Original Study

Treatment of symptomatic thoracic disc herniations with lateral interbody fusion

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Background: Symptomatic thoracic herniated discs have historically been treated using open exposures (i.e., thoracotomy), posing a clinical challenge given the approach related morbidity. Lateral interbody fusion (LIF) is one modern minimally disruptive alternative to thoracotomy. The direct lateral technique for lumbar pathologies has seen a sharp increase in procedural numbers; however application of this technique in thoracic pathologies has not been widely reported.

Methods: This study presents the results of three cases where LIF was used to treat symptomatic thoracic disc herniations. Indications for surgery included thoracic myelopathy, radiculopathy and discogenic pain. Patients were treated with LIF, without supplemental internal fixation, and followed for 24 months postoperatively.

Results: Average length of hospital stay was 5 days. One patient experienced mild persistent neuropathic thoracic pain, which was managed medically. At 3 months postoperative all patients had returned to work and by 12 months all patients were fused. From preoperative to 24-month follow-up there were mean improvements of 83.3% in visual analogue scale (VAS), 75.3% in Oswestry Disability Index (ODI), and 79.2% and 17.4% in SF-36 physical (PCS) and mental component scores (MCS), respectively.

Conclusions: LIF is a viable minimally invasive alternative to conventional approaches in treating symptomatic thoracic pathology without an access surgeon, rib resection, or lung deflation.

Keywords: Complications; lateral; minimally invasive; spine; thoracotomy

Submitted Oct 01, 2015. Accepted for publication Oct 06, 2015.
doi: 10.3978/j.issn.2414-469X.2015.10.02
View this article at: http://dx.doi.org/10.3978/j.issn.2414-469X.2015.10.02

Introduction

Several challenges exist in the successful surgical treatment of symptomatic thoracic herniated discs (1,2). Historically, surgical approaches have been associated with limited efficacy [decompressive laminectomy (3)], unacceptably high morbidity (4), or both. Posterior approaches limit adequate exposure of anterior pathology without spinal cord retraction or nerve root sacrifice, while anterior approaches typically require a broad exposure to access relatively small pathology. The exposure afforded by a thoracotomy approach has been considered the "gold standard" visualization for thoracic disc pathology but at the cost of elevated rates of intercostal neuralgia (5,6), diaphragmatic disfiguration, pulmonary complications (4-7), excessive blood loss (7-9), and infection (6,8). Endoscopic approaches to the anterior thoracic column have eliminated much of the morbidity associated with thoracotomy though, unfortunately, this has been replaced with a new profile of surgical challenges including a steep and long learning curve (10), extensive and expensive instrumentation and staffing, the potential for emergent conversion to open exposures, visualization of three dimensional anatomy in two dimensions, and difficulty in placing anterior instrumentation (10-12).

Modern minimally disruptive approaches for thoracolumbar pathology have been developed under direct visualization using specialized access systems, standard

surgical techniques, and small incision exposures with limited soft tissue dissection (2,13-16). In recent years, the direct lateral approach has become a popular technique for treating lumbar pathologies, although its application in the thoracic spine is not widely reported. The aim of this study was to present a representative case series of a mini-open lateral approach for anterior thoracic access in the treatment of symptomatic thoracic herniated discs.

Methods

Study design

A prospective registry was analyzed retrospectively for three patients who underwent a minimally invasive lateral approach for thoracic discectomy and interbody fusion (XLIF®, NuVasive®, Inc. San Diego, CA, USA) by a single surgeon (GMM). Data collected included patient (demographic and indication), treatment (operative and complications), and outcome (clinical, radiographic, return to work, and functional improvements). Radiographic evidence of fusion was assessed using high definition computed tomography (CT) (Somatom Definition Flash, Siemens AG, Erlangen, Germany) at 6- and 12-month follow-up. Fusion was defined as the presence of bridging interbody trabecular bone according to Williams *et al*. (17). All patients were followed for 24 months postoperatively.

Surgical technique

The surgical technique for both lumbar and thoracic lateral interbody fusion (LIF) has been previously reported (2,15,16,18), and can be used in the treatment of a variety of degenerative conditions of the thoracolumbar spine from approximately T4 to L5, blocked superiorly by the axilla and inferiorly by the iliac crest. Briefly, the patient is treated in the lateral decubitus position on a radiolucent operative table with a true lateral and anteroposterior orientation orthogonal to the floor, confirmed on fluoroscopy. The table break should be placed more superior than for a lumbar approach to allow for some separation of the ribs on the approach side during lateral flexion under table break. The side of the approach is dictated by both the presenting pathology and relevant vascular anatomy. The target vertebral level was marked at the beginning of the operation by placing a Kirschner wire in the spinous process immediately inferior to the pathological thoracic disc to reduce the risk of wrong level surgery. Motor evoked potentials were monitored intraoperatively (NV M5®, NuVasive, Inc., CA, USA) and thus, total intravenous anesthesia was used to avoid attenuation of motor pathway signals.

The approach begins with skin incision approximately 4-5 cm in length, parallel with and between the ribs, 90 degrees lateral to the disc space. Blunt dissection, aided by periosteal elevators and doyens, through the intercostal muscles at the superior margin of the inferior rib is performed to encourage preservation of the neuromuscular bundle.

For solitary thoracic pathology, a transpleural approach was employed by incising the parietal pleura, introducing the initial dilator, coursing down the rib to the rib head over the target disc space, verified by lateral fluoroscopy. For pathologies at the thoracolumbar junction, a retropleural transdiaphragmatic approach was performed and care was taken to preserve the visceral pleura to avoid pneumothorax and/or haemothorax. Following exposure into the space, a series of three sequential dilators and a self retaining split blade retractor (MaXcess IV® retractor, NuVasive, Inc., CA, USA) are introduced and secured to the operating table by a rigid articulating arm. Once the desired exposure is achieved, decompression, endplate preparation, and intervertebral polyetheretherketone (PEEK) implant placement (CoRoent XL-T®, NuVasive, Inc., CA, USA) are performed using standard operative techniques. Preoperative examination of axial magnetic resonance imaging (MRI) can aid in the identification of any vascular anatomy (aorta) with respect to the degree of contralateral annular release possible.

Interbody spacers were filled with a combination of bone morphogenetic protein (rhBMP-2, Infuse®, Medtronic, Inc., Memphis, TN, USA) and Mastergraft β-TCP granules (Medtronic, Inc., Minneapolis, USA). The cages were sealed with Surgicel® (Ethicon, Inc. Somerville, NJ, USA) or fat graft, supplemented with tissue glue to avoid extravasation of rhBMP-2 into the thoracic cavity. Chest tubes can be placed at the surgeon's discretion.

Results

Patient demographic and treatment information is summarized in *Table 1*. Clinical and radiographic outcomes are summarized in *Table 2*.

Case 1

A 49-year-old male presented with a 4-day history

Table 1 Patient demographic and treatment information

Case no.	Age	Sex	BMI	Indication	Level	Side	Bone graft	Chest tube	EBL (mL)	LOS (days)
1	49	Male	33.9	TDH	T6-7	Right	rhBMP-2	No	< 50	5
2	62	Female	27.4	TDH	T9-10	Left	rhBMP-2	No	< 50	5
3	74	Male	24.6	DDD	T12-L1	Left	rhBMP-2	Yes	< 50	5

BMI, body mass index; DDD, degenerative disc disease; EBL, estimated blood loss; LOS, length of stay; rhBMP-2, recombinant human Bone Morphogenetic Protein-2; TDH, thoracic disc herniation.

Table 2 Patient outcomes

Case no.	Complications	Follow-up	Fusion	Return to work (full-time)	Preoperative				24-month follow-up			
					VAS	ODI	PCS	MCS	VAS	ODI	PCS	MCS
1	None	24 months	6 months	3 months	10	84	11	54	1	0	50	55
2	Neuropathic thoracic pain	24 months	6 months	6 months	9	56	33	44	1.5	24	48	62
3	None	24 months	12 months	5 weeks	8	38	33	46	2	20	40	52

MCS, mental component score; ODI, Oswestry Disability Index; PCS, physical component score; VAS, visual analogue scale.

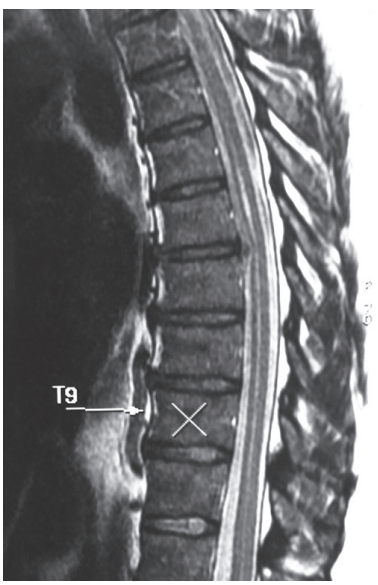

Figure 1 Case 1: preoperative sagittal T2-weighted thoracic magnetic resonance imaging (MRI) showing T6-7 soft tissue central disc prolapse causing cord compression with high intrinsic cord signal. Level marker at T9 vertebra.

of progressive myelopathy with bladder and bowel dysfunction, unsteadiness and leg numbness. He had no medical comorbidities and was a non-smoker. Examination demonstrated spastic gait, positive Romberg's test, lower limb hyperreflexia with midthoracic sensory level and saddle anesthesia. Thoracolumbar MRI revealed an acute central T6-7 soft central disc prolapse compressing the spinal cord causing intrinsic high cord signal (*Figure 1*). MRI brain excluded mass lesion and demyelination. Two days of 16 mg dexamethasone treatment was provided without symptom response or improvement. Hence, the patient underwent a right transpleural T6-7 LIF. After complete channel discectomy, a ball tipped hook was used to remove the extruded central disc fragment through a rent in the ruptured posterior longitudinal ligament (PLL). The disc space was distracted with sequential interbody spacer trials until the appropriate height was achieved, followed by cage placement (6×16×35 mm^3, 10 degree, CoRoent XL-T). Estimated blood loss (EBL) was less than 50 mL. A postoperative chest tube was not required for drainage. Postoperative chest radiography excluded pneumothorax and CT confirmed cord decompression and satisfactory prosthesis placement at T6-7. The patient exhibited rapid resolution of myelopathic symptoms and was discharged 5 days postoperatively. At 6 weeks postoperative the skin incision was well healed with excellent cosmesis (*Figure 2*) and he was no longer taking analgesic medication. The patient returned to light work duties at 8 weeks and then to full duties 3 months postoperatively. Solid fusion was confirmed on CT at 6-month follow-up (*Figure 3*). The patient reported a vast improvement in pain, from a visual

analogue scale (VAS) of 10/10 preoperatively, to 1/10 at 24-month follow-up. There were also improvements in Oswestry Disability Index (ODI) (84 to 0), and SF-36 physical component score (PCS) (11 to 50) and mental component score (MCS) (54 to 55).

Case 2

A 62-year-old female presented with a 3-week history of severe left lower thoracic radicular pain. The patient had no neurological deficit on examination. She had no medical comorbidities and was a non-smoker. Initial chest CT and ultrasound were unremarkable. MRI thoracolumbar scan showed an acute, moderate sized, left sided T9-10 foraminal soft disc prolapse extending superiorly into the left T9-10 foramen with significant compression of the exiting left T9 nerve root (*Figure 4*). The patient was unresponsive to opiate analgesia, pregabalin (Lyrica®, Pfizer, New York, NY, USA) and CT guided left T9 transforaminal epidural nerve root injection. The patient underwent a left sided transpleural T9-10 LIF. Following formal discectomy, a ball tipped blunt hook was inserted superiorly into the T9-10 foramen for removal of extruded disc fragments. A standalone interbody cage (6×16×40 mm^3, zero degree, CoRoent XL-T) was placed. EBL was less than 50 mL. A chest tube was not required. Postoperative chest radiography excluded pneumothorax. CT showed satisfactory prosthesis placement at T9-10 with no residual neural compression (*Figure 5*). The patient reported reduction in preoperative thoracic pain (VAS 9/10 to 5/10), further improved to 2-3/10 with a CT guided T9-10 epidural injection. She was discharged to home 5 days after surgery. At 3 months postoperative, the patient continued to exhibit mild persistent neuropathic thoracic pain requiring paracetamol and pregabalin 75 mg daily, but had returned to part-time work duties. At 6-month follow-up she had solid interbody fusion, confirmed on CT, and had resumed full-time work. At 24 months follow-up the patent reported further improvement in pain (VAS 1-2/10); her ODI

Figure 2 Case 1: postoperative photograph showing the surgical scar at 6 weeks for thoracic lateral interbody fusion (LIF).

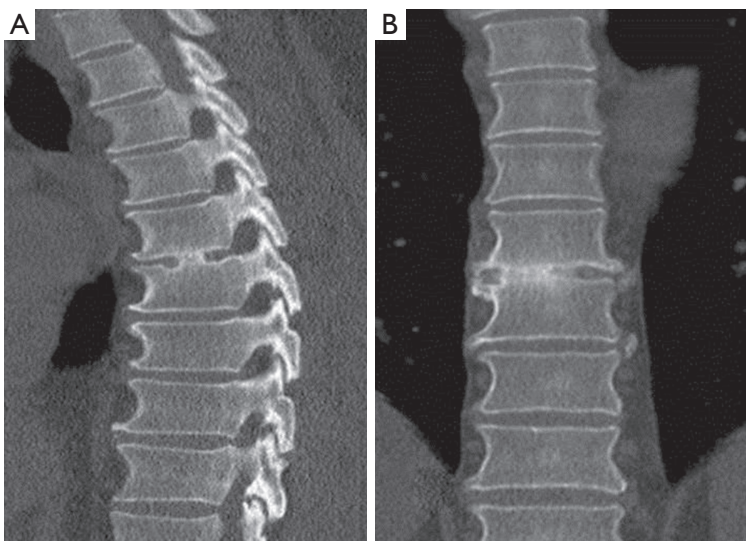

Figure 3 Case 1: postoperative thoracic computed tomography (CT) (A) sagittal and (B) coronal demonstrating solid interbody fusion T6-7 level at 6 months.

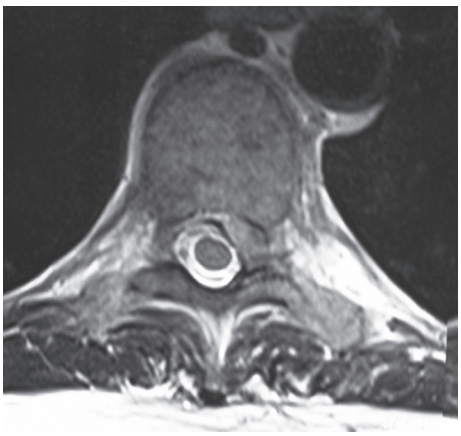

Figure 4 Case 2: preoperative axial T2-weighted thoracic magnetic resonance imaging (MRI) showing left T9-10 soft tissue foraminal disc prolapse.

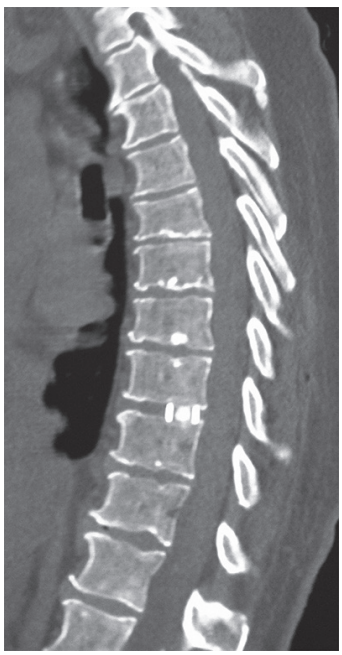

Figure 5 Case 2: postoperative sagittal thoracic computed tomography (CT) showing interbody cage T9-10 level at 48 hours.

(56 to 24), PCS (33 to 48) and MCS (44 to 62) were also improved.

Case 3

A 74-year-old male presented with a 12-month history of progressive low back pain (VAS 8/10) with an inability

Figure 6 Case 3: preoperative sagittal thoracolumbar computed tomography (CT) demonstrating multilevel degenerative disc disease most marked at T12-L1.

to stand for more than 10 minutes or participate in recreational activities. No neurologic deficit was revealed on initial examination, comorbidities included hypertension and prior history of tobacco use. Preoperative CT thoracolumbar scan demonstrated multilevel degenerative disc disease (DDD) most marked at T12-L1 with a degenerative grade I spondylolisthesis at L3-4 (*Figure 6*). Isotope Tc^{99m} bone scan coregistered with CT showed radiotracer uptake mainly at T12-L1 disc level and lesser extent at L3-4 disc and L5-S1 facet joints. The patient was unresponsive to opiate analgesia, CT guided facet joint or transforaminal epidural nerve root injections. The patient underwent a left retropleural transdiaphragmatic T12-L1 LIF with an interbody cage (8×18×45 mm^3, zero degree, CoRoent XL-T). EBL was less than 50 mL. A 24 gauge intercostal drain was placed intraoperatively and removed 24 hours postoperatively. Postoperative CT demonstrated satisfactory prosthesis placement at T12-L1. The patient was discharged to home on day 5. He ceased all analgesia and returned to normal work duties 5 weeks postoperatively. A solid fusion was confirmed on CT at 12 months (*Figure 7*). The patient reported improvements in low back pain (VAS 8/10 to 2/10), ODI (38 to 20), PCS (33 to 40) and MCS (46 to 52) at 24 month follow-up.

Discussion

Symptomatic thoracic disc herniation requiring surgical

Figure 7 Case 3: postoperative coronal thoracolumbar computed tomography (CT) demonstrating solid interbody fusion T12-L1 level at 12 months.

intervention is rare (19), representing only a small portion of spinal surgeries for all disc herniations (20,21). Conventional open surgical approaches have high complication rates and approach related morbidity, which extends recovery and return to normal activities (6,9,22,23).

Historically, the surgical treatment of thoracic disc herniations was approached posteriorly with decompressive laminectomy (24). In 1969, Perot and Munro reviewed the literature on the treatment of thoracic disc herniation with laminectomy and found that of the 91 patients reported at the time, only 56% experienced either partial or complete symptom resolution, with 18% being rendered paraplegic and 7% dead (24). From these early failures, anterior approaches were adopted to better address thoracic disc pathology, namely central and calcific discs. While thoracotomy has been suggested to be the "gold standard" visualization for thoracic pathology, the associated morbidity negates much of the benefits. Following thoracotomy, overall complication rates have been reported as high as 150% (5) with blood loss measured in liters (7,22), length of hospital stay measured in weeks (6,22,25,26), and post thoracotomy pain persisting in as many as 30% of patients 5 years postoperatively (27).

Modern minimally disruptive procedures that use specialized retractors for direct visualization and standard surgical techniques with minimal soft tissue dissection have emerged as viable options for thoracic discectomy (2,13-16). In the current study, three patients were successfully treated with a mini-open lateral approach for treatment of degenerative thoracic pathology (*Tables 1*,*2*). No intraoperative complications were observed and in each case, EBL was less than 50 mL. All patients were discharged 5 days postoperatively. Two patients experienced full symptom resolution and returned to full-time work by 3 months postoperative. One patient reported mild persistent pain postoperatively, but returned to full-time work at 6 months. Two patients were fused at 6-month follow-up and the remaining patient was fused at 12 months. At 24 month follow-up patients reported mean improvements of 83.3% in VAS, 75.3% in ODI, and 79.2% and 17.4% in SF-36 PCS and MCS, respectively.

Three contemporary studies have reported similar outcomes using this approach for thoracic pathology. Deviren *et al*. (15) reported outcomes in 12 patients who were treated with LIF for thoracic disc herniations with an average follow-up of 28 months. All patients had chest tubes inserted for 24 hours postoperatively. Average hospital stay was 5 days. Two complications were observed: one pleural effusion and one case of intercostal neuralgia. Patient pain (VAS) improved from 9 to 3 (67%) preoperatively to last follow-up. All 8 patients with preoperative myelopathy improved postoperatively.

In a 22 patient study by Karikari *et al*. (28) three patients were treated for thoracic disc herniations. Average blood loss and hospital stay were 67 mL and 3.7 days, respectively. Peri or postoperative complications were not encountered through an average of 17 months follow-up. All patients had evidence of radiographic fusion. Improvement in VAS averaged 46% (8.3 to 4.5) from preoperative to last follow-up.

In a multicenter study by Uribe *et al*. (2), 60 consecutive patients underwent LIF for thoracic disc herniation with an average follow-up of 11 months. Median operative time was 182 minutes with 290 mL blood loss and 5 days hospital stay. Minor complications occurred in 7% of patients. Four patients had major complications including pneumonia, extrapleural free air, new lower extremity weakness, and wound infection in posterior hardware. From preoperative to last follow-up, VAS improved 60% (7.8 to 3.1). Symptomatology substantially improved: myelopathy improved in 83%, radiculopathy improved in 87%, and back pain improved in 91% of cases. At last follow-up, 80% of patients experienced "excellent" or "good" overall outcomes, with 15% exhibiting "fair" or "unchanged" outcomes, and only 5% categorized as "poor".

Direct lateral surgery has proven to be an effective procedure when treating lumbar pathologies, given

the minimally disruptive approach and preservation of stabilizing, anatomical structures. This study is a representative case series of commonly seen thoracic pathologies, central cord compression, nerve root compression and symptomatic disc degeneration, with which this technique can be adopted.

Conclusions

Treatment of thoracic degenerative disease with a minimally invasive lateral technique for discectomy and interbody fusion has only recently been reported. Our results are consistent with the literature in showing both efficacy in symptom resolution and fusion, but with substantially decreased procedural morbidity compared to conventional open approaches. Additionally, the procedure can be performed without an access surgeon, rib resection or lung deflation. Although only a limited number of cases are reported in this study, the positive outcomes presented are encouraging for the future treatment of thoracic disc pathologies with the LIF approach.

Acknowledgements

None.

Footnote

Conflicts of Interest: GM. Malham has received travel support from Medtronic, NuVasive and Stryker.

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Cite this article as: Malham GM, Parker RM. Treatment of symptomatic thoracic disc herniations with lateral interbody fusion. J Spine Surg 2015;1(1):86-93. doi: 10.3978/j.issn.2414-469X.2015.10.02

Contributions: (I) Conception and design: GM Malham; (II) Administrative support: RM Parker; (III) Provision of study materials or patients: GM Malham; (IV) Collection and assembly of data: RM Parker; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

