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Mid-term changes in spinopelvic sagittal alignment in lumbar spinal stenosis with coexisting degenerative spondylolisthesis or scoliosis after minimally invasive lumbar decompression surgery: minimum 5-year follow-up

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Abstract:

BACKGROUND CONTEXT: Recently, the number of patients with lumbar spinal stenosis (LSS) who present with a coexisting spinal deformity such as degenerative spondylolisthesis (DS) and scoliosis (DLS) has been increasing. Lumbar decompression without fusion can lead to a reactive improvement in the lumbar and sagittal spinopelvic alignment, even if a sagittal imbalance exists preoperatively. However, the mid- to long-term impact of the coexistence of DS and DLS on the change in sagittal spinopelvic alignment and clinical outcomes after decompression surgery remains unknown.

PURPOSE: This study aimed to investigate whether the coexistence of DS or DLS in patients with LSS is associated with differences in radiological and clinical outcomes after minimally invasive lumbar decompression surgery.

STUDY DESIGN/SETTING: A retrospective analysis of prospectively collected data.

PATIENT SAMPLE: A total of 169 patients who underwent minimally invasive lumbar decompression surgery and follow-up >5 years postoperatively.

OUTCOME MEASURES:

Self-report measures: Low back pain (LBP)/leg pain/leg numbness visual analog scale (VAS) scores and the Japanese Orthopedic Association scores

Physiologic measures: Standing sagittal spinopelvic alignment

METHODS: In total, 81 patients with LSS, 50 patients with LSS and DS (≥3 mm anterior slippage), and 38 patients with LSS and DLS (≥15° coronal Cobb angle) were included in the current study. Clinical and radiological outcome results before surgery and at 2 and 5 years after surgery were compared among the groups.

RESULTS: In patients with LSS with coexisting DS, the clinical outcomes at 2 and 5 years after surgery were similar to those of patients with only LSS. In patients with LSS with coexisting DLS, the VAS LBP and leg pain at 2 years after surgery was significantly higher (34.7 vs 27.8, P=0.014; 27.8 vs 14.7, P=0.028) and the achievement rate of the minimal clinically important difference in VAS LBP and leg pain was significantly lower than that of the LSS group (36.1% vs 54.2%, P=0.036; 58.3% vs 69.9%, P=0.10). The clinical outcomes except VAS leg numbness at 5 years after surgery were similar to those of patients with only LSS. The reoperation rate of the DS group was significantly lower than that of the LSS group (4.0% vs 14.8%; P=0.01); however, the reoperation rate of the DLS group was comparable to that of the LSS group (15.8% vs 14.8%; P=0.493). Lumbar lordosis (LL), sacral slope, pelvic tilt, and pelvic incidence-LL had significantly improved and been maintained for 5 years after the surgery in both the DS and the DLS groups. The sagittal vertical axis had improved at 2-year follow-up; however, no significant difference was observed at the 5-year follow-up in both the DS and the DLS groups.

CONCLUSION: Mid-term clinical outcomes in patients with LSS with and without deformity were comparable. Lumbar decompression without fusion can result in a reactive improvement in the lumbar and sagittal spinopelvic alignment, even with coexisting DS or DLS. Minimally invasive surgery could be considered for most patients with LSS.

Keywords: Lumbar spinal stenosis, Scoliosis, Spondylolisthesis, minimally invasive lumbar decompression surgery, Spinopelvic alignment, Long-term; 5-year follow-up study

Introduction

There has been an increase in the number of elderly patients with degenerative lumbar disorders as well as the number of lumbar surgeries for lumbar spinal stenosis (LSS)[1]. Furthermore, an increasing number of patients with LSS present with a coexisting spinal deformity such as degenerative spondylolisthesis (DS) and scoliosis (DLS)[2].

Minimally invasive decompression surgery may improve symptoms but does not interfere with the natural course of the disease. Recently it was reported that lumbar decompression without fusion can lead to a reactive improvement in the lumbar and sagittal spinopelvic alignment, even if a sagittal imbalance exists preoperatively[3–7]. However, the mid- to long-term impact of the coexistence of DS and DLS on the change in sagittal spinopelvic alignment and clinical outcomes after decompression surgery remains unknown. This study aimed to compare the minimum 5-year radiographic changes of sagittal spinopelvic alignment and clinical outcomes after minimally invasive lumbar decompression surgery between patients with LSS and patients with LSS with coexisting DS or DLS.

Methods

We performed a retrospective cohort study on patients who underwent minimally invasive lumbar decompression surgery for LSS with or without DS or DLS. All study participants provided informed consent, and the study protocol was approved by the Institutional Review Board at Osaka City University of post-graduate medical school (no. 3170). The clinical indications for surgery were leg pain and/or leg numbness inducing intermittent claudication (rather than back pain), mainly derived from spinal canal stenosis. We proactively performed minimally invasive lumbar decompression surgery as the optimal first-line surgical treatment for the vast majority of patients with LSS with coexisting DLS or DS. The criteria for additional fusion procedures in our institution were Cobb angle >25°, severe LBP, segmental kyphosis >5° during flexion, changes in segmental disc wedging between the standing and prone position >5°, or lateral disc slippage >3 mm. We reviewed 169 patients who underwent bilateral decompression by a unilateral approach using a microscope or microendoscope at our institute between 2008 and 2013 and conducted a follow-up for more than 5 years postoperatively (88 women, 81 men; mean age at surgery, 69.5±9.2 years). The patients were divided into three groups: LSS group (without DS or DLS; n=81), DS group (LSS patients with anterior slip of >3 mm; n=50), and DLS group (with ≥15° coronal Cobb angle; n=38). Preoperative demographic and clinical characteristics are listed in Table 1.

Surgical intervention

All patients underwent bilateral decompression through a unilateral approach to decompress the central and bilateral lateral recess using a microscope or the METRx Microendoscopic Discectomy System (Medtronic Sofamor Danek, Warsaw, IN, USA), performed as previously described[8,9].

Clinical evaluations

Clinical outcomes were evaluated using the Japanese Orthopaedic Association (JOA) scoring system and visual analog scale (VAS) score for low back pain (LBP), leg pain (LP), and leg numbness and achievement of the minimal clinically important difference (MCID) of VAS for low back pain or leg pain. The MCID of the VAS for LBP and LP was defined as 21 and 28, respectively, as previously reported[10]. The JOA score improvement ratio (%) was calculated as follows: (postoperative JOA score - preoperative JOA score)/ (29 - preoperative JOA score) × 100.

Reoperation was defined as lumbar revision surgery performed for progression of lumbar degeneration or postoperative instability regardless of the index decompression level or other lumbar levels.

Radiographic evaluation

Patients underwent full-length standing whole-spine radiography (posteroanterior and lateral) preoperatively (within 2 weeks of surgery) and at 2 and 5 years after surgery. Images were assessed by three authors (H.S., H.T., and K.Y.), who were blinded to the outcomes. Films were measured using an electronic software (Surgimap for Windows.exe). The following spinopelvic parameters were evaluated before surgery and at the 2- and 5-year follow-up: cervical lordosis (CL), cervicothoracic kyphosis (CTK), thoracic kyphosis (TK), lumbar lordosis (LL), sagittal vertical axis (SVA), sacral slope (SS), pelvic tilt (PT), pelvic incidence (PI), and PI-LL. As reported previously [11,12] the SVA, PT, and PI-LL were categorized as follows: normal sagittal alignment (SVA <50 mm) and sagittal malalignment (SVA ≥50 mm), appropriate pelvic retroversion (PT <20°) and compensatory pelvic retroversion (PT ≥20°), and appropriate PI-LL (PI−LL <10°) and PI-LL mismatch (PI−LL ≥10°).

Statistics

The differences between the LSS and DS groups and the LSS and DLS groups were investigated. Differences in categorical variables and continuous variables were analyzed using the chi-square test and Mann-Whitney U test, respectively. A paired t-test was used to compare two means from the same individual. All statistical analyses were performed using SPSS software, Version 25 (IBM Corp. USA). Statistical test results were considered significant at P<0.05.

Results

Clinical outcomes after surgery among the LSS, DS, and DLS groups are presented in Table 2. No significant difference was noted in the clinical outcomes between the LSS and DS group at 2-year follow-up. In the DLS group, the VAS LBP and leg pain at 2 years after surgery was significantly higher (34.7 vs 27.8, P=0.014; 27.8 vs 14.7, P=0.028) and the achievement rate of the minimal clinically important difference in VAS LBP and leg pain was significantly lower than that of the LSS group (36.1% vs 54.2%, P=0.036; 58.3% vs 69.9%, P=0.10). No significant difference was observed in these variables except VAS leg numbness between the DLS and LSS groups at the 5-year follow-up. Nevertheless, the DLS group tended to have higher VAS and lower JOA scores than the LSS group.

Table 3 shows a summary of perioperative complications. There was no significant difference in perioperative complications among the groups. The reoperation rate in the DS group was significantly lower than that in the LSS group (4.0% vs 14.8%; P=0.01), although reoperation rates in the DLS and LSS groups were comparable (15.8% vs 14.8%; P=0.493).

Table 4 shows the comparison of preoperative radiographic parameters according to each group. The main findings in the LSS group were significant increase in LL and SS and decrease in TK and SVA at the 2-year follow-up and significant increase in LL and SS and decrease in PT and PI-LL at the 5-year follow-up. Moreover, the postoperative radiographic changes of the DS and DLS groups after surgery were similar to those of the LSS group. Lumbar lordosis was found to be significantly increased after decompression surgery at the 5-year follow-up in all the groups; however, SVA was significantly decreased compared with the baseline SVA across all groups only at the 2-year follow-up. Furthermore, we investigated whether there was any difference in the amount of change in postoperative radiographic change among the groups (Table 5). The main findings were that radiographic parameter changes in PI-LL at 2-year follow-up were significantly larger in the DS and DLS groups than in the LSS group. There were no significant differences in the extent of postoperative LL, SVA, and SVA change at 5-year follow-up.

The distribution of the patients according to the cutoff values (SVA ≥50 mm, PT ≥20°, and PI−LL ≥10°) before surgery and at 2-year and 5-year follow-up are shown in Figure 1. The distribution of SVA ≥50 mm tended to be higher in the DLS group at 5 years after surgery than in the DS and LSS groups (P=0.035). The distribution of PT ≥20° was significantly higher in the DLS group than in the LSS group, not only before surgery (P=0.004) but also at 5 years after surgery (P=0.012). The remaining parameters were comparable among the three groups.

Discussion

This is the first study to compare the 5-year change in spinopelvic sagittal alignment after minimally invasive lumbar decompression surgery for LSS among patients with and without DS or DLS. The present study revealed that the effectiveness and radiological changes after minimally invasive lumbar decompression surgery alone observed in patients with DS and DLS were not inferior to those of patients with LSS without a deformity. LL, PT, and PI-LL had significantly improved and been maintained for 5 years after the surgery in both the DS and the

DLS groups. We believe that the present results will be useful data in the evaluation of the natural course of LSS and the selection of surgical methods.

Recently, it has been reported that lumbar decompression without fusion can lead to a reactive improvement in the lumbar and sagittal spinopelvic alignment, even if sagittal imbalance exists preoperatively[3–7]. However, the effect of a coexistence with DS or DLS has not been discussed. Firstly, the concept of segmental instability and deformity are controversial with varying definitions, and suspected instability is used as an indication for fusion surgery. The absence of segmental instability was often defined as DS less than grade 1, <10° of intervertebral angle change, and segmental kyphosis during flexion <5° on functional radiographs[5–7]. The cut-off between adult spinal deformity and LSS with scoliosis tends to be defined between 15° and 20° coronal Cobb angle[5–7]. In the present study, we excluded patients with DS with segmental instability and severe deformity (>25°). Our study suggested that lumbar decompression without fusion can lead to a reactive improvement in the lumbar and sagittal spinopelvic alignment in approximately 2 years after surgery, even with coexisting DS and DLS. Preoperative sagittal malalignment may include true and irreversible malalignment even with coexisting DS without segmental instability and mild DLS.

There are few reports on long-term comparative changes in sagittal spinopelvic alignment; therefore, our study could provide additional information. We postulated that the improvement effect of sagittal alignment diminished with age; however, LL, SS, PT, and PI-LL had been maintained for 5 years after surgery in both the DS and DLS groups. Additionally, the sagittal vertical axis had improved at the 2-year follow-up; however, no significant difference was observed at the 5-year follow-up in both the DS and DLS groups. LL significantly improved at the 5-year follow-up after decompression surgery, although aging may influence deterioration of spinal alignment.

Decompression without fusion has been well accepted as the optimal treatment for patients with uncomplicated LSS. However, there is a conflicting evidence and large practice variation regarding the surgical treatment of DS and DLS. In the present study, the clinical outcomes of the DS group were comparable to those of the LSS group, and the clinical outcomes of the DLS group were slightly inferior to those of the LSS group at 2 year and 5 years after surgery.

The clinical guidelines and systemic reviews of the DS[13,14] and a randomized clinical trial (RCT)[15] have recommended instrumented fusion over decompression, whereas decompression alone has been recommended in another RCT[16], registry studies[17], and systematic reviews[18,19]. Based on the present study, there were no significant differences in the improvements of the VAS and JOA scores, reoperation rate, and improve effect of sagittal alignment at 2- and 5-year follow-up between the LSS and DS groups. The coexistence of DS did not affect the clinical outcomes of minimally invasive decompression surgery after eliminating patients with segmental instability.

Few small-sample studies have evaluated the performance of minimally invasive decompression surgery for LSS with DLS than the study about DS[8,20–25]. Excellent clinical outcomes without DLS progression after microendoscopic and full-endoscopic lumbar decompression were reported[22–25] and approximately 60% of patients with LSS coexisting DLS experienced relief from LBP after decompression surgery[23]. Based on the present study, minimally invasive decompression could be considered as the primary surgical option for LSS with mild to moderate deformity, and this finding is consistent with those of previous reports. Further, distribution of SVA ≥50 mm and PT ≥20° tended to be higher in the DLS group at 5 years after surgery than that in the DS and LSS groups. The present study does not provide evidence that minimally invasive decompression alone should be the preferred method for all types of DLS. Adding fusion to decompression may lead to better outcomes for subgroups. Due to a lack of evidence for defining such subgroups, it is necessary to identify variables associated with the best treatment for each individual.

The current study had several limitations. First, we recorded a low follow-up rate of patients because of incomplete postoperative data. A prospective study with a larger sample size and longer follow-up should be performed to confirm our findings. Second, our study involved a single-center cohort, and all patients underwent surgery in the same institution. Third, we did not examine the standard decompression surgery technique, and all study participants underwent microscopic bilateral decompression by a unilateral approach and microendoscopic laminectomy. Therefore, we could not compare the improvement of sagittal parameters and clinical outcomes between standard decompression and minimally invasive decompression techniques.

In conclusion, mid-term clinical outcomes in patients with LSS with and without deformity were comparable. Lumbar decompression without fusion can result in a reactive improvement in the lumbar and sagittal spinopelvic alignment, even with coexisting DS or DLS. Therefore, minimally invasive lumbar decompression surgery should be considered for most patients with LSS.

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Figure legend

Fig 1 Distribution of patient sagittal malalignment, compensatory pelvic retroversion, and PI-LL mismatch among three patient groups (LSS, LSS with DS, and LSS with DLS) before surgery and at 2-year and 5-year follow-up.

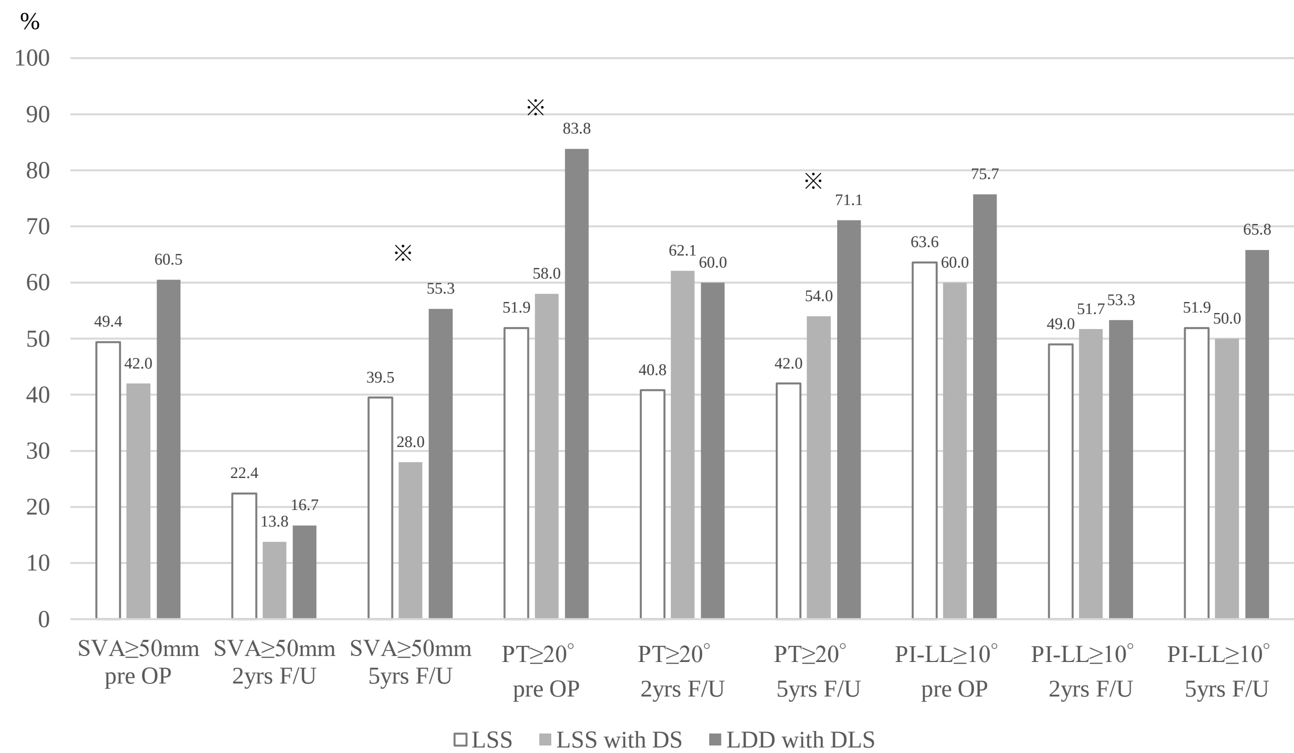

Fig 1. Distribution of patient sagittal malalignment, compensatory pelvic retroversion, and PI-LL mismatch among three patient groups (LSS, LSS with DS and LSS with DLS) before surgery and at a 2-year and 5-year follow-up

* Chi-square test

Table 1

Patient demographics and preoperative clinical data

		LSS	LSS with DS	P-Value	LSS with DLS	P-Value
No, of patients	n (%)	81	50		38	
Age	mean (SD)	68.4 (9.2)	69.4 (9.5)	0.913	72.1 (8.4)	0.115
Sex (female)	n (%)	**33 (40.7)**	**27 (54.0)**	**0.027**	**21 (55.3)**	**0.017**
BMI (Kg/m^2)	mean (SD)	24.1±3.3	24.3±3.9	0.086	24.0±3.8	0.926
ASA Physical Status Classification				0.651		0.714
I	n (%)	18 (21.0)	8 (16.7)		4 (10.5)	
II	n (%)	63 (77.8)	39 (81.3)		32 (84.2)	
III	n (%)	1 (1.2)	1 (2.1)		2 (5.3)	
Disease duration (m)	mean (SD)	**27.9 (26.6)**	**36.2 (39.6)**	**0.049**	28.5 (32.3)	0.337
Maximal walking distance (m)	mean (SD)	**261.6 (224.4)**	**178.2 (151.7)**	**0.002**	**175.4 (192.3)**	**0.024**
Pre OP VAS LBP	mean (SD)	49.7 (30.3)	42.3 (31.2)	0.110	51.5 (33.2)	0.717
Pre OP VAS Leg pain	mean (SD)	63.36 (27.1)	58.71 (31.2)	0.940	65.32 (27.7)	0.291
Pre OP VAS Leg numbness	mean (SD)	59.0 (27.8)	63.3 (29.6)	0.780	62.7 (26.1)	0.241
Pre OP JOA score	mean (SD)	13.7 (4.3)	13.3 (4.1)	0.945	13.02 (5.2)	0.843
Surgical instrument (MED)	n (%)	56 (61.5)	39 (66.1)	0.720	8 (42.1)	0.194
Decompression segments				0.441		0.274
1	n (%)	60 (74.1)	36 (72.0)		23 (60.5)	
2	n (%)	16 (19.8)	13 (26.0)		10 (26.3)	
3	n (%)	5 (6.2)	1 (2.0)		5 (13.2)	
Operation time (min)	mean (SD)	154.0 (62.2)	140.3 (53.9)	0.689	149.2(50.9)	0.243
Bleeding (ml)	mean (SD)	59.4 (66.8)	50.3 (47.8)	0.511	67.3 (60.0)	0.298

BMI; Body mass index, ASA; American Society of. Anesthesiologists, MED; microendoscpic surgery

Table 2.
Comparison of clinical outcomes in patients with or without DS and DLS who underwent minimally invasive lumbar decompression surgery

		LSS	LSS with DS	P-Value	LSS with DLS	P-Value
No, of patients	n	81	50		38	
2 yrs F/U						
LBP	mean (SD)	21.2 (23.4)	13.1 (17.45)	0.167	**34.7 (30.2)**	**0.014**
Leg pain	mean (SD)	14.7 (22.6)	13.0 (22.5)	0.932	**27.8 (32.4)**	**0.028**
Leg numbness	mean (SD)	28.9 (26.7)	28.9 (30.6)	1.000	36.7 (32.7)	0.388
JOA score	mean (SD)	25.4 (8.4)	25.1 (3.4)	0.967	23.1 (4.2)	0.191
JOA score Improvement ratio	mean (SD)	85.0 (124.0)	74.6 (21.9)	0.802	63.1 (25.7)	0.427
Achievement rate of the MCID in VAS LBP	n (%)	39 (54.2)	24 (58.5)	0.110	**13 (36.1)**	**0.036**
Achievement rate of the MCID in VAS LP	n (%)	51 (69.9)	26 (63.4)	0.471	**21 (58.3)**	**0.010**
5 yrs F/U						
LBP	mean (SD)	25.0 (25.5)	17.1 (25.1)	0.293	32.3 (30.3)	0.413
Leg pain	mean (SD)	13.9 (22.9)	17.6 (27.2)	0.732	26.5 (28.0)	0.061
Leg numbness	mean (SD)	25.1 (26.0)	33.66 (32.6)	0.294	**40.5 (29.4)**	**0.040**
JOA score	mean (SD)	24.3 (4.7)	24.6 (4.3)	0.942	23.1 (4.0)	0.430
JOA score Improvement ratio	mean (SD)	70.7 (26.9)	67.5 (28.6)	0.352	57.5 (24.4)	0.804
Achievement rate of the MCID in VAS LBP	n (%)	30 (47.6)	18 (48.6)	0.977	15 (50.0)	0.607
Achievement rate of the MCID in VAS LP	n (%)	45 (70.3)	21 (56.8)	0.272	17 (56.7)	0.068

LBP, Low Back Pain, LP, Leg Pain, VAS, visual analogue scale, JOA, Japanese orthopedic association, MCID, Minimal clinically important difference,

Table 3
Summary of complications

		LSS	LSS with DS	P-Value	LSS with DLS	P-Value
No, of patients	n (%)	81	50		38	
Perioperative complications						
Dural tear	n (%)	6 (7.4)	6 (12.0)	0.649	3(7.9)	0.053
Hematoma	n (%)	0 (0)	0 (0)	0.393	1 (2.6)	-
Neurological deficit	n (%)	1 (1.1)	0 (0)	0.607	0 (0)	0.579
Reoperation						
The same level	n (%)	**6 (7.4)**	**0 (0)**	**0.028**	2 (5.3)	0.150
The other level	n (%)	6 (7.4)	2 (4.0)	0.169	4 (10.5)	0.811
Total	n (%)	**12 (14.8)**	**2 (4.0)**	**0.010**	6 (15.8)	0.493

Table 4

Comparison of sagittal spinal parameters in patients with or without DS and DLS who underwent minimally invasive lumbar decompression surgery

		LSS		**LSS with DS**		**LSS with DLS**	
			P-Value vs Pre OP		P-Value vs Pre OP		P-Value vs Pre OP
No, of patients		81		50		38	
Pre OP							
CL	mean (SD)	17.0(9.1)		14.8(8.2)		15.2(10.6)	
CTK	mean (SD)	11.0(7.2)		9.3(5.6)		8.8(8.1)	
TK	mean (SD)	27.3(12.7)		29.1(8.4)		27.5(14.5)	
LL	mean (SD)	28.8(13.8)		39.3(10.6)		28.0(17.6)	
SVA	mean (SD)	50.9(42.2)		47.2(23.3)		57.1(40.3)	
SS	mean (SD)	25.6(7.4)		29.0(8.5)		24.3(10.3)	
PT	mean (SD)	20.7(9.9)		25.0(9.4)		27.1(9.3)	
PI	mean (SD)	44.4(8.2)		53.9(12.5)		51.7(12.3)	
PI-LL	mean (SD)	15.9(15.5)		14.6(11.9)		23.7(15.8)	
2yrs F/U							
CL	mean (SD)	14.8(11.2)	0.206	14.3(14.6)	0.846	16.8(14.4)	0.735
CTK	mean (SD)	**14.4(8.2)**	**0.004**	12.1(7.3)	0.092	**12.6(7.3)**	**0.011**
TK	mean (SD)	**24.3(11.2)**	**0.008**	30.5(9.8)	0.259	27.7(17.3)	0.745
LL	mean (SD)	**35.9(17.0)**	**<0.001**	**46.3(11.7)**	**<0.001**	**41.6(18.7)**	**0.005**
SVA	mean (SD)	**38.8(39.4)**	**0.024**	**30.1(34.7)**	**0.011**	**38.6(31.2)**	**0.023**
SS	mean (SD)	**30.9(9.5)**	**<0.001**	**33.7(7.4)**	**0.004**	32.7(10.3)	0.061
PT	mean (SD)	18.5(11.2)	0.167	**21.7(9.3)**	**0.016**	**23.0(9.3)**	**0.048**
PI	mean (SD)	**48.9(10.2)**	**0.007**	55.2(11.5)	0.421	55.6(10.8)	0.676
PI-LL	mean (SD)	14.1(16.8)	0.334	**8.9(13.8)**	**0.004**	**14.0(15.9)**	**0.004**
5yrs F/U							
CL	mean (SD)	17.1(16.5)	0.370	16.4(16.4)	0.213	22.8(18.9)	0.664
CTK	mean (SD)	**15.8(8.2)**	**<0.001**	**16.8(8.5)**	**<0.001**	**13.6(7.9)**	**0.004**
TK	mean (SD)	27.5(22.4)	0.463	29.7(8.8)	0.087	29.1(14.6)	0.491
LL	mean (SD)	**36.2(14.9)**	**<0.001**	**43.6(13.5)**	**0.001**	**38.1(18.5)**	**0.029**
SVA	mean (SD)	49.8(45.3)	0.956	45.9(35.0)	0.391	61.8(48.9)	0.494
SS	mean (SD)	**29.8(9.3)**	**0.001**	**33.3(9.2)**	**0.001**	**31.2(12)**	**0.043**
PT	mean (SD)	**18.2(9.5)**	**0.007**	**20.9(9.9)**	**0.019**	**24.1(8.4)**	**0.044**
PI	mean (SD)	47.5(10.1)	0.188	54.2(11.4)	0.256	55.5(10.9)	0.609
PI-LL	mean (SD)	**12.1(14.2)**	**0.010**	**10.6(13.8)**	**0.009**	**17.0(16.7)**	**0.028**

CL, Cervical Lordosis, CTK, Cervicothoracic Kyphosis, TK, Thoracic Kyphosis, LL, Lumber Lordosis; SS, Sacral Slop, PT, Pelvic Tilt, PI, Pelvic Inclination, SVA, Sagittal Vertical Axis

Table 5

Comparison of radiographic parameter changes in patients with or without DS and DLS after minimum invasive lumbar decompression surgery

		LSS	**LSS with DS**	**P-Value**	**LSS with DLS**	**P-Value**
No, of patients	n (%)	80	50		38	
Value at 2 yrs F/U minus value before surgery						
CL	mean (SD)	-2.2(12.2)	0.5(13.0)	0.822	1.7(12.7)	0.377
CTK	mean (SD)	3.3 (7.6)	2.8 (8.7)	0.955	3.7(6.8)	0.968
TK	mean (SD)	**-3.0(7.5)**	**1.4(6.4)**	**0.027**	0.2(7.0)	0.137
LL	mean (SD)	7.0 (12.2)	7.0(7.8)	1.000	**13.6(14.2)**	**0.050**
SVA	mean (SD)	-12.1(36.4)	-17.1(34.0)	0.827	-18.6(38.5)	0.725
SS	mean (SD)	5.3(7.7)	4.8(8.1)	0.963	8.4(9.6)	0.252
PT	mean (SD)	-2.3(10.9)	-3.3(6.9)	0.874	-4.1(7.1)	0.657
PI	mean (SD)	4.5(10.7)	1.3(8.7)	0.105	3.8(9.6)	0.959
PI-LL	mean (SD)	-1.8(12.4)	-5.7(9.8)	0.373	**-9.7(12.7)**	**0.014**
Value at 5 yrs F/U minus value before surgery						
CL	mean (SD)	1.5(15.4)	2.5(14.1)	0.934	6.0(16.9)	0.308
CTK	mean (SD)	5.2(8.6)	5.9(7.8)	0.883	5.4(8.4)	0.989
TK	mean (SD)	-2.4(29.1)	1.6(6.6)	0.531	1.3(7.4)	0.646
LL	mean (SD)	5.5(11.24)	5.6(11.1)	1.000	8.7(13.3)	0.366
SVA	mean (SD)	0.2(38.8)	-4.3(35.4)	0.786	2.4(41.7)	0.955
SS	mean (SD)	3.4(8.7)	4.3(8.9)	0.879	5.8(10.4)	0.397
PT	mean (SD)	-2.7(8.5)	-2.6(7.6)	0.998	-2.5(6.8)	0.995
PI	mean (SD)	1.6(10.8)	1.6(10.1)	1.000	3.0(9.5)	0.791
PI-LL	mean (SD)	-3.6(12.0)	-3.9(10.3)	0.985	-5.9(12.2)	0.577

CL, Cervical Lordosis, CTK, Cervicothoracic Kyphosis, TK, Thoracic Kyphosis, LL, Lumber Lordosis; SS, Sacral Slop, PT, Pelvic Tilt, PI, Pelvic Inclination, SVA, Sagittal Vertical Axis