

Original Article

Lumbopelvic parameters and the extent of lumbar fusion

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Abstract

Background: Following lumbar fusion, sacroiliac (SI) joint pain has been regarded as a form of adjacent segment disease. Prior studies suggest increased stress to the SI joint and pelvis with lumbar fusion. Limited studies have evaluated the relationship between the extent of lumbar fusion and its potential influence on lumbopelvic parameters, which may provide the insights to persistent back pain.

Methods: Three hundred fifty-five patients underwent lumbar fusions at our institution between fall 2010 and winter 2012; 80 patients met criteria for the study. Inclusion criteria included appropriate imaging available (preoperative and postoperative lateral films), follow-up >1-year, fusion where the rostral extent was up to L1 and the caudal extent was at most S1. Exclusion criteria included prior lumbar fusion, history of SI joint syndrome, follow-up <1-year, fusion involving thoracic levels, and inadequate films (inability to visualize appropriate anatomy). The patients were divided into groups based on the extent of fusion. The patients were evaluated based on age, sex, diagnosis, lumbar lordosis, pelvic incidence, pelvic tilt, and sacral slope. The preoperative values were compared among the groups, the postoperative values were compared among the groups, and the pre- and post-operative values were compared within each group.

Results: There were no statistically significant differences between pre- and post-operative lumbopelvic parameters within each fusion group.

Conclusion: The results imply that the extent of instrumentation, including the involvement of the sacrum, may not alter lumbopelvic parameters. This appears to argue against the idea that longer fusion constructs induce more stress on the pelvis and SI joint.

Key Words: Lumbar fusion, lumbopelvic parameters, sacropelvic parameters

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Quick Response Code:**INTRODUCTION**

Lumbopelvic parameters have been employed to evaluate the sagittal alignment after lumbar fusion with respect to sacroiliac (SI) joint pain.^[2,4,8] However, no prior studies have explored the relationship between the extent of lumbar fusion (the number of instrumented levels) and its potential influence on lumbopelvic parameters. The objective of this study was to evaluate that relationship with the hypothesis that increasing the extent of fusion intensifies stress to the sacrum and alters lumbopelvic

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parameters accordingly. Assessment of this relationship may provide the insights on SI joint dysfunction and may clarify whether such dysfunction contributes to failed back surgery syndrome.

MATERIALS AND METHODS

The approval of the institutional board review at our hospital was obtained prior to the study.

Between fall 2010 and winter 2012, 355 patients underwent lumbar fusions at our institution. Six spine surgeons performed the surgeries. The study's inclusion and exclusion criteria are outlined in Table 1. Eighty patients (42 males, 38 females) met study criteria, where the mean age was 57.9 years and the mean follow-up period was 518 days. The most common diagnosis was lumbar stenosis with instability. Subsequently, the patients were grouped based on the extent of fusion [Table 2]. The groups L3–L5, L3–S1, L4–L5, L4–S1, and L5–S1 were analyzed; other groups did not possess enough patients.

The clinical data (age, sex, diagnosis, levels of fusion, and extent of follow-up) were collected via chart review. Pre- and post-operative lateral X-rays were evaluated for lumbopelvic parameters using a picture archiving and communication system. The lumbopelvic parameters, which included lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS), were assessed as previously reported.^[2,3] LL is the Cobb angle between the inferior endplate of T12 and the superior endplate of S1. PI is the angle between a line drawn from the center of the femoral head to the midpoint of the sacral end plate and a line perpendicular to the center of the sacral end plate. PT is the angle between the vertical axis and the line joining the middle of the sacral end plate and the hip axis. SS is the angle between the horizontal axis and the superior endplate of the sacrum.

For each lumbopelvic parameter, the lumbar fusion groups were compared via one-way ANOVA. If a significant finding ($P < 0.05$) was discovered, *post-hoc* testing ensued, where each lumbar fusion group was compared with each other group through all permutations via the Student's *t*-test to discover the significance found by ANOVA. To compare the preoperative value to the postoperative value of a lumbopelvic parameter, the Student's *t*-test was also utilized, where $P < 0.05$ was considered as significant.

RESULTS

Table 3 summarizes the comparison among the different fusion groups. Preoperatively, there was statistical significance upon the evaluation of PT values across the fusion groups ($P = 0.017$); after *post-hoc* testing,

Table 1: Inclusion and exclusion criteria

Inclusion criteria	
Appropriate imaging available (pre- and post-operative lateral films)	
Follow-up >1-year	
Fusion where the rostral extent is up to L1 and the caudal extent at most S1	
Exclusion criteria	
Prior lumbar fusion	
History of SI joint syndrome	
Follow-up of <1-year	
Fusion involving thoracic levels	
Inadequate films (inability to visualize appropriate anatomy)	

Table 2: Patient demographics

Clinical information	Relevant Data	Percentage
Number of patients	80	
Age, years, mean±SD (range)	57.9±11.5 (27-82)	
Male gender	42	52.5
Average follow-up (days)	518	
Diagnosis		
Lumbar instability/stenosis	41	51.2
Degenerative spondylolisthesis	27	33.8
Isthmic spondylolisthesis	5	6.3
Synovial cyst	4	5.0
Recurrent disc herniation	3	3.8
Fusion level***		
L1-L4	1	1.25
L1-L5	1	1.25
L2-L5	3	3.75
L2-S1	1	1.25
L3-L4	1	1.25
L3-L5	9	11.25
L3-S1	17	21.25
L4-L5	12	15
L4-S1	28	35
L5-S1	7	8.75

***Other permutations for the extent of fusion (i.e., L1-L2) were not observed.
SD: Standard deviation

the significance was discovered between L3–L5 and L4–S1 ($P = 0.0076$). Postoperatively, there were no statistical significances across the fusion groups among all lumbopelvic parameters. Comparisons between preoperative values to postoperative values for each respective fusion group revealed no significant changes after surgery.

DISCUSSION

Postfusion lower back pain may be caused by SI joint dysfunction or pseudoarthrosis. In particular, SI joint involvement ranges up to 40%.^[5,7,9] Since the SI joint is adjacent to a fused segment, SI joint pain has

Table 3: Lumbopelvic parameters and various lumbar fusion groups

	L3-L5	L3-S1	L4-L5	L4-S1	L5-S1	P
LL						
Pre	48.93±15.29	49.33±17.91	41.48±13.35	49.12±13.78	49.40±15.37	0.60
Post	45.39±12.12	45.72±16.32	43.27±8.28	45.08±12.13	45.74±15.17	0.58
P	0.59	0.54	0.70	0.25	0.66	
SS						
Pre	33.03±13.96	34.16±10.77	30.43±8.79	36.75±11.79	36.23±9.45	0.56
Post	37.63±12.60	33.25±11.10	34.02±9.27	35.62±10.09	37.30±10.65	0.82
P	0.47	0.81	0.34	0.70	0.85	
PT						
Pre	28.86±14.11	18.79±9.79	25.27±10.09	16.84±10.00	23.89±8.33	0.017
Post	21.42±13.30	18.40±10.62	19.72±9.14	19.47±9.89	25.24±13.38	0.69
P	0.27	0.06	0.69	0.33	0.82	
PI						
Pre	67.76±13.66	61.22±11.20	67.76±13.56	64.61±11.04	62.87±5.96	0.53
Post	66.26±11.93	59.65±8.50	63.93±11.15	66.39±11.89	67.27±10.42	0.31
P	0.81	0.65	0.46	0.57	0.35	

LL: Lumbar lordosis, SS: Sacral slope, PT: Pelvic tilt, PI: Pelvic incidence

been regarded as a form of adjacent segment disease.^[4,7] SI joint degeneration, as observed on computed tomography imaging, has been correlated with instrumented lumbar fusion.^[4] In addition, based on a finite element lumbar spine-pelvis model, Ivanov *et al.*^[5] observed that longer lumbar fusion constructs induced more angular motion of the sacrum and applied more stress across the SI joint; the group believed the results depicted a mechanism for low back pain after lumbar fusion surgery.

Given the potential for SI joint dysfunction after lumbar fusion, SI joint pain has been evaluated in the context of lumbopelvic sagittal alignment in prior studies. Briefly, the lumbopelvic sagittal alignment is composed of spinal (LL) and pelvic parameters (PI, PT, and SS);^[10] PI is a constant parameter independent of pelvic orientation, whereas SS and PT are influenced by pelvic orientation.^[1,2] Shin *et al.*^[10] found that a larger PT and inadequately restored LL after lumbar fusion may play a central role in the development of SI joint pain. Cho *et al.*^[2] noticed that lumbar fusion patients who had SI joint pain exhibited a retroverted pelvis (larger PT) and vertical sacrum (smaller SS), while patients without SI joint pain exhibited similar morphology to asymptomatic patients.

Despite these reported relationships between lumbopelvic parameters and SI joint pain/residual pain after lumbar fusion (as noted above), the details surrounding lumbar fusion have been limited. In particular, the relationship between the extent of fusion (the number of instrumented levels) and its potential influence on lumbopelvic parameters has not been heavily explored. Shin *et al.*^[10] and Cho *et al.*^[2] from the above studies did not provide details regarding the extent of lumbar fusion. Lazennec *et al.*^[8] briefly touched upon this

topic in their cohort of patients who received L4–S1 or L5–S1 fusions. With the evaluation of all patients collectively, the group noted that patients with pain after lumbar fusion demonstrated PT greater than twice the normal value, while their sacrum remained significantly vertical (smaller SS) compared to those without pain. The authors divided lumbosacral fusions between L5–S1 and L4–S1, and found similar trends among the subgroups; the trend for the L4–S1 group was more pronounced compared to the trend for the L5–S1 group. This suggested that a 2-level lumbosacral fusion induced more significant changes to PT and SS compared to a 1-level lumbosacral fusion. However, a striking finding was that patients who were later found to have postlumbar fusion pain were also characterized by a preoperatively more vertical sacrum than the nonfusion patients or the fusion patients who were pain-free at last follow-up. As such, the extent of fusion may not have altered lumbopelvic parameters so much as the patients may have been predisposed to postfusion pain based on the preoperative alignment.

In our study, analysis of the preoperative values revealed a significant difference between the L3–L5 fusion group and the L4–S1 fusion group, but no other significant differences among other groups. The trend may be partly explained since our patient population had varying underlying pathologies, which according to Jackson *et al.*,^[6] may demonstrate differing parameters. Interestingly, the postoperative values were not significantly different from the preoperative values. This implies that the extent of instrumentation, including the involvement of the sacrum, may not alter lumbopelvic parameters. Compared to Lazennac *et al.*,^[8] our study may be more robust as it assessed up to four levels of

fusion, incorporating fusions that involved or did not involve the sacrum.

The study had several limitations. The patient population possessed different diagnoses, which may distort the comparison among preoperative values. Moreover, the study was a retrospective analysis.

CONCLUSIONS

Based on the prior studies, lumbopelvic parameters, particularly LL, SS, and PT, may correlate with SI joint pain/residual pain after lumbar fusion. However, the details surrounding lumbar fusion in those studies have been limited. In particular, the relationship between the extent of fusion (the number of instrumented levels) and its potential influence on lumbopelvic parameters has not been heavily explored. Since strategies toward lumbar fusion may influence the development of SI joint pain postoperatively, investigation of this relationship may shed light on the mechanism for the development of SI joint pain. This study suggests that the extent of instrumentation may not alter lumbopelvic parameters, and implies that the extent of instrumentation may not contribute to SI joint pain.

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Conflicts of interest

There are no conflicts of interest.

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