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Research Article

Radiographic Results Following Lateral Lumbar Interbody Fusion (LLIF) and Indirect Decompression of Severe Spinal Stenosis

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Abstract

Introduction: Prior studies have demonstrated the extent of indirect decompression that occurs following lateral lumbar interbody fusion (LLIF) within the immediate post-operative period. There have been conflicting reports on the ability of LLIF to adequately decompress severe central canal stenosis. This study provides data regarding the extent of indirect decompression that occurs with long term follow up (>6 months), in the setting of severe pre-operative spinal stenosis.

Methods: The retrospective case series reviewed 10 consecutive patients (11 spinal levels, limited to L3-L4 and L4-L5 segments) with severe (Schizas C or D) spinal stenosis that underwent LLIF with posterior instrumentation but without direct decompression. Each patient had an incidental post-operative MRI of the lumbar spine at least 6 months from the index procedure. Pre- and post-operative axial T2 MRI images were reviewed and the qualitative (Schizas) and quantitative (DSCA) degree of spinal stenosis were analyzed.

Results: All of the examined patients demonstrated a transition from severe (Schizas C or D) pre-operative stenosis to minimal or no spinal stenosis (Schizas A). There was an average pre- to post-operative increase in DSCA of 133.6% (SD +/- 54.5%) at an average of 13.0 months (SD +/-3.5 mo) following lateral lumbar interbody fusion, posterior instrumentation and indirect decompression.

Conclusion: Evidence of indirect decompression of the neural elements following LLIF has been documented in the acute post-operative period. The qualitative and quantitative radiographic data in this study support evidence that LLIF is effective in indirectly decompressing severe spinal stenosis.

Keywords: *Indirect Decompression; Spinal Stenosis; Lateral Lumbar Interbody Fusion; LLIF; XLIF*

Introduction

Lateral lumbar interbody fusion (LLIF) has become increasingly popular for the treatment of lumbar spinal stenosis when combined with an indication for spinal fusion. LLIF utilizes a lateral transpsoas approach to the lumbar spine for discectomy and placement of an interbody device.[1] Compared to posterior techniques, this approach allows for a more thorough discectomy and disc space preparation as well as placement of a large interbody device situated on the lateral apophyseal rings of the vertebral body.[2] Restoration of disc height in the setting of a preserved anterior longitudinal ligament provides ligamentotaxis for subsequent reduction of spondylolisthesis and tensioning of the annulus and the hypertrophic ligamentum flavum. These unique technical aspects allow for the phenomenon of indirect decompression. This reduction of spondylolisthesis and tensioning of the ligamentum flavum have been shown radiographically to enlarge the area for the neural foramina and central canal post-operatively.[3] In select cases, indirect decompression via LLIF can obviate the need for a direct posterior decompression in the form of laminectomy, laminotomy, facetectomy, or foraminotomy.[4,5] Avoiding an open decompression reduces the rate of complications germane to those procedures, including, increased blood loss, epidural hematoma, CSF leak, nerve root injury, epidural fibrosis, and additional muscle disruption.[6] However, there is debate as to the effectiveness in indirect decompression to treat severe central canal stenosis. [7-9]

Oliveira et al have used MRI and radiographs to quantify the indirect decompression that occurs in the immediate post-operative period (within 2 weeks of surgery). They documented an average of 41.9% increase in disc height, 13.5% increase in foraminal height, 24.7% increase in foraminal area and 33% increase in central canal area.[3] Although initial indirect decompression data is promising, the long-term prognosis will depend on the ability of the implant to maintain, or amplify, the initial indirect decompression of the central canal.

Materials and Methods

A retrospective review was performed to identify 10 sequential patients (11 spinal levels (limited to L3-L4 and L4-L5)) that had the pre-operative finding of severe spinal stenosis (Schizas C or D)[10] of the central canal, indication for spinal fusion (instability or spinal deformity), underwent LLIF with indirect decompression, and had incidental lumbar spine MRIs performed at least six months from the index procedure. All 10 of the study patients had neurogenic claudication as a pre-operative symptom. Axial MRIs of these patients were reviewed, and the qualitative pre-and post-op degree of stenosis according to the Schizas[10] classification was recorded. Sectra IDS7 (Sectra, Linkoping, Sweden) software was utilized in order to quantify the cross-sectional area of the thecal sac (DSCA) in the pre-and post-operative state. The qualitative (Schizas) and quantitative (DSCA) degrees of pre-and post-operative spinal stenosis were compared.

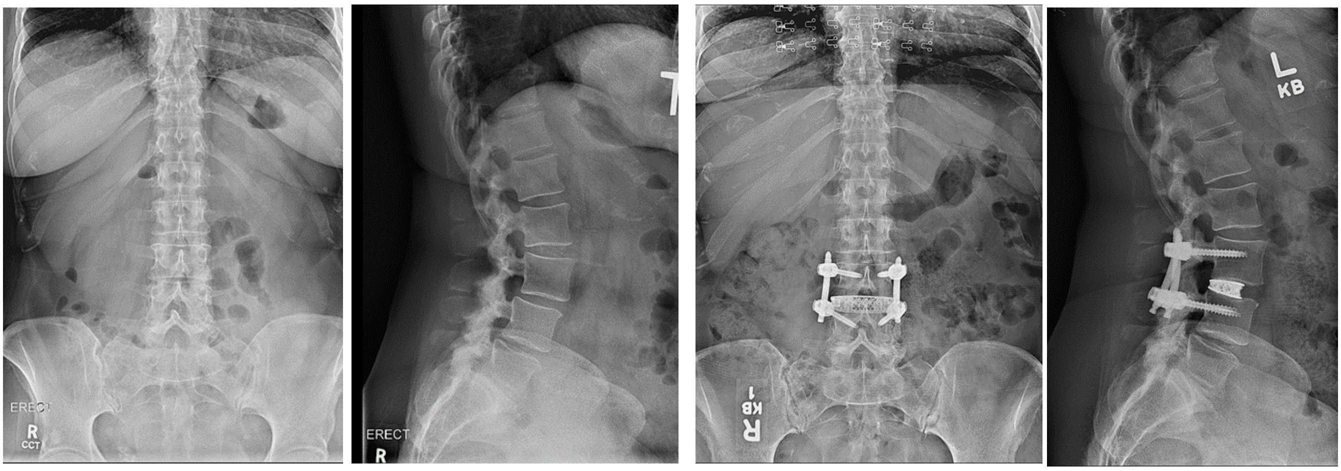
In one particular case, a patient underwent a pre-operative MRI, a post-operative MRI on post-op day 2, and then another MRI at 19 months post-op. In order to evaluate for the phenomenon of chronologic improvement of indirect decompression with time[11], the post-op day 2 MRI was qualitatively assessed for degree of stenosis (Schizas), and was compared to the pre-operative and 19-month post-operative MRI.

Results

The eleven spinal segments in this study demonstrated severe pre-operative spinal stenosis (6 Schizas C, 5 Schizas D), and an average pre-operative DSCA of 63.9 mm^2 (Range: 44.0-91.69 mm^2, SD +/-16.8mm^2). There was an average duration between the date of surgery and the post-operative MRI of 13.0 months (Range: 8.4–19 months, SD +/-3.5 months). All post-operative axial T2 MRI images qualitatively improved to minimal to no central canal spinal stenosis (Schizas A) and demonstrated an average post-operative DSCA of 144.5mm^2 (Range: 109.7 – 215.3 mm^2, SD+/-33.7 mm^2). The average increase in DSCA was 133.6% (SD +/- 54.5%). The findings are summarized in Table 1. A representative example of a patient that is included in the above data is demonstrated in Figures 1 and 2.

A case example is presented in which the patient had a pre-operative MRI, followed by incidental MRIs on post-op day 2, and another at 19 months post-op. The images qualitatively demonstrate the phenomenon of 'progressive indirect decompression' with spinal stenosis assessed pre-operatively as Schizas D (Figure 3), with progression to Schizas C on post-operative day 2 (Figure 4) and further progression to Schizas A at 19 months post-op (Figure 5).

By the time of their 6-week follow-up appointment, all 10 of the patients that were included in this study reported resolution of their pre-operative symptoms of neurogenic claudication.



A B C D

Figure 1: (a-d) Pre-operative standing AP (Fig. 1a) and lateral (Fig. 1b) X-rays of the lumbar spine demonstrating a grade I spondylolisthesis at L3-L4. Post-operative AP (Fig. 1c) and lateral (Fig. 1d) X-rays of the lumbar spine demonstrating L3-L4 lateral lumbar interbody fusion with posterior percutaneous instrumentation. No direct decompression was performed

Table 1: Pre-operative and post-operative data following lateral lumbar interbody fusion with instrumentation, without direct decompression.

Spinal level analyzed	Pre-op Schizas	Post-op Schizas	Pre-op DSCA (mm^2)	Post-op DSCA (mm^2)	% increase DSCA	Months between surgery and post-op MRI
L4-L5	C	A	83.4	142.9	71.3	16.5
L4-L5	D	A	64.0	130.2	103.4	14.7
L3-L4	C	A	45.4	151.1	232.7	8.4
L4-L5	C	A	50.7	102.0	100.2	8.4
L3-L4	D	A	65.2	215.3	230.0	10.6
L4-L5	C	A	91.7	197.3	115.2	17.4
L4-L5	D	A	44.0	126.5	187.5	10.7
L3-L4	C	A	68.5	133.5	94.8	12.2
L3-L4	C	A	89.4	162.0	81.2	12.4
L4-L5	D	A	49.7	109.7	120.7	13.0
L3-L4	D	A	51.3	118.7	131.4	19.0
Average:			63.9	144.5	133.6	13.0
Standard Deviation:			16.8	33.7	54.5	3.5
Range:			(44.0 - 91.7)	(109.7 - 215.3)	(81.2 - 230.0)	(8.4-19)

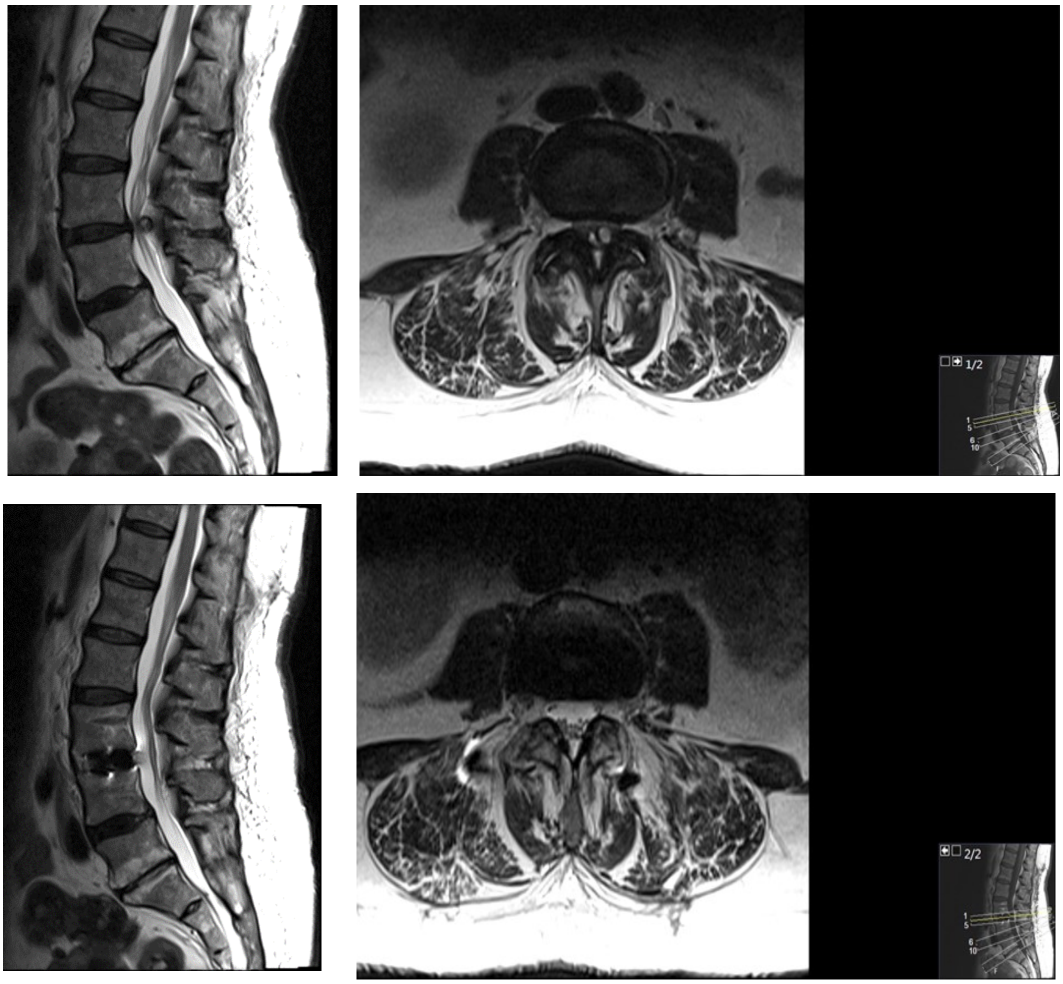


Figure 2: *(a-d) Mid-sagittal (Fig. 2a) and axial T2 MRI (Fig. 2b) of L3-L4 demonstrating severe spinal stenosis and bilateral facet cysts. Post-operative mid-sagittal (Fig. 2c) and axial T2 MRI (Fig. 2d) of L3-L4, 10.6 months post-op, demonstrating full resolution of central canal stenosis and bilateral facet cysts.*

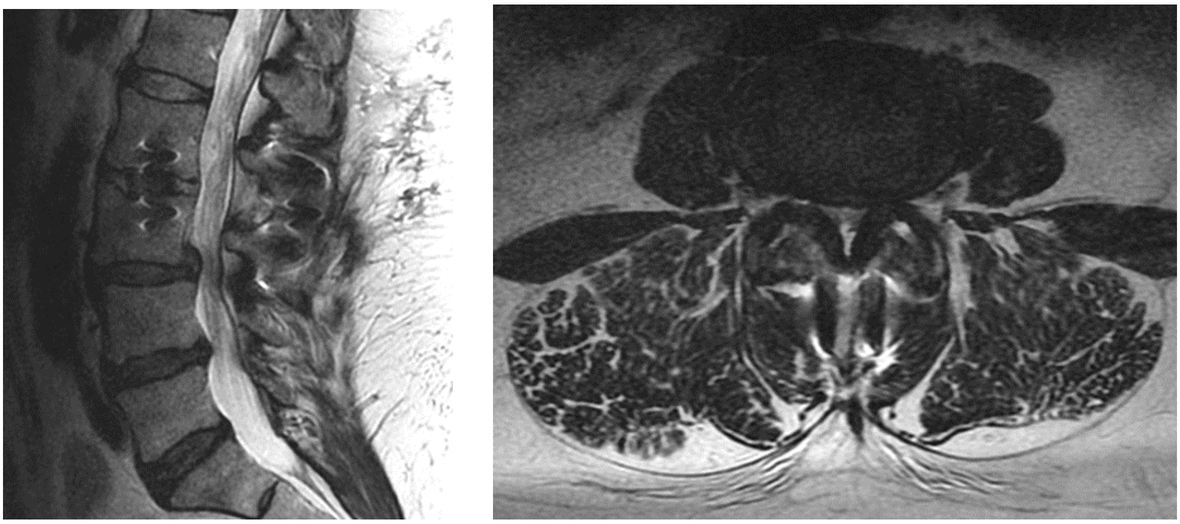


Figure 3: *(a,b) Preoperative mid-sagittal (Fig 3a) and axial (Fig 3b) T2 MRI of L3-L4 level with Schizas D central canal stenosis.*

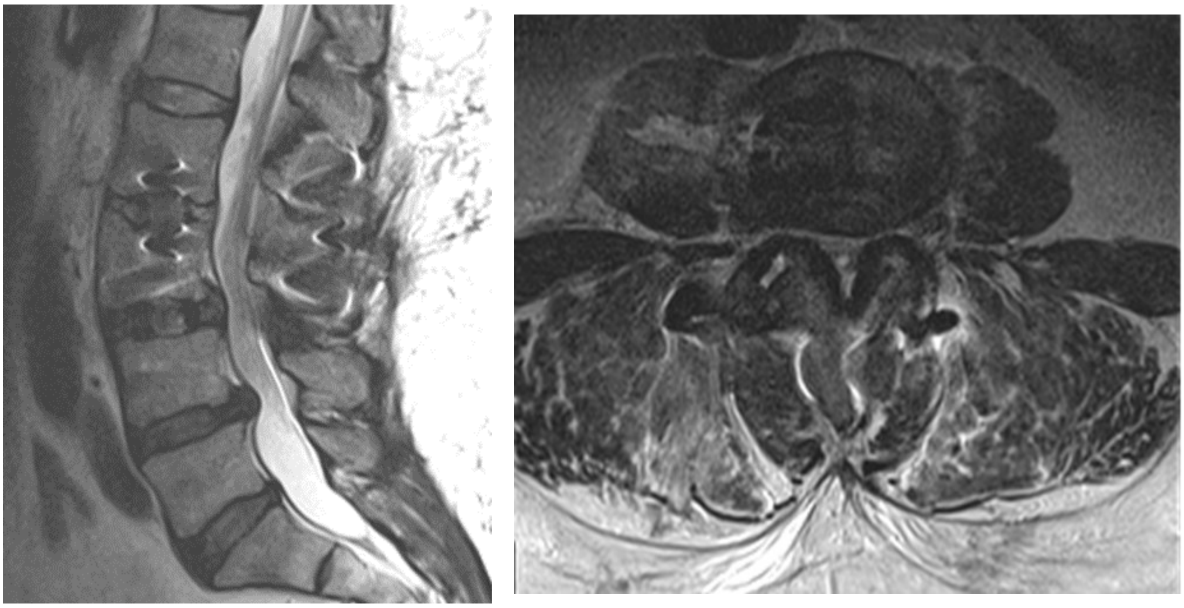


Figure 4: *(a,b) Post-operative day 2 mid-sagittal (Fig 4a) and axial (Fig 4b) T2 MRI of L3-L4 (operative) level with Schizas C central canal stenosis.*

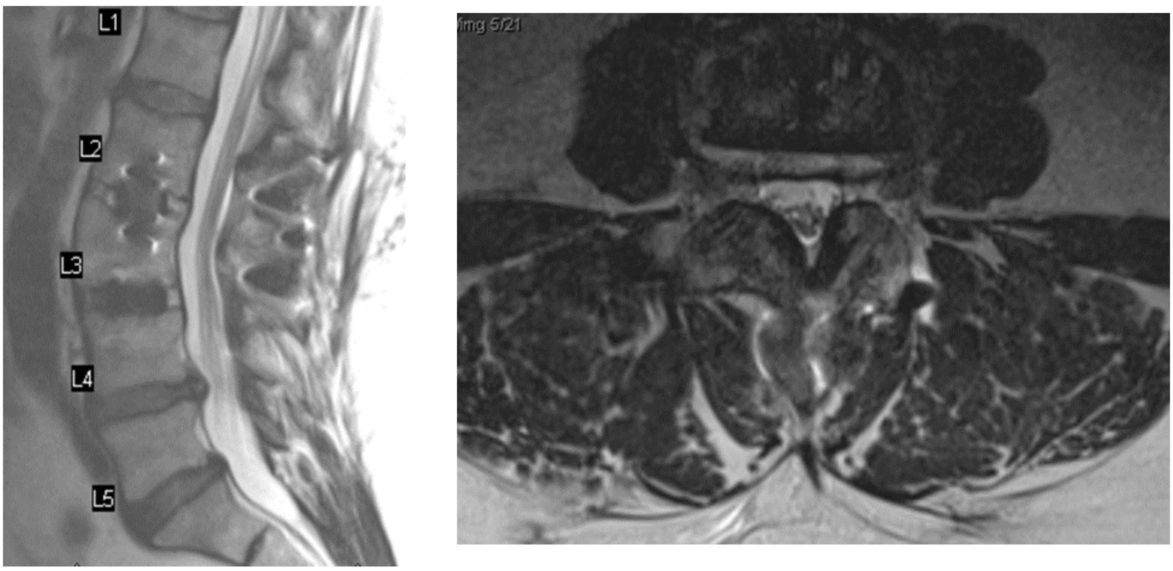


Figure 5: *(a,b) 19 months post-operative mid-sagittal (Fig 5a) and axial (Fig 5b) T2 MRI of the L3-L4 (operative) level with Schizas A central canal.*

Discussion

Indirect decompression via lateral lumbar interbody fusion (LLIF) is a technique that can be applied to patients with pre-operative symptomatic spinal stenosis that also have an indication for spinal fusion. Indirect decompression carries a number of advantages over open decompression including the decreased risk of CSF leak, direct trauma to the neurologic elements within the thecal sac, and epidural fibrosis. Prior studies have suggested uncertainty about the ability for indirect decompression to treat severe spinal stenosis[7-9]. The results of our study demonstrated that after 6 months, all of the analyzed spinal segments improved from severe central canal stenosis (Schizas C/D) to minimal to no spinal stenosis (Schizas A).

The data also demonstrate an average improvement of DSCA of 133.6%, which far exceeds the 33% enlargement of the spinal canal that was reported in the study by Oliveira et al[3] that analyzed the results of indirect decompression in the immediate (within 2 weeks of the index surgery) post-operative period. Not only does this study provides evidence that LLIF is successful in dramatically 'decompressing' severe spinal stenosis (Schizas C, D) via an indirect method, it also reinforces the concept that we have termed 'progressive indirect decompression'. The most reasonable explanation for the discrepancy in the 133.6% increase in DSCA compared to the 33% in the Oliveira study is that indirect decompression progresses with time. Oliviera et al's[3] study assessed patients within 2 weeks of surgery while this study assessed patients at a minimum of 6 months from surgery. In addition, an example of 'progressive indirect decompression' is radiographically demonstrated in the case of a patient that demonstrated progressive enlargement of the spinal canal between their post-op day 2 (Figure 4) MRI and the one obtained at 19 months post-op (Figure 5). The process of 'progressive indirect decompression' is further supported by Nakashima et al's[11] 2019 publication that describes a chronologic progression of indirect decompression over a two-year time period.

Conclusion

The findings in this study help provide additional evidence for the utility of LLIF and indirect decompression in the setting of severe spinal stenosis, and to further characterize the phenomenon of 'progressive indirect decompression'. LLIF has demonstrated the ability to result in the radiographic resolution of even the most severe (Schizas D) cases of spinal stenosis. Interestingly, this study also demonstrates that the full extent of radiographic decompression may not occur for multiple months from the index procedure. LLIF appears to be a viable option to treat severe spinal stenosis in patients that concurrently require a spinal fusion, without performing a direct decompression. The avoidance of a direct decompression can thereby reduce the intraoperative risks of dural tear, direct injury of the neural elements within the cauda equina, post-operative epidural hematoma and post-operative epidural fibrosis.

Further research may include prospective imaging studies of cases of LLIF that involve indirect decompression for symptomatic lumbar stenosis to further validate the findings of this study. Such information could be useful for patient counseling, pre-operative planning, and post-operative expectations.

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