Spondylolisthesis and Scoliosis Progression and Associated Revision Rates Following Bilateral Lumbar Spine Microscopic Decompression

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Abstract:

Lumbar spine microscopic decompression (LSMD) is a common surgical procedure for decompressing neural elements. Although the optimal extent of decompression remains a critical consideration, limited evidence-based guidelines define the threshold for instrumented fusion to maintain biomechanical stability. Existing studies suggest that unilateral LSMD generally does not result in iatrogenic instability. However, the potential instability associated with bilateral segmental decompression (BLSMD) is less well-defined, particularly in patients with pre-existing degenerative lumbar scoliosis (SC) or spondylolisthesis (SL).

This retrospective study included patients undergoing BLSMD without instrumented fusion. Pre-existing SC was defined as Cobb's angle ≥10° and SL as any anterior-posterior slip of operated level adjacent vertebral bodies. The primary outcome was new or progressive SC/SL measured on pre and postoperative radiographs. Secondary outcomes were revision rates, changes in Visual Analog Scores (bVAS/lVAS), and Oswestry Disability Index (ODI) scores, collected preoperatively and 1-2 years postoperatively. Baseline characteristics such as age, BMI, sex, and number of levels operated were also collected.

A total of 31 patients were reviewed comprising 15 female and 16 male patients with a mean age of 61.4 years (21-78) and BMI of 26.5 (18-41). There were 14 one-level, 12 two-level, and 4 three-level BLSMD performed. Patients with pre-existing SC and SL had a 66% and 23% incidence of radiological progression, respectively, compared to 0% in patients without pre-existing deformity. Progression cases were associated with high reoperation rates (up to 75%) and seemed to have inferior clinical outcomes than those without progression.

In patients undergoing BLSMD, pre-existing SC/SL is linked to a higher incidence of radiological progression and higher reoperation rates. For patients with SC/SL, careful consideration should be given to limiting decompression, potentially exploring fusion options, and implementing close postoperative radiographic monitoring.

Keywords:

Scoliosis, Spondylolisthesis, Segmental decompression, Bilateral, Lumbar spine

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Introduction

Lumbar spine microscopic decompression (LSMD) offers effective relief for patients suffering from various degenerative spinal conditions causing compression of neural elements. It aims to decompress impinged neural structures, thereby improving pain and restoring function[1)]. However, the optimal extent of decompression remains a critical consideration, as excessive bone and tissue removal can potentially destabilize the spine. Determining the threshold at which instrumented fusion becomes necessary to maintain biomechanical stability lacks definitive evidence-based guidelines[2,3)].

Unilateral LSMD (ULSMD) is a single-sided interlaminar approach to decompress the spinal canal, whereas bilateral LSMD (BLSMD) refers to a two-sided approach through

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both the left and right interlaminar spaces to decompress the spinal canal. Thus far, the literature suggests that ULSMD is generally associated with minimal instability, and the potential impact of bilateral LSMD (BLSMD) is less well-defined and remains unclear[4,5]. This is of particular concern in patients with pre-existing degenerative lumbar scoliosis (SC) or spondylolisthesis (SL) as these underlying deformities may predispose patients to further progression of their spinal instability[6].

It is crucial to understand the risk of progression or new onset of spinal deformity when considering BLSMD in patients with pre-existing SC/SL, as it may influence revision rates, clinical recovery, and the potential need for fusion.

In this retrospective review, we review all patients undergoing BLSMD at our institution and evaluate the incidence of new development or progression of SC and SL and alongside their revision rates and clinical scoring outcomes.

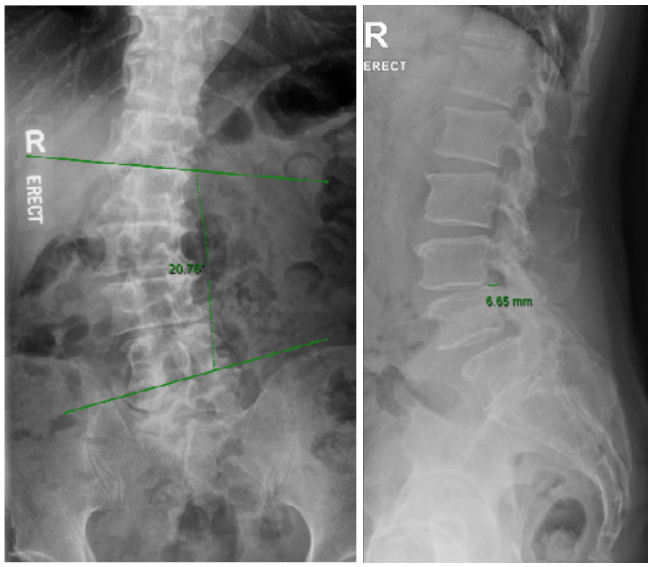

Figure 1. Measurement of Cobb's angle (left) and measurement of spondylolisthesis (right).

Materials and Methods

Ethics approval and subjects

The institutional review board approved the conduct of this study and subsequently a retrospective review for all patients aged 20-85 years undergoing BLSMD from August 2018 to October 2021. Indications for the operation were spinal canal stenosis, prolapsed intervertebral discs, endplate spurs, ligamentum flavum hypertrophy, degenerative spondylolisthesis, degenerative scoliosis, and facet hypertrophy with bilateral symptoms. Patients were given followup appointments at 1-2 years postsurgery for a routine review with postoperative radiographs.

Surgical technique

The principles of decompression and technique for BLSMD were similar for all patients and done under microscopic guidance. Decompression was done bilaterally through a single posterior midline incision. The extent of decompression was based on preoperative magnetic resonance imaging (MRI) and clinical symptoms. Up to three levels of decompression were performed of which the operative procedure consisted of partial superior and inferior laminotomy, partial bilateral facetectomy, flavectomy, and/or discectomy of the affected areas. Decompression was considered complete when stenosed elements were removed and the dural sac, with exiting and traversing nerve roots, were free. Patients were ambulatory on postoperation day 1 without any orthosis and were advised to avoid strenuous activities for 2 months.

Clinical data and measurements

Data points were collected preoperatively and between 1 and 2 years postoperatively for all patients undergoing BLSMD. Baseline scores were collected during preoperative consultation visits. Postoperative scores were collected as part of routine followup visit after the operation. The data points collected were as follows: patient demographic data (age, gender, BMI), Visual Analog Scoring (VAS), Oswestry Disability Index (ODI) Scoring, and standing erect lumbar spine radiographs[7-9].

Scoliosis was defined as Cobb's angle of ≥10° where Cobb's angle is defined as the angle between the extension line of the upper end plate of the most inclined vertebral body and the extension line of the lower end plate of the most inclined vertebral body[10,11]. Spondylolisthesis was defined as the anterior-posterior translation of a vertebral body relative to an adjacent vertebra[12].

Primary outcome

The primary outcome was new or progression of SC or SL by comparing the pre and postoperative erect AP and lateral lumbar spine radiographs using the institutions picture archiving and communication system. New onset or progression of SC was defined as a change of Cobb's angle of >3° in order to account for the standard measuring error of ± 3°[13]. New onset or progression of spondylolisthesis was defined as progression of anterior-posterior translation ≥2 mm of the operated level to account for interobserver error of ±2 mm[14] (Fig. 1).

The radiographs were reviewed by two independent reviewers with any discrepancy being discussed with a third independent rate.

Secondary outcome

The secondary outcomes of revision rates, changes in Visual Analog Scores for the back and legs (bVAS), and ODI scores were reviewed.

Revision surgery from date of index operation till current date was recorded and included nerve root blocks, repeat decompression, or fusion of the previously operated levels including one level up and below.

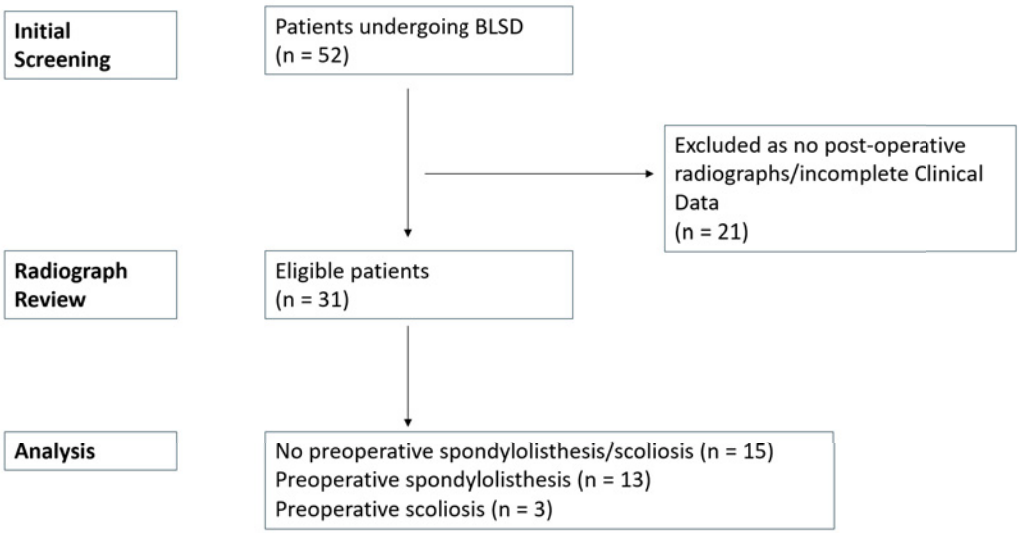

Figure 2. Flowsheet of included participants.

Table 1. Patient Characteristics and Operative Summary.

	No Pre-existing Scoliosis/Spondylolisthesis n=15	Pre-existing Scoliosis n=3	Pre-existing Spondylolisthesis n=13	All n=31
Age in Years (Mean)	59.3 (21-78)	69 (63-74)	63 (48-73)	61.4 (21-78)
Gender	Female: 5	Female: 0	Female: 10	Female: 15
	Male: 10	Male: 3	Male: 3	Male: 16
BMI (Mean)	25.2 (18.0-41.2)	27.8 (23.3-34.2)	27.7 (18.8-41.6)	26.5 (18-41)
Number of Operated Levels	1-Level: 10	1-Level: 1	1-Level: 4	1-Level: 14
	2-Level: 3	2-Level: 2	2-Level: 7	2-Level: 12
	3-Level: 2		3-Level: 2	3-Level: 4

The VAS is a self-reported pain rating scale where participants put a mark along a 10 cm line that represents a continuum between "no pain" and "worst pain"[15]. Patients graded the pain of their back and lower limb radiculopathy symptoms and these values were recorded.

ODI is a composite score comprising of ten different questions. Patients were given a ten-section questionnaire of which each was scored based on a 0-5 scale with a total score of 50. The index was calculated by the summed score divided by the total score multiplied by 100 and expressed as a percentage. For every question not answered, the denominator was reduced by 5[9].

Results

Clinical notes and radiographs of 52 patients who underwent BLSMD within the specified period were reviewed. Of 52 patients, 21 were excluded due to either missing postoperative radiographs taken 1-2 years after surgery or incomplete clinical data. A total of 31 patients were eligible and included in the study. Preoperatively, 15 patients had no deformity, 13 had SL, and 3 had SC (Fig. 2).

The demographic data and surgical characteristics for all 31 patients were collated and are summarized in Table 1.

None of the cases without pre-existing SC/SL (0/15, 0%) had new onset SC/SL. Among patients with pre-existing SC/SL, 66% of SC patients (n=2/3) and 15% of SL patients (n=2/13) experienced progression of their deformity (Table 2). Table 3 shows the characteristics and outcome data of the four patients with radiological progression.

Revision rates were 13.3% for patients without pre-existing SC/SL, 66% for those with SC, and 23% for those with SL. Improvements in bVAS were 5.2, 2.6, and 5.3, respectively. Improvements in lVAS were 4.2, 3.3, and 5.7, respectively. Improvements in ODI were 19, 8.7, and 13.8, respectively.

Three out of the four patients with SC/SL progression underwent revision procedures (75%). Of the two SL patients, one had a revision nerve root block and the other had no revision. Of the two SC patients, one required a revision decompression and the other eventually underwent fusion surgery. On average, the mean improvement in bVAS, lVAS, and ODI scores for patients experiencing progression was 1, 2.3, and 10, respectively. These improvements appear significantly lower than those of the entire cohort (4.9, 4.7, and 15.6).

Table 2. Summary of Results of Primary and Secondary Outcome.

	No Pre-existing Scoliosis/Spondylolisthesis n=15	Pre-existing Scoliosis n=3	Pre-existing Spondylolisthesis n=13
Primary Outcome:			
Progression of Spondylolisthesis/Scoliosis	0/15 (0%)	2/3 (66%)	2/13 (15%)
Secondary Outcomes:			
Revisions (Fusion/Decompression/Nerve Root Blocks)	2/15 (13.3%)	2/3 (66%)	3/13 (23%)
Mean VAS (Back) Improvement	5.2 (0-8)	2.6 (2-4)	5.3 (0-10)
Mean VAS (Leg) Improvement	4.2 (0-7)	3.3 (1-5)	5.7 (0-10)
Oswestry Disability Index Improvement	19 (6-31)	8.7 (1-22)	13.8 (0-28)

Table 3. Patients with Progression of Preoperative Scoliosis/Spondylolisthesis.

Demographic Data	Surgical Characteristics	Progression of Scoliosis/Spondylolisthesis	Clinical Outcomes	Revision
59 y/o Male BMI 21.7	Bilateral L3/4 and L4/5 Decompression	Spondylolisthesis 7.3 → 13.7mm	bVAS: 8 → 7 lVAS: 8 → 7 ODI: 41 → 17	1) Right L5 Nerve Root Block
74 y/o Male BMI 23.3	Bilateral L 4/5 Decompression	Scoliosis 11.5 → 20.8°	bVAS: 7 → 5 lVAS: 7 → 6 ODI: 34 → 31	1) Right L4/5 Decompression
62 y/o Female BMI 31.4	Bilateral L3/4 and L4/5 Decompression	Spondylolisthesis 2.5 → 6.7mm	bVAS: 0 → 0 lVAS: 6 → 0 ODI: 29 → 17	Nil
63 y/o Male BMI 34.2	Bilateral L2/3 and L3/4 Decompression	Scoliosis 10.4 → 22.4°	bVAS: 7 → 6 lVAS: 7 → 6 ODI: 29 → 28	1) Bilateral L5/S1 Decompression and Right L5/S1 Foraminal Decompression 2) Right L4/5 and L5/S1 TLIF with Bilateral L4/5 Decompression

Discussion

Decompressive spine surgery involves a delicate balance between removing the offending structures while protecting the integrity of the spinal column. The extent of decompression directly correlates with the stability of the spine, particularly with regard to preserving the posterior elements, facet, and pars[16]. However, there is limited information regarding spine stability following bilateral decompression. In vitro porcine models have shown that bilateral laminotomy is comparable in stability to unilateral laminotomy and is more stable than laminectomies[4,17].

Current literature indicates that radiographic progression of SC after unilateral laminotomy is minimal, with an average change of 1.8° and reoperative rates ranging from 3% to 33% (averaging 9.7%)[18]. However, patients with preoperative scoliosis seem to have less favorable outcomes following decompression than those without pre-existing SC[19]. For scoliotic patients, it is generally agreed that curves above 30° with neural compression warrant decompression and fusion[20,21]. In patients with less severe curves (10-30°), outcomes following either decompression or short-segment fusion have been equivocal[20,22]. Importantly, most existing studies focus on unilateral approaches, where more posterior spinal elements are preserved. Our retrospective review suggests that following BLSMD, patients with pre-existing SC, particularly those with SC progression, face a high risk of reoperation and poorer clinical outcomes. Considering fusion or a unilateral approach during the index operation may reduce this risk.

Reports of radiographic progression of SL after segmental decompression are relatively high, with rates up to 55%[5,23]. Despite this, patients often remain asymptomatic, and clinical outcomes following decompression appear similar to those undergoing fusion[5,23,24]. A cutoff value of 13% of SL slip has been suggested as a predictor for poor outcomes following decompression[23]. However, as with SC cases, these studies primarily examine unilateral approaches. Reoperation rates for decompression in SL patients have been reported between 3.7% and 11%, significantly lower than our reported 23% at 2 years[25,26]. This difference might be attributed to our study's focus on bilateral surgery potentially destabilizing the spine and allowing greater spondylolisthesis progression.

The decision of when to perform concurrent instrumentation and fusion for spinal stability alongside decompression remains controversial. Routine fusion in all lumbar spine decompression surgeries is unnecessary and carries higher perioperative and late complications[27-30]. In patients with existing degenerative grade 1 spondylolisthesis, the SLIP study showed improved clinical outcomes when performing upfront fusion compared to laminectomy alone at 4 years[31].

However, reports of adjacent segment disease following instrumented fusion reaching up to 35% after 10 years underscore that upfront fusion should be carefully considered[32]. Preoperative variables such as spondylolisthesis, scoliosis, clinical symptoms of instability, facet joint tropism, asymmetrical muscle bulk, bone mineral density, and small intervertebral discs have been identified as factors affecting stability[31,33-37]. Based on our study, careful attention should be paid to patients with pre-existing SC/SL given the risk of radiological progression and reoperation. In cases with significant risk factors, considering fusion alongside the index decompression may be worthwhile. In addition, the advent of endoscopic spine surgery, with its minimally invasive nature and reduced bony work, and other approaches such as unilateral or over-the-top bilateral decompression, may provide viable options to reduce the risk of instability[38].

Limitations

This study has some limitations. First, the small patient sample size prevented a more detailed breakdown and statistical comparison between groups. Second, patients with existing scoliosis and spondylolisthesis have an inherently higher risk of progression, potentially contributing to the observed progression that may or may not be related to the index surgery performed. Finally, a medium- to long-term study would be valuable to analyze revision rates, as patients might delay revision fusion/surgery beyond the 1-2 year observation period.

Conclusion

Following one- to three-level bilateral lumbar spine microscopic decompression, patients with pre-existing scoliosis (SC) and spondylolisthesis (SL) have an incidence of radiological progression of 66% and 23%, respectively, compared with a 0% rate observed in patients without pre-existing deformity. In these cases of progression, there seems to be a high revision rate of up to 75% and clinical outcomes appear to also be inferior compared with patients without progression. However, further studies are warranted for further confirmation of these results due to the small patient numbers in this study. For patients with SC/SL, careful consideration should be given to limiting decompression and potentially considering fusion, along with close postoperative radiographic monitoring due to their increased risk of progression.

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Author Contributions: Conceptualization: H.B.C., Y.H. Methodology: W.W., H.B.C., Y.H. Data Collection: W.W., A.K.S.T., Y.H. Formal Analysis: W.W., A.K.S.T., K.Z.K.L. Resources: W.W., D.G., C.H.S.S. Writing-Original Draft Preparation: W.W., A.K.S.T., K.Z.K.L. Writing-Review & Editing: D.G., C.H.S.S. Supervision: H.B.C., Y.H. Project Administration: W.W. All authors have read and agreed to the published version of the manuscript.

Ethical Approval: SingHealth Centralized Institutional Review Board approved the conduct of this study (2024/2280).

Informed Consent: Nil required.

This study involves a retrospective medical record review of all patients admitted under the care of the coinvestigators in our institution in a certain time frame. This is related to a clinical and radiographic audit of an institution's previous cases. The probability and magnitude of harm or discomfort anticipated in the research are not greater than those ordinarily encountered in daily life. The information collected is not sensitive in nature and the data have been collected and are derived from standard clinically indicated procedures. The conduct of this study has been approved by the institutional review board.

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