Impact of Preoperative Age-Adjusted Sagittal Imbalance on Radiographic and Clinical Outcomes following One-Level Minimally Invasive Transforaminal Lumbar Interbody Fusion for Degenerative Spondylolisthesis

Omri Maayan, Andre Samuel, Pratyush Shahi[1], Tejas Subramanian, Avani Vaishnav, Anthony Pajak[1], Maximilian Kevin Korsun[1], Sravisht Iyer, Sheeraz Qureshi[2]
[1]Hospital For Special Surgery, [2]Minimally Invasive Spine Surgery

INTRODUCTION:

Prior studies investigating the use of Minimally Invasive Transforaminal Lumbar Interbody Fusion (MI-TLIF) for treatment of degenerative lumbar conditions and concomitant sagittal deformity have not stratified patients by preoperative pelvic incidence–lumbar lordosis (PI-LL) mismatch, which is the earliest parameter to deteriorate in mild sagittal deformity. The present investigation seeks to determine the impact of preoperative PI-LL mismatch on clinical outcomes and sagittal balance restoration among patients undergoing MI-TLIF for degenerative spondylolisthesis (DS).

METHODS:

Patient-reported outcome measures (PROMs) and radiographic parameters were measured preoperatively and at all follow-up visits in patients undergoing one-level MI-TLIF for DS. PROMs included the Oswestry Disability Index (OD), Visual Analog Scale (VAS) Back/Leg, Short Form-12 (SF-12), and Patient-Reported Outcomes Measurement Information System (PROMIS). Minimal clinically important difference (MCID) for PROMs was also evaluated. Radiographic parameters included pelvic incidence (PI), lumbar lordosis (LL), pelvic tilt (PT), and sagittal vertical axis (SVA). Patients were grouped based on preoperative PI-LL mismatch according to age-adjusted alignment goals. Univariate analysis was used to compare changes in radiographic parameters and PROMs between groups preoperatively and the most recent follow-up visit.

RESULTS:

A total of 80 patients undergoing one-level MI-TLIF for DS were included. Mean age and BMI were 63.2 ± 11.7 years and 27.7 ± 5.8 kg/m2, respectively. Sixty-six (82.5%) patients were operated at L4-L5. Overall, 47 (58.8%) of patients exhibited preoperative PI-LL mismatch based on age-adjusted alignment goals. There were significantly more patients with higher grade spondylolisthesis in the unbalanced PI-LL group (27.7% vs. 3.0%, p=0.004). There were no other differences in patient demographics and perioperative characteristics between balanced (n=33) and unbalanced (n=47) groups (Table 1). Mean clinical and radiographic follow up were 17.0 ± 7.9 months and 8.27 ± 2.9 months, respectively. Patients with PI-LL mismatch did not exhibit significant improvement in sagittal alignment parameters after one-level MI-TLIF. Patients with preoperative sagittal imbalance also showed worse PI-LL (16.0 ± 11.2 vs. 0.54 ± 10.9, p<0.001), PT (25.9 ± 6.9 vs. 18.7 ± 6.4, p<0.001), and SVA (49.4 ± 36.6 vs. 22.8 ± 34.6, p=0.013) at long-term follow up (Table 2). Both patients with and without preoperative PI-LL mismatch demonstrated significant improvements in all PROMs (p<0.05) except for SF-12 MCS (Table 3, Figure 1). Achievement of MCID for VAS Back was significantly greater among patients with preoperative PI-LL mismatch (85.7% vs. 65.5%, p=0.045; Table 4).

DISCUSSION AND CONCLUSION:

One-level MI-TLIF did not restore sagittal alignment in patients with preoperative PI-LL mismatch. Patients with preoperative sagittal imbalance exhibited a significantly greater proportion of higher-grade spondylolisthesis and worse preoperative PROMs. Yet, these patients showed comparable clinical outcomes to those without sagittal imbalance at ≥6 months postoperatively, as well as greater achievement of MCID. Thus, while improvement in overall alignment has traditionally been a primary goal among patients with sagittal imbalance, the discordant relationship between radiographic parameters and PROMs demonstrated in the present study suggests that achievement of good long-term clinical outcomes may not always necessitate correction of sagittal deformity directly. Patients may undergo one-level MI-TLIF if there is sufficient clinical and radiographic evidence that symptoms are arising from a particular spinal level, provided that the sagittal imbalance is relatively mild.

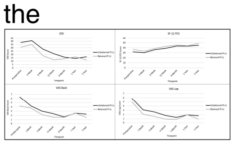

Figure 1. Change in Patient-Reported Outcome Measures Over Time Between Sagittal Balance Groups

Table 1. Patient Demographics and Perioperative Characteristics

	Unbalanced PI-LL (n=47)	Balanced (n=33)	P-Value
Age	61.7 ± 11.7	65.3 ± 11.7	0.18
Gender, male	16 (34.0)	13 (39.4)	0.62
Body Mass Index, kg/m2	28.0 ± 6.1	27.2 ± 5.4	0.59
Charlson Comorbidity Index	2.6 ± 1.6	2.5 ± 1.8	0.92
Meyerding Spondylolisthesis Grade			**0.004**
I	34 (72.3%)	32 (97.0%)	
II	13 (27.7%)	1 (3.0%)	
ASA Score			
I	6 (12.8%)	2 (6.1%)	0.17
II	33 (70.2%)	29 (87.9%)	
III	8 (17.0%)	2 (6.1%)	
TLIF Level			0.29
L4-L5	37 (78.7)	29 (87.9)	
L5-S1	10 (21.3)	4 (12.1)	
Implant Type			0.65
Tritanium PL	6 (12.8)	4 (12.1)	
Altera	37 (78.7)	24 (72.7)	
Other	4 (8.5)	5 (15.2)	
Implant Lordosis, degrees			
L4-L5	13.8 ± 2.7	13.0 ± 3.9	0.35
L5-S1	1.1 ± 3.6	2.8 ± 5.4	0.12
Operative Time	114.1 ± 61.2	129.8 ± 69.8	0.29
Length of Stay	41.9 ± 28.4	43.2 ± 21.9	0.82
Operative Complications	0	0	-

Table 2. Changes in Radiographic Parameters Between Unbalanced and Balanced PI-LL Groups

	Unbalanced PI-LL (n=47)	Balanced (n=33)	P-Value (Unbalanced vs Balanced)
PI-LL, degrees			
Preoperative	18.8 ± 11.2	-3.3 ± 7.3	**<0.001**
Long-Term Follow Up	16.0 ± 11.2	0.54 ± 10.9	**<0.001**
Delta	-2.6 ± 12.3	4.2 ± 8.4	**0.008**
P-Value (Preop vs LTFU)	0.11	**0.008**	-
Pelvic Incidence, degrees			
Preoperative	62.0 ± 11.9	50.7 ± 8.3	**<0.001**
Long-Term Follow Up	61.0 ± 12.3	53.2 ± 8.6	**0.002**
Delta	-1.0 ± 7.8	2.6 ± 5.6	**0.026**
P-Value (Preop vs LTFU)	0.38	**0.012**	-
Lumbar Lordosis, degrees			
Preoperative	43.3 ± 11.0	54.0 ± 9.4	**<0.001**
Long-Term Follow Up	45.1 ± 11.5	52.7 ± 11.9	**0.005**
Delta	1.9 ± 11.2	-1.3 ± 8.5	0.18
P-Value (Preop vs LTFU)	0.26	0.39	-
Pelvic Tilt, degrees			
Preoperative	26.2 ± 9.1	16.4 ± 6.0	**<0.001**
Long-Term Follow Up	25.9 ± 6.8	18.7 ± 6.4	**<0.001**
Delta	-0.3 ± 8.2	2.4 ± 5.6	0.11
P-Value (Preop vs LTFU)	0.79	**0.02**	-
Sagittal Vertebral Axis, mm			
Preoperative	53.2 ± 36.8	9.0 ± 34.8	**0.001**
Long-Term Follow Up	49.4 ± 36.6	22.8 ± 34.6	**0.013**
Delta	-5.3 ± 40.2	4.6 ± 25.0	0.48
P-Value (Preop vs LTFU)	0.61	0.55	-
Anterior Disc Height			
Preoperative	5.8 ± 2.8	6.6 ± 2.7	0.20
Long-Term Follow Up	8.3 ± 2.7	8.7 ± 2.9	0.56
Delta	2.5 ± 3.3	2.1 ± 3.0	0.62
P-Value (Preop vs LTFU)	**<0.001**	**<0.001**	-
Posterior Disc Height			
Preoperative	4.5 ± 1.5	4.8 ± 1.5	0.40
Long-Term Follow Up	6.1 ± 2.2	5.8 ± 1.5	0.56
Delta	1.7 ± 1.9	1.1 ± 1.9	0.18
P-Value (Preop vs LTFU)	**<0.001**	**0.003**	-

PI=Pelvic Incidence, LL=Lumbar Lordosis, LTFU=Long Term Follow-Up

Table 3. Patient-Reported Outcome Measures Between Sagittal Balance Groups

Patient-Reported Outcome Measures	Unbalanced PI-LL (n=47)	Balanced (n=33)	P-Value (Unbalanced vs Balanced)
ODI			
Preoperative	38.0 ± 18.2	30.84 ± 17.6	0.10
Early Postoperative Timepoint (Delta 1)	20.9 ± 14.5 (16.2 ± 17.8)	16.4 ± 14.5 (16.0 ± 20.7)	0.20 (0.96)
Late Postoperative Timpoint (Delta 2)	17.0 ± 16.9 (20.3 ± 18.7)	13.8 ± 14.0 (16.1 ± 18.8)	0.43 (0.38)
P-Value (Preoperative vs Late Postoperative)	**<0.001**	**<0.001**	-
PROMIS			
Preoperative	36.2 ± 7.2	38.6 ± 9.3	0.23
Early Postoperative Timepoint (Delta 1)	42.4 ± 7.3 (6.4 ± 7.7)	46.7 ± 7.7 (8.2 ± 8.4)	**0.025** (0.39)
Late Postoperative Timpoint (Delta 2)	47.7 ± 11.4 (12.6 ± 9.1)	48.3 ± 8.4 (10.2 ± 12.2)	0.84 (0.40)
P-Value (Preoperative vs Late Postoperative)	**<0.001**	**0.001**	-
VAS Back			
Preoperative	6.4 ± 2.7	4.2 ± 2.9	**0.002**
Early Postoperative Timepoint (Delta 1)	2.4 ± 2.0 (3.9 ± 2.9)	1.8 ± 1.8 (2.4 ± 3.3)	0.23 **(0.039)**
Late Postoperative Timpoint (Delta 2)	2.2 ± 2.4 (4.0 ± 2.9)	2.3 ± 2.8 (1.9 ± 4.0)	0.95 **(0.017)**
P-Value (Preoperative vs Late Postoperative)	**<0.001**	**0.023**	-
VAS Leg			
Preoperative	5.8 ± 2.9	5.0 ± 3.5	0.25
Early Postoperative Timepoint (Delta 1)	1.8 ± 1.9 (4.0 ± 3.0)	1.3 ± 2.1 (3.4 ± 3.6)	0.36 (0.49)
Late Postoperative Timpoint (Delta 2)	1.8 ± 2.7 (3.9 ± 3.4)	1.6 ± 2.5 (3.3 ± 4.0)	0.77 (0.49)
P-Value (Preoperative vs Late Postoperative)	**<0.001**	**<0.001**	-
SF-12 PCS			
Preoperative	31.9 ± 9.1	36.9 ± 10.2	**0.036**
Early Postoperative Timepoint (Delta 1)	39.2 ± 10.0 (7.4 ± 11.0)	42.0 ± 9.2 (5.1 ± 13.3)	0.13 (0.47)
Late Postoperative Timpoint (Delta 2)	44.4 ± 13.2 (12.6 ± 13.4)	44.9 ± 10.8 (7.4 ± 15.8)	0.88 (0.16)
P-Value (Preoperative vs Late Postoperative)	**<0.001**	**0.028**	-
SF-12 MCS			
Preoperative	51.4 ± 10.5	50.7 ± 10.7	0.80
Early Postoperative Timepoint (Delta 1)	54.9 ± 9.6 (3.7 ± 9.8)	55.7 ± 8.1 (4.3 ± 11.8)	0.70 (0.77)
Late Postoperative Timpoint (Delta 2)	50.6 ± 10.1 (-0.4 ± 9.7)	55.4 ± 8.7 (3.7 ± 11.4)	0.057 (0.13)
P-Value (Preoperative vs Late Postoperative)	0.79	0.12	-

ODI=Oswestry Disability Index, PROMIS=Patient-Reported Outcomes Measurement Information System, VAS=Visual Analog Scale, SF-12=Short Form-12, PCS=Physical Component Scale, MCS=Mental Component Scale

Table 4. Minimum Clinically Important Difference for Patient-Reported Outcome Measures

Patient-Reported Outcome Measures	Unbalanced PI-LL (n=47)	Balanced (n=33)	P-Value
ODI			
Achivement of MCID, n (%)	31 (73.8)	19 (73.1)	0.95
Time to MCID, months	4.2 ± 5.1	4.4 ± 7.2	0.90
PROMIS			
Achivement of MCID	30 (81.1)	20 (83.3)	0.82
Time to MCID, months	3.5 ± 3.5	3.5 ± 5.5	0.98
VAS Back			
Achivement of MCID	36 (85.7)	19 (65.5)	**0.045**
Time to MCID, months	1.9 ± 3.9	1.1 ± 0.80	0.39
VAS Leg			
Achivement of MCID	34 (81.0)	20 (71.4)	0.35
Time to MCID, months	1.2 ± 1.1	2.4 ± 5.1	0.28
SF-12 PCS			
Achivement of MCID	24 (61.5)	20 (76.9)	0.19
Time to MCID, months	4.3 ± 4.0	5.2 ± 6.9	0.62
SF-12 MCS			
Achivement of MCID	22 (56.4)	15 (57.7)	0.92
Time to MCID, months	2.4 ± 3.0	1.3 ± 0.81	0.07

ODI=Oswestry Disability Index, PROMIS=Patient-Reported Outcomes Measurement Information System, VAS=Visual Analog Scale, SF-12=Short Form-12, PCS=Physical Component Scale, MCS=Mental Component Scale