0.01***	

Note: Asterisks (*) indicate statistically significant differences (P < 0.05)

PI = pelvic incidence, LL = lumbar lordosis, LTFU = long-term follow-up, ODI = Oswestry Disability Index, VAS = Visual Analog Scale, SF-12 = Short Form 12, PCS = Physical Component Score, MCS = Mental Component Score

Table 4: Multivariate logistic regression of risk factors for achieving MCID for ODI at long term follow up

	Odds Ratio (95% Confidence Interval)	P-value
Age, in years		
< 60	0.65 (0.05 - 8.44)	0.74
60 - 69	Reference	-
70 - 79	0.29 (0.03 - 2.57)	0.27
80 - 89	0.17 (0.01 - 2.28)	0.18
Gender		
Male	0.35 (0.06 - 2.25)	0.27
Female	Reference	-
Body Mass Index		
Normal	Reference	-
Overweight	0.73 (0.10 - 5.39)	0.76
Obese	0.40 (0.03 - 5.12)	0.48
Number of Laminectomy Levels		
Single level	Reference	-
Multi-levels	0.61 (0.01 - 11.74)	0.88
Laminectomy Levels		
L1/2 - L3/4	Reference	-
L4/5	1.75 (0.14 - 22.09)	0.66
L5/S1	0.66 (0.06 - 7.46)	0.73
Preoperative PI-LL		
Unbalanced	Reference	-
Balanced (Age-adjusted)	0.96 (0.15 - 5.92)	0.96

Note: Asterisks (*) indicate statistically significant association (P < 0.05)

PI = pelvic incidence, LL = lumbar lordosis, ODI = Oswestry Disability Index, MCID = minimum clinically important difference

Table 5: Multivariate linear regression of risk factors for increased time to achieving MCID for ODI

	Additional Time, in weeks (95% Confidence Interval)	P-value
Age, in years		
< 60	-20.59 (-63.04 - 21.86)	0.32
60 - 69	Reference	-
70 - 79	-29.62 (-70.55 - 11.30)	0.15
80 - 89	-22.55 (-85.08 - 39.98)	0.46
Gender		
Male	8.22 (-27.32 - 43.76)	0.63
Female	Reference	-
Body Mass Index		
Normal	Reference	-
Overweight	-7.37 (-42.04 - 27.29)	0.66
Obese	-19.73 (-80.37 - 40.92)	0.50
Number of Laminectomy Levels		
Single level	Reference	-
Multi-levels	-11.94 (-82.67 - 75.84)	0.44
Laminectomy Levels		
L1/2 - L3/4	Reference	-
L4/5	15.73 (-49.39 - 80.85)	0.62
L5/S1	24.62 (-38.35 - 87.59)	0.42
Preoperative PI-LL		
Unbalanced	Reference	-
Balanced (Age-adjusted)	2.54 (-36.23 - 41.32)	0.89

Note: Asterisks (*) indicate statistically significant association (P < 0.05)

PI = pelvic incidence, LL = lumbar lordosis, ODI = Oswestry Disability Index, MCID = minimum clinically important difference