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Indirect Decompression of the Neural Elements Utilizing Direct Lateral Interbody Fusion Procedure

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ABSTRACT

Introduction: Patients suffering from degenerative scoliosis curves often present with radicular symptoms mainly on the concave side of their curves. Standard treatment includes posterior decompressions, followed by fusions. These procedures carry large morbidity rates. We have observed resolution of radicular and stenotic symptoms with Direct Lateral Interbody Fusions (DLIF). **Aim:** In this study we radiographically assess indirect decompression effect of DLIF procedure. **Methods:** We conducted a case series of four patients with 2-stage procedures. All patients presented with back pain and leg symptoms. Stage one included the insertion of the DLIF polyetheretherketone cages and rh-BMP2. This was followed by a second stage posterior fixation utilizing percutaneous pedicle screws and rods. Plain radiographs were utilized to determine the concave and convex sides of the scoliosis. Pre- and post-DLIF measurements were made from axial and sagittal MRIs. Measurements included central, subarticular, and foraminal areas. Statistical significance was estimated via paired sample *t*-test. **Results:** All patients had complete resolution of leg symptoms with remarkable improvement in all areas measured. When both concave and convex sides of the curve are considered, an increase of 49% in the central canal, 82% in the subarticular area, and 71% in the foraminal area was measured. When only the concave levels were measured, there was a 90% increase (0.22 cm² vs. 0.41 cm²) in the subarticular area and 77% (0.46 cm² vs. 0.81 cm²) increase in the foraminal area (*p* < .001). **Conclusion:** The DLIF procedure provides an indirect decompression of the neural elements along with its role in spinal fusion. This negates the need for posterior decompression surgery in degenerative scoliosis associated with spinal stenosis, which might lead to less blood loss and surgical time in these complex surgeries.

Key words: decompression, fusion, scoliosis, DLIF.

1. INTRODUCTION

Since the introduction of lateral transposas approach^{1,2} to the lumbar spine and determining it to be safe, several intervertebral cages such as the Extreme lateral interbody fusion (XLIF) and the Direct lateral Interbody fusion (DLIF) systems. To insert these cages in the intervertebral spaces, surgeons would have to dissect through soft tissues only contrary to the posterior, postero-lateral and transforaminal approaches, which require removal of the posterior bony elements. Surgeons have started to experience excellent fusion rates within the anterior column with the benefit of shorter operating time and much less blood loss^{3,4} with a relatively short learning curve⁵.

Another potential benefit of inserting large intervertebral cages is the indirect decompression of the neural elements through the distraction of the vertebrae. One cadaveric study has shown improvement in

the neuroforaminal volume and area when vertebrae were distracted with the BAK Interbody fusion system⁶. Measurements were based on CT images as well as silicone molds. A more recent clinical study done by Prof. Pimenta and his group demonstrated the indirect increase in the central canal areas foraminal areas, and disk height after utilizing the XLIF system on patients with lumbar stenosis⁷. All measurements were based on CT scan as well as Lateral plane radiographs.

2. AIM

The objective of this study was to observe similar the change in the areas accommodating the neural elements namely the thecal sac and the exiting nerve roots after the utilization of the DLIF system for severely degenerated thoracolumbar and lumbar spines within the adult scoliosis patients.

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3. METHODS

A retrospective chart review of four patients with advanced degenerative scoliosis and clinically significant back and leg symptoms treated at Foothills medical center, Calgary, Alberta. Average age was sixty-six years old (range 53-75). All three female and one male patient underwent a two-stage spine procedure. The first stage involved a multilevel thoracolumbar and / or lumbar discectomy through a lateral transpoas approach and fusion with the DLIF polyetheretherketone cages filled with recombinant human bone morphogenic proteins type II (rh-BMP2). Local stimulation along with continuous electromyography (EMG) neuromonitoring were utilized and interpreted by an electrophysiologist in all four patients during the first stage. The patients were then brought back to the operating room for the second stage where they had multilevel posterior percutaneous placement of pedicle screws and connecting them with pre-contoured rods using the CD Horizon Longitude system. The second stage aimed at addressing the sagittal correction of the curve, stabilizing the coronal correction achieved with the DLIF cages and enhancing the fusion with a posterior column construct.

All preoperative MRIs were part of the routine diagnostic workup for patients with this disease. MRIs were also obtained in between the two stages of the procedure for the four patients in this study as part of the initial evaluation of this new surgical technique at our center. The MRIs were done primarily to check the final position of these cages once inserted, as they were not amenable to any other imaging techniques. It was determined however that subsequent patient having the same procedure wouldn't require them.

Three patients had five DLIF cages inserted from (T12-L5) while one patient had only three cages inserted due to an auto fusion at two levels (T12-L1 and L2-L3). A total of eighteen DLIF cages were inserted. All eighteen intervertebral levels with the DLIF cages had clear preoperative and postoperative magnetic resonance imaging. Eighteen intervertebral levels with clear images were included in this study. Axial and Sagittal T2 reconstruct-

ed images were used as a validated tool for taking the measurements to obtain our data ^{8,9}. Measurements for left and right foraminal areas were obtained from the reconstructed sagittal cuts that were representative of the narrowest part at the center of the foramina. Central canal and subarticular zones were measured at the disc level. The MRIs provided clear readable sagittal images for the entire foramina in all eighteen levels while the rest of the zones were read from seventeen levels only included in the reconstructed axial cuts files. A single independent orthopedic surgeon measured five zones on each individual intervertebral level for each patient. (Right and left foramina, Right and left Subarticular zone, and Central Canal Zone) and recorded all zones on all four patients. Measurements were obtained utilizing Osirix® DICOM Viewer software. A Paired *t*-test was used to compare the measurements pre- and postoperatively for all five zones. All statistical analyses were computed with use of PASW software (formerly SPSS, version 19.0, SPSS, Chicago, Illinois).

4. RESULTS

Clinical outcome

All four patients in this study underwent a successful two-stage procedure and were discharged home in a good condition with complete resolution of their leg symptoms.

Much to our surprise patients were able to walk with assistance to have their postoperative MRIs after the first stage of the procedure.

Radiographic outcome

There was a remarkable improvement in all areas measured. When both concave and convex sides of the curve are considered, an increase of 49% in the central canal, 82% in the subarticular area, and 71% in the foraminal area was measured. When only the concave levels were measured (14 levels), there was a 90% increase (0.22cm² vs. 0.41cm²) in the subarticular areas and 77% (0.46 cm² vs. 0.81cm²) increase in the foraminal areas. (*p* < .001) (Table 1,2; Figure 1)

Reading (n)	PREOP mean CI	POSTOP mean (CI)	t-TEST	Effect Size (r)	P VALUE
Central areas (17)	1.2 (0.53 to 2.2)	1.79 (1.27 to 2.26)	<i>t</i> (17) = -4.1	r=0.51	< 0.001
Right Lateral Recess areas (17)	0.22 (0.15 to 0.28)	0.40 (0.35 to 0.46)	<i>t</i> (16) = -4.83	r=0.6	< 0.001
Left Lateral Recess areas (17)	0.23 (0.13 to 0.16)	0.42 (0.37 to 0.47)	<i>t</i> (16) = -6.49	r=0.72	< 0.001
Right Foramina (18)	0.58 (0.49 to 0.66)	0.93 (0.83 to 1.03)	<i>t</i> (17) = -6.39	r=0.71	< 0.001
Left Foramina (18)	0.54 (0.42 to 0.66)	0.95 (0.79 to 1.12)	<i>t</i> (17) = -5.49	r=0.64	< 0.001

Table 1. MRI measurements of all five zones. * All readings in cm2

Reading (n)	PREOP mean CI	POSTOP mean (CI)	t-TEST	Effect Size (r)	P VALUE
Lateral Recess areas (14)	0.21	0.4	<i>t</i> (14) = -.46	r=0.65	< 0.001
Foramina (14)	0.46	0.41	<i>t</i> (14) = -6.2	r = 0.75	< 0.001

Table 2. MRI measurements of the lateral recess and foramina located on the concave side of the curves. *All readings in cm2

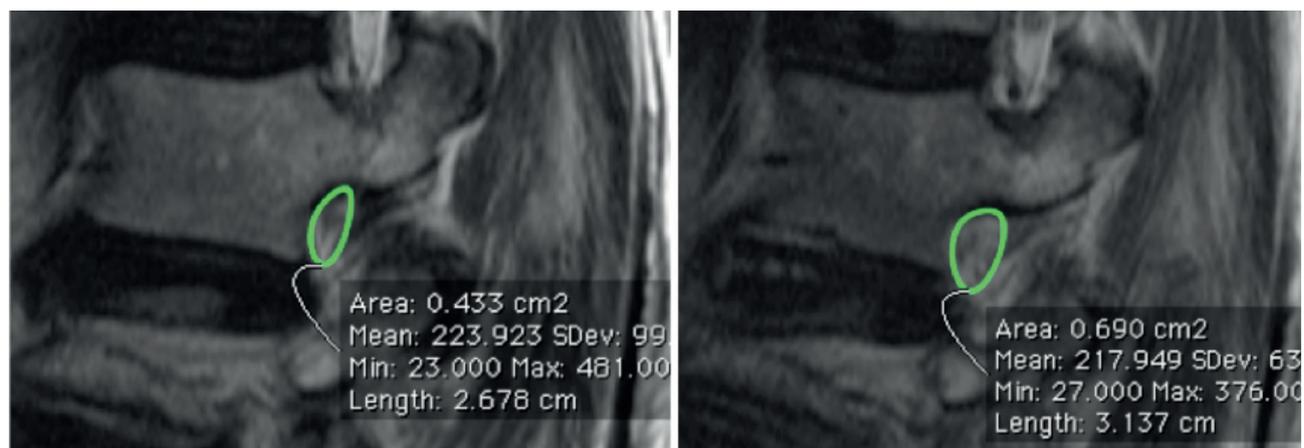


Figure 1. Pre- and postoperative T2 Sagittal MRIs cuts through the concave side of a scoliosis curve with an increase in the size of the Left L1-L2 foramen after placement of the DLIF cage.

5. DISCUSSION

Patients with degenerative scoliosis in the thoracolumbar and the lumbar spine will often present with leg symptoms, primarily pain followed by numbness and weakness. These symptoms are hard to fit under a single nerve root radiculopathy pattern as often more than one nerve root are being involved with a end result of pain, paresthesia and muscle weakness distributed over several dermatomes and myotomes. Furthermore It has been shown that nerve roots on the concave side of the scoliosis curve are subjected to more compression in the foraminal zone, which leads to more radiculopathy symptoms in the leg on the ipsilateral side of the concave side of the curve¹¹. However with continued degeneration in all levels of the scoliosis curves both concave and convex side become equally affected¹².

Surgical correction of adult spine deformities offers dramatic improvement to the patients' symptoms and quality of life^{13,14}. This is achieved by proper restoration of patients' balance and normal or near normal anatomical alignment. Traditional Surgical procedures would often utilize a circumferential (anterior and posterior) or stand-alone posterior approach¹⁵. This would often involve large amount of bony resection in the form of different types of vertebral osteotomies along with bony decompression necessary to address concurrent spinal stenosis. Although surgical intervention is known to be beneficial, reported complications although multi-factorial, are found to be, to be as high as 55% to 75% with blood loss being a major concern¹⁶⁻¹⁸. Furthermore complications grow exponentially with the number of operated levels and advanced patients' age¹⁹⁻²¹, a factor that denies many of them this valuable surgical management

This considerable high rate of complications has led to development of several minimally invasive surgical techniques such as the lateral transpsoas approach which was quickly adopted by many scoliosis surgeons due to the relative ease of the technique as well as the lower rate of complications as has been shown by several reports. This could be attributed to the minimal muscle dissection required as well as the absence of the bony resection that is

typical of an open procedure through a posterior only or circumferential approaches.

Concurrent central, lateral recess as well as foraminal stenosis are very common in adult deformity^{11,12}. This happens primarily due to an alteration in the disc height and constituency which creates an unstable segment which leads to hypertrophy in the posterior bony and ligamentous elements and further collapse resulting in the stenosis mentioned above.

With the transpsoas technique, coronal deformity is addressed through the restoration of the intervertebral heights by diligent resection of the degenerated discs and the insertion of the large interbody cages that cover a substantial amount of the endplate and recover its parallel alignment. During the preparation of the disc space and removal of the cartilaginous endplates, one should be cautious not to cause a fracture in the often-osteoporotic endplate, as this will minimize the cage's distraction effect. Moreover surgeons should be extremely careful not to breach the anterior or posterior annulus along with the anterior and posterior longitudinal ligaments respectively as that might lead to over distraction and more importantly risk of having a vascular, visceral and/or neural injury⁷. Sagittal deformity was addressed during the second stage of the procedure with the utilization of percutaneous pedicle screws and the pre-contoured rods to restore the normal anatomical alignment and more specifically the restoration of the lumbar lordosis, which plays a genuine role in patients' quality of life^{22,23}.

In our study we have noticed that the large lordotic and almost rectangular shaped cages cause a uniform distraction of the vertebral bodies as well as the posterior elements, which has lead to the assumption that it is resulting in an indirect decompression of the neuroelements. This belief was consolidated with substantial improvement in patients' leg symptoms postoperatively with this surgical technique, future direction of our research to monitor patients' clinical short and long-term result

We would like to acknowledge some of the limitations of this study. In this study, an opportunity sample of

four patients provided eighteen degenerated discs that underwent the same procedure (insertion of the DLIF cages). This was a sample of convenience and therefore cannot be used to make inferences about the general population. However, a random sample would've been difficult to get when evaluating the very first few patients who had this new technique along with the post-operative MRIs that were deemed necessary by our surgical group during the initial evaluation phase of this new technique. Furthermore, the author didn't find a good reason to believe that this sample would behave differently from a random sample from the same population. Further, based on previously published literature⁷, a priori power analysis (G*power: Faul and Erfelder 1992)¹⁰ determined that in order to detect a statistically significant difference of 42% with 80% power and type I error of 0.05, we needed to increase our sample size to eight patients or forty levels (five cages per patient). Nevertheless, we were able to show that inserting the DLIF cages was associated with statistically significant increase in all five zones accommodating the neuroelements. Moreover, since the objective of this study was to investigate potential changes in the areas for the neuroelements, a dependent sample paired t test was used to analyze the difference in the measurements before and after surgery. The difference was substantial, with a moderate to high effect size. However, having done the *t*-test seven times, one would worry that this will cause inflation in type I error rate. Therefore, to maintain the familywise error rate, Bonferroni correction method was used and determined that in order for our test to be significant we should have a *p* value of less than 0.007, which was achieved in this study. ($p < 0.001$). Lastly, one of the major limitations in this is the lack of inter-observer reliability. A single independent orthopedic surgeon took and recorded all the measurements. An intra observer reliability test was done with the same surgeon repeating the measurements over a period of time. Reliability was estimated by computing the concordance correlation coefficient (CCC) with 95% confidence intervals (CIs) using STATA software, version 11(Stat corp, College Station, Texas) with a substantial result (CCC=0.97, 95% CI = 0.9–1). However, to minimize the inherent bias with this approach it would've been more appropriate to rely on inter-observer reliability by having more than one individual taking the measurements.

6. CONCLUSION

The main goal of this study was to assess the effect of DLIF procedure in changing the zones containing the neural elements through MRI interpretation and to assess the possibility of avoiding posterior surgical decompression. We have shown that the DLIF procedure provides an indirect decompression of the neural elements along with its role in spinal fusion. This might obviate the need for posterior decompression surgery in degenerative scoliosis with concurrent spinal stenosis, which often is associated with increase blood loss and increased surgical time in these complex surgeries compared to the minimally invasive surgical technique used in this study.

However, we recommend further research to be done looking specifically at long-term clinical outcomes and how they correlate with the radiographic findings. Future directive is to observe patients' short and long-term result and how they contrast to the general population.

- **Author's contribution:** S.S. gave substantial contributions to the conception, design, analysis and interpretation of data. S.S. drafted and critically revised paper for important intellectual content and gave final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
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