

Extreme lateral interbody fusion for unilateral symptomatic vertical foraminal stenosis

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Abstract

Purpose Asymmetric loss of disc height in adult deformity patients may lead to unilateral vertical foraminal stenosis and radiculopathy. The current study aimed to investigate whether restoration of foraminal height on the symptomatic side using extreme lateral interbody fusion (XLIF) would alleviate unilateral radiculopathy.

Methods In a retrospective study, patients with single-level unilateral vertical foraminal stenosis and corresponding radicular pain undergoing XLIF were included. Functional data (visual analog scale (VAS) for buttock, leg and back, as well as Oswestry Disability Index (ODI)) and radiographic measurements (bilateral foraminal height, disc height, segmental coronal Cobb angle and regional lumbar lordosis) were collected preoperatively, postoperatively and at the last follow-up.

Results Twenty-three patients were included, among whom 61 % had degenerative scoliosis. History of previous surgery at the level of index was present in 43 % of patients. Additional instrumentation was performed in 91 %. The foraminal height on the stenotic side was significantly increased postoperatively ($p < 0.001$), and remained significantly increased at the last follow-up of

11 ± 3.7 months ($p < 0.001$). Additionally, VAS buttock and leg on the stenotic side, VAS back and ODI were significantly improved postoperatively and at the last follow-up ($p \leq 0.001$ for all parameters). The foraminal height on the stenotic side showed correlation with the VAS leg on the stenotic side, both postoperatively and the last follow-up ($r = -0.590$; $p = 0.013$, and $r = -0.537$; $p = 0.022$, respectively).

Conclusions Single-level XLIF is an effective procedure for treatment of symptomatic unilateral foraminal stenosis leading to radiculopathy. In deformity patients with radicular pain caused by nerve compression at a single level, when not associated with other symptoms attributable to general scoliosis, treatment with single-level XLIF can result in short- and mid-term satisfactory outcome.

Keywords Extreme lateral interbody fusion · Scoliosis · Unilateral radiculopathy · Foraminal stenosis · Foraminal height

Introduction

Symptomatic foraminal stenosis causing radiculopathy can result from the loss of disc height and compression of the nerve root. Hasegawa and colleagues demonstrated in a cadaveric study that a posterior disc height of less than 4 mm and concomitant foraminal height of less than 15 mm are associated with significant nerve root compression [1]. Unrecognized or recurrent foraminal stenosis has been associated with failed back surgery syndrome [2]. Direct and indirect decompressions are two main treatment strategies. Extreme lateral interbody fusion (XLIF) can effectively restore disc height and foraminal height, and thereby achieve indirect decompression of neural elements

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with symptomatic improvement [3, 4]. Oliveira and colleagues report that XLIF leads to an average of 41.9 % increase in disc height and 13.5 % increase in foraminal height [3] which has been corroborated by Kepler and colleagues [5]. Moreover, Elowitz and colleagues have demonstrated that restoration of disc height also alleviates lumbar stenosis by stretching and unbuckling of ligaments [4]. Radiographic decompression of neural elements is paralleled by symptomatic improvement in patients with spinal stenosis [4]; however, correlation between increase in the foraminal height and functional improvement has not been shown in previous studies [5]. The current study attempted to investigate the utility of single-level XLIF in patients with unilateral radicular pain due to unilateral vertical foraminal narrowing.

Materials and methods

In a retrospective cohort, using the following inclusion/exclusion criteria, patients were selected consecutively from our XLIF database, including cases operated by two surgeons at a single center, between 2007 and 2013. This is an IRB-approved study and was conducted in adherence to human ethic guidelines.

Inclusion criteria

Patients presenting primarily with unilateral radicular pain due to single-level degenerative unilateral vertical foraminal narrowing (foraminal height less than 15 mm [1]) that were surgically treated by single-level extreme lateral interbody fusion (XLIF) [6].

Exclusion criteria

Non-degenerative cases, including patients with tumor or trauma pathology.

Outcome evaluation

Radiographic outcome was evaluated by comparing preoperative, immediate postoperative and last follow-up measurements. Standing radiographs were used to measure segmental coronal Cobb angle (the angle between the top and bottom endplates of vertebrae of the index level) and the regional lumbar lordosis (the angle between the cephalad endplates of L1 and S1). Available CT scans or MRI studies were used to measure bilateral foraminal heights (FH) and disc height (DH) (mean of the anterior and posterior disc heights). Clinical outcome was assessed using Oswestry Disability Index (ODI) and visual analog scores (VAS) for back, buttock and leg,

taken preoperatively, postoperatively and at the last follow-up.

Statistical analysis

For continuous variables with repeated measurements, the differences were assessed using the paired *t* test. All

Table 1 Patient demographics

Patient demographics	Frequency (%)
Age at surgery (years) ^a	66.0 ± 2.0
Gender	
Male	13 (56.6 %)
Female	10 (43.4 %)
Diabetes	
Yes	4 (17.4 %)
No	19 (82.6 %)
Smoking	
Yes	2 (8.7 %)
No	21 (91.3 %)
Steroid medication	
Yes	2 (8.7 %)
No	21 (91.3 %)
Previous spine surgery at the index level	
Yes	10 (43.5 %)
No	13 (56.5 %)
Concomitant pathology (with degenerative unilateral vertical foraminal narrowing to less than 15 mm)	
Degenerative scoliosis (coronal Cobb angle >10°)	14 (60.9 %)
Spondylolisthesis	13 (56.5 %)
Lateral listhesis	3 (13.0 %)
Post-laminectomy syndrome	8 (34.8 %)
Adjacent segment disease	2 (8.7 %)
Index level	
L2/3	5 (21.7 %)
L3/4	3 (13.0 %)
L4/5	15 (65.2 %)

^a Mean ± SE

Table 2 Surgical details

Surgical details	Frequency (%)
Instrumentation	
None	2 (8.7 %)
Lateral plate	5 (21.7 %)
Pedicle–rod instrumentation	16 (69.6 %)
Additional laminectomy	
Yes	4 (17.4 %)
No	19 (82.6 %)

Table 3 Radiographic outcome

Radiographic values ^a	Preoperative	Postoperative	<i>p</i> value	Last follow-up	<i>p</i> value
Stenotic foraminal height (mm)	11.0 ± 0.5	18.1 ± 0.5	<0.001*	17.1 ± 0.5	<0.001*
Contralateral foraminal height (mm)	16.9 ± 0.5	20.9 ± 0.7	<0.001*	19.3 ± 0.7	0.003*
Disc height (mm)	5.1 ± 0.4	9.7 ± 0.4	<0.001*	8.2 ± 0.5	<0.001*
Segmental coronal Cobb angle	7.2 ± 1.2	4.5 ± 0.8	0.001*	6.0 ± 1.1	0.018*
Regional lumbar lordosis	40.4 ± 3.1	45.4 ± 2.1	0.02*	44.1 ± 2.6	0.264

* *p* values <0.05 are considered to be statistically significant

^a Mean ± SE—measurements were all performed at the symptomatic level, with the exception of regional lumbar lordosis (LL); LL was measured as the angle between the cephalad endplates of L1 and S1

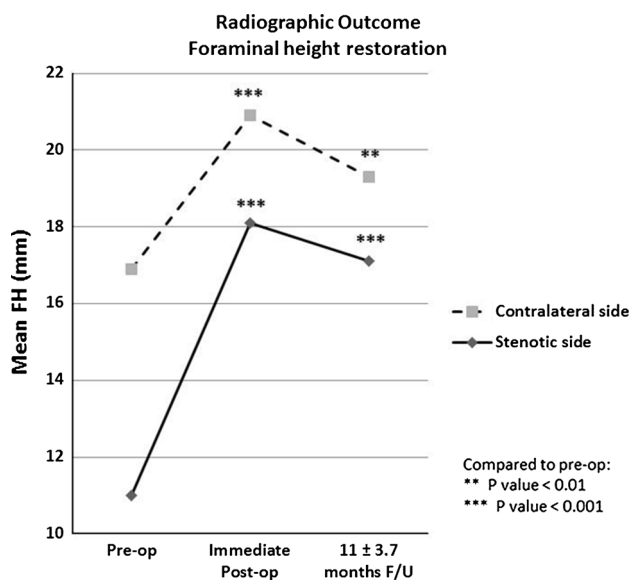


Fig. 1 Radiographic outcome; foraminal height restoration— foraminal height restoration on the stenotic side and the contralateral side; comparison between preop, immediate postop and 11 ± 3.7 months F/U values

analyses were performed using appropriate statistical software (Version 20.0.0, SPSS Inc., Chicago, IL).

Results

A total of 23 patients with single-level unilateral foraminal narrowing and concomitant unilateral radiculopathy, treated by single-level XLIF, were included. Patient demographics and surgical details have been summarized in Tables 1 and 2, respectively. Degenerative scoliosis was detected on preoperative imaging in 61 % of patients. History of previous spinal surgery at the index level was present in 43 %. Additional posterior decompression was performed in four cases (17.4 %), in whom severe spinal stenosis was detected on preoperative imaging. Instrumentation for stabilization was performed in 91 % of patients.

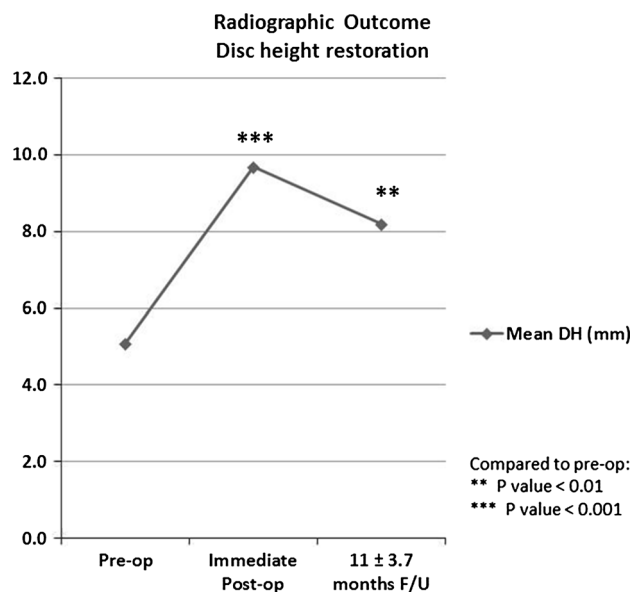


Fig. 2 Radiographic outcome; disc height restoration—comparison between preop, immediate postop and 11 ± 3.7 months F/U values

All radiographic parameters showed significant improvement postoperatively. Moreover, at the last follow-up of 11 ± 3.7 months after surgery, the improvement was durable in all radiographic parameters, except for regional lumbar lordosis (Table 3; Figs. 1, 2, and 3).

As for clinical outcome, preoperative VAS buttock and leg on the stenotic side, VAS back and the ODI (7.3, 7.2, 6.5 and 48.0, respectively) were significantly improved postoperatively (to 1.5, 2.3, 3.3 and 25.4, respectively) and at the last follow-up (to 0.7, 1.1, 3.3 and 23.0, respectively) (Table 4; Fig. 4).

At the last follow-up, minimally clinically important difference (MCID) for the ODI (defined as ≥12 points improvement) and VAS buttock and VAS leg (defined as ≥3 points improvement) was achieved in 88.2, 88.2 and 82.3 % of the patients, respectively [7–9].

The postoperative FH on the stenotic side showed correlation with the VAS buttock and VAS leg on the stenotic

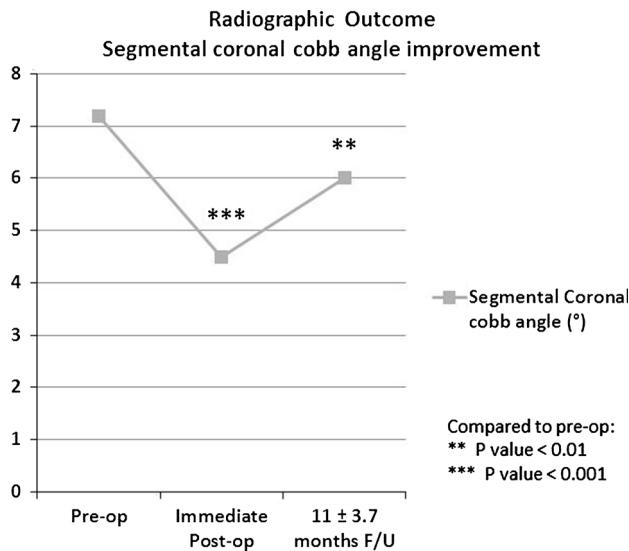


Fig. 3 Radiographic outcome; segmental coronal Cobb angle improvement—comparison between preop, immediate postop and 11 ± 3.7 months F/U values

side ($r = -0.588$; $p = 0.013$ and $r = -0.590$; $p = 0.013$, respectively). Likewise, at the last follow-up, FH on the stenotic side showed correlation with VAS leg on the stenotic side ($r = -0.537$; $p = 0.022$) (Fig. 5).

Only one patient (4.3 %) required reoperation due to wound infection, requiring washout and revision of the instrumentation.

Discussion

The optimal treatment strategy for lumbar spinal deformity with neurogenic pain remains controversial. Foraminal stenosis with mild scoliosis that is accompanied by unilateral loss of the foraminal height might be treated by decompressive procedures without stabilization [10, 11].

Nerve root decompression in the lateral recess can be achieved by laminectomy, medial facetectomy or medial foraminotomy [12]. Decompression of vertical stenosis may be accomplished by partial pediclectomy [13].

Nonetheless overall, foraminal decompression can be achieved through various surgical techniques including open foraminotomy, traditional open laminectomy/hemilaminectomy, open facetectomy with/without fusion, tubular contralateral approach, tubular extraforaminal ipsilateral approach, endoscopic foraminoplasty, decompression using iO-Flex® System, XLIF and anterior lumbar interbody fusion (ALIF; at L4/5 and L5/S1 levels) [14–19].

We recently reported successful results for minimally invasive foraminal decompression via a tubular contralateral approach in patients without instability or deformity [20]. In patients with deformity or instability, decompression alone has a higher rate of recurrent radicular pain compared to fusion surgery [21–24]. Our study on MIS foraminotomy through the contralateral approach showed improvements in VAS for buttock and leg pain on the symptomatic side, with similar and comparable values to the current study. There was a postoperative decrease of 5.6 points in VAS buttock (as compared to 5.8 in the current study) and a decrease of 4.5 point in VAS leg (as compared to 4.9 in the current study).

Many studies have so far shown efficacy of XLIF in treatment of adult deformity [25–28]. The literature review performed by Berjano et al. [29] found that surgical strategies for avoidance of imbalance, defining ideal fusion levels, and lower number of levels of lumbar scoliosis are the factors that can lead to significant advantages.

It is important to note that 61 % of patients in the current study had degenerative scoliosis. Satisfactory short- and mid-term outcome was achieved through single-level XLIF. The findings suggest that in deformity patients with radicular pain caused by nerve compression at a single level, when not accompanied by other symptoms attributable to general scoliosis, single-level XLIF can be an effective alternative procedure to relieve symptoms, without the need to perform an extensive procedure to correct deformity.

In the current study, we demonstrate that single-level XLIF allows for decompression of symptomatic unilateral vertical foraminal stenosis. In the early 1980s, Inoue et al.

Table 4 Clinical outcome

Outcome scores ^a	Preoperative	Postoperative	<i>p</i> value	Last follow-up	<i>p</i> value
Stenotic side VAS buttock	7.3 ± 0.7	1.5 ± 0.8	<0.001*	0.7 ± 0.4	<0.001*
Contralateral side VAS buttock	0.9 ± 0.5	1.1 ± 0.6	0.728	0.5 ± 0.2	0.500
Stenotic side VAS leg	7.2 ± 0.7	2.3 ± 0.8	<0.001*	1.1 ± 0.5	<0.001*
Contralateral side VAS leg	0.9 ± 0.6	1.0 ± 0.6	0.826	0.6 ± 0.2	0.751
VAS back	6.5 ± 0.8	3.3 ± 0.6	0.001*	3.3 ± 0.6	0.001*
Oswestry Disability Index	48.0 ± 4.2	25.4 ± 4.2	<0.001*	23.0 ± 4.8	<0.001*

* *p* values <0.05 are considered to be statistically significant

^a Mean ± SE

Fig. 4 Clinical outcome; VAS buttock, leg and back—visual analog scores (VAS) for buttock and leg pain on the stenotic side and on the contralateral side, and VAS for back pain; comparison between preop, immediate postop and 11 ± 3.7 months F/U values

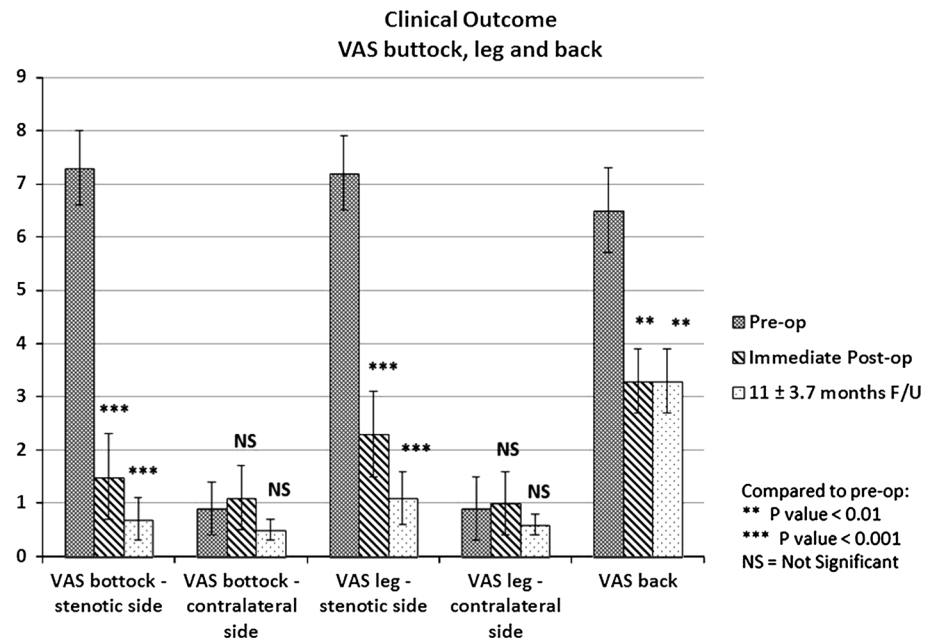
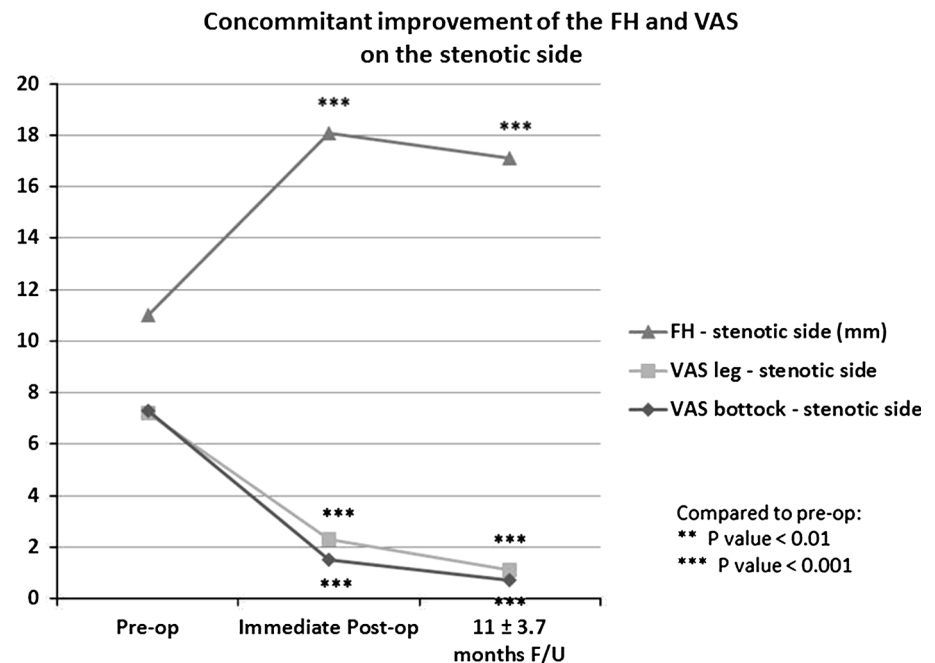


Fig. 5 Concomitant improvement of the foraminal height and VAS scores on the stenotic side. Comparison between preop, immediate postop and 11 ± 3.7 months F/U values



performed a clinical study on 350 patients who had undergone anterior discectomy and interbody fusion (ALIF). They observed favorable outcome in 223 cases that had long-term 10 years follow-up, which they attributed to the restoration of disc height and to the correction of spinal alignment [30]. More specifically, previous studies have shown that XLIF results in indirect decompression of the neural elements by FH and DH restoration [3, 31, 32]. Our previous study on 145 XLIF levels corroboratively demonstrated that significant improvements in FH and DH

could be achieved by XLIF that are durable over time. Khajavi et al. [33] found that also in patients with degenerative spondylolisthesis, XLIF results in significant clinical and radiographic improvements. They reported 19.7 % increase in FH [34]. Our results support those studies. Our study found 64 % increase in the FH on the stenotic side and 23 % on the contralateral side. Our higher rates of improvements can be attributed to supplementary instrumentation and specific attention to the results on the stenotic site [3, 4, 32].

It has been shown that significant nerve root compression commonly occurs with a foraminal height <15 mm [1]. Corroboratively, in our study 33.3 % of patients with FH <15 mm experienced residual leg pain after surgery, compared to only 11 % of patients with FH of \geq 15 mm.

Another major advantage of XLIF in the treatment of adult deformity is its lower rate of morbidity and complication, in comparison to open corrective surgeries [28, 29, 35, 36].

In the current study, only one patient (4.3 %) required reoperation that was performed for revision of instrumentation, due to wound infection.

The study was limited in a number of ways. The sample size was small and the type of fusion construct was not similar in all patients. These necessitate interpretation of the results with caution. Larger series are required to better define the benefits of XLIF for patients with different types of deformity. Despite limitations, however, the current study showed meaningful clinical improvement in the majority of patients (82–88 %). More importantly, significant correlation was found between the increase in the foraminal height and improvement of radicular pain on the symptomatic side.

Conclusion

Single-level XLIF results in effective restoration of foraminal height, as well as satisfactory relief of the clinical symptoms. Radiographic improvement is durable at mid-term follow-up and correlates with clinical improvement on the symptomatic side. In deformity patients with radicular pain caused by nerve compression at a single level, if no other symptoms attributable to general scoliosis are accompanied, treatment with single-level XLIF can result in short- and mid-term satisfactory outcome.

Conflict of interest The authors report no conflicts of interest for the current manuscript.

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