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Results of hemivertebrectomy and fusion for symptomatic thoracic disc herniation

Received: 25 February 2002
Revised: 30 May 2002
Accepted: 7 June 2002
Published online: 22 October 2002
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Abstract We retrospectively analysed ten consecutive patients (age range 32–77 years) treated surgically from 1994 to 1999 for symptomatic thoracic disc herniation between the 6th and 12th thoracic discs. Clinically, eight patients had varying grades of back pain and eight patients had paraparesis. Radiography showed calcification in 50% of the herniated discs. Two patients had two-level thoracic disc herniation. Hemivertebrectomy followed by discectomy and fusion was carried out in all patients. Instrumentation with cages was performed in eight patients and bone grafting alone in two patients. The average follow-up was 24 months (range 13–36 months). Six patients had an excellent or good outcome, three had a fair outcome and one had a poor outcome. One patient had atelectasis, which recovered within 2 days of surgery. Another patient had devel-

oped complete paraplegia, detected at surgery by SSEPs, and underwent resurgery following magnetic resonance (MR) scan with complete corpectomy and instrumented fusion. At 2 years, she had a functional recovery. The patient with poor outcome had undergone a previous discectomy at T9/10. He developed severe back pain and generalised hyper-reflexia following corpectomy and fusion for disc herniation at T10/11. We advocate anterior trans-thoracic discectomy following partial corpectomy for symptomatic thoracic disc herniation between the 6th and 12th thoracic discs. This procedure offers improved access to the thoracic disc for an instrumented fusion, which is likely to decrease the risk of iatrogenic injury to the spinal cord.

Keywords Thoracic disc herniation · Hemivertebrectomy · Thoracic discectomy

Introduction

Thoracic disc herniation is a common finding on magnetic resonance imaging (MRI) in asymptomatic individuals. Wood et al. reported a prevalence of 37%, with deformation of the spinal cord occurring in 26% of cases [31]. Herniated discs can occur at any level in the thoracic spine; however, the majority occur at caudal levels, with the highest frequency between the T8 and T11 vertebra, and most are located in a central or centro-lateral position [1, 2, 7].

It has been estimated that the annual incidence of symptomatic thoracic disc herniation is one patient per million population [8, 21]. Patients may present with a variety of vague symptoms, with most reporting varying grades of back pain with or without symptoms of radiculopathy or myelopathy. Establishing the diagnosis of thoracic disc herniation and the specific level of involvement is done most accurately with MRI [7, 31]. Most symptomatic thoracic disc herniations can be managed favourably with non-operative treatments [7].

Surgery for thoracic disc herniation accounts for less than 2% of all disc surgery [18, 20]. Surgical treatment is

Table 1 Clinical data before and after surgery for thoracic disc herniation

Case	Age	Sex	Level (MRI diagnosis)	Symptoms (back pain, motor power, sensory loss, weakness)	Motor power	Sensory loss	Urinary symptoms	Operation	Complications	Improvement			Outcome	
										Back pain	Motor ^a	Sensory		Sphincter
1	48	M	T7/8 & T10/11	No back pain, bilat. leg weakness (3 mths)	Gr 4+	None	Mild (urgency)	T7/8 discectomy, T10/11 partial corpectomy & bone graft	None	Mod	Gr 5	None	Recovered	Fair
2	48	F	T9/10	Back pain (6 mths), left foot drop	Gr 0 in left L4 & L5, wheel-chair	Bilat. below T9	Severe incont.	T9 partial corpectomy, Moss cage & bone graft + Ventrofix	None	Mild	Gr 4	Complete	Recovered	Good
3	31	F	T11/12	Back pain (6 mths), left leg weakness	Gr 3+	Bilat. below L3	None	T12 partial corpectomy, Moss cage & bone graft + Ventrofix	None	Severe	Gr 5	Complete	Recovered	Fair
4	77	M	T9/10	Back pain (1 mth), bilat. leg weakness	Gr 2, wheel-chair	Bilat. below T10	Mod. incont.	T10 partial corpectomy, Moss cage & bone graft + ant. fixation	Atelectasis, ventilator for 2 days	None	Gr 5	Complete	Recovered	Excellent
5	32	F	T6/7	Severe back pain (3 yrs)	Gr 5	None	None	T7 discectomy, partial corpectomy + bone graft	None	Mod.	Gr 5	None	None	Fair
6	61	F	T10/11	Severe back pain (10 yrs), bilat. leg weakness (2 mths)	Gr 1, wheel-chair	Bilat. below T10	Severe incont., loss of sensation	T10 partial corpectomy, Moss cage, graft + ant. fixation	None	Occasional	Gr 4	Complete	Recovered	Good
7	51	M	T10/11, previous discectomy at T9/10	No back pain, right leg weakness (1 wk)	Gr 2, wheel-chair	Bilat. below L1	None	T11 partial corpectomy, Moss cage, bone graft + ant. fixation	None	Severe	Gr 4, generalised hyper-reflexia	Complete	None	Poor
8	48	F	T7/8	Back pain (3 mths), bilat. leg weakness (5 wk)	Gr 3, wheel-chair	Bilat. below T7	Mod. incont.	T8 partial corpectomy, Moss cage, bone graft + ant. fixation	Immediate complete loss of motor function on SSEPs, MRI, T8 total corpectomy, re-insertion of large Moss cage	None	Gr 4, independent crutch walker	Complete	Recovered	Good

Table 1 (continued)

Case	Age	Sex	Level (MRI diagnosis)	Symptoms (back pain, weakness)	Motor power	Sensory loss	Urinary symptoms	Operation	Complications	Improvement			Outcome
										Back pain	Motor ^a	Sensory	Sphincter
9	54	M	T10/11	Back pain (1 mth), bilat. leg weakness	Gr 2, wheel-chair	Bilat. below T11	Mod incont.	T11 partial corpectomy, Moss cage, bone graft + ant. fixation	None	None	Gr 5,	Complete	Recovered
10	49	M	T11/12	Back pain (3 mths), bilat. leg weakness	Gr 2 (left), Gr 4 (right)	Bilat. below L1	Mild	T12 partial corpectomy, Syncage, bone grafts + Ventrofix	None	None	Gr 4 (left), Gr 5 (right)	Complete	Recovered
													Excellent

^a According to the Medical Research Council grading system

indicated in patients with neurological deficit or intractable thoracic back pain. Laminectomy with or without discectomy has been associated with uniformly poor results and higher complication rates [3, 16, 19]. Surgical outcomes have been significantly improved with the widespread adoption of posterolateral and transthoracic approaches for thoracic discectomy. The transthoracic approach for central and centrolateral disc herniations provides better visualization of the disc and allows a more direct and complete decompression of the spinal canal [6, 9, 11, 20, 23, 24, 25, 26, 28, 29, 30].

Mulier and Dubois reported partial or total neurological recovery in 93% of patients after a transthoracic approach, versus 87% recovery after posterolateral approaches [23]. The role of partial or complete vertebrectomy and the need for interbody fusion with or without spinal instrumentation have not been clearly determined in the literature.

The purpose of this paper is to report the short-term results of transthoracic hemivertebrectomy, decompression of the spinal canal, and interbody fusion with or without instrumentation.

Materials and methods

Ten consecutive patients (five male, five female) were treated surgically for symptomatic thoracic disc herniation between 1994 and 1999 by the two senior authors (J.K.W. and S.M.H.M.). The average age of the patients at presentation was 50 years (range 32–77 years). The duration of symptoms prior to treatment ranged from 1 week to 10 years. All patients had some degree of thoracic back pain. The initial neurological evaluation demonstrated weakness and spasticity of varying grades in eight patients, of whom five had paraplegia with inability to ambulate and three had monoparesis. Motor strength was graded using the classification of the Medical Research Council. Pre-operatively, two patients had grade 0 or 1 power, five patients had grade 2 or 3 power, one had grade 4 and the remaining two had normal power in the lower limb muscle groups. Two patients had isolated weakness of L4 and L5 myotomes in the left side (grade 0 and grade 3 respectively). Five of these patients had complete sensory loss caudal to the level of disc herniation. Complaints of sphincter dysfunction were noted in seven patients, and consisted primarily of incontinence or retention (Table 1).

All patients underwent anteroposterior and lateral roentgenograms and MRI of the thoracic spine. Calcified discs were seen on plain roentgenograms in five patients. The levels of disc herniation were as follows: T6/7 ($n=1$), T7/8 ($n=2$), T9/10 ($n=2$), T10/11 ($n=4$) and T11/12 ($n=2$). One patient had two herniations involving the T7/8 and T10/11 levels. One patient with a T10/11 herniation had undergone surgery for a T9/10 disc herniation 10 years previously.

Surgical technique

Somatosensory evoked potential monitoring (surface electrodes) was utilized in all cases. The proximal recording electrodes were placed at C2 and C7, with stimulating electrodes at the ankle. Under general anaesthesia, the patient was placed in the lateral decubitus position with the midportion of the spine flexed to afford a good exposure. A left-sided transpleural anterior approach was used in nine patients, and one patient had right-sided approach. The

Table 2 Classification of results of thoracic discectomy and fusion

Evaluation	Criteria
Excellent	Asymptomatic, full activity, no back pain
Good	Mild spasticity or weakness of legs, return to work, occasional back pain necessitating analgesia
Fair	Mild to moderate spasticity or weakness of legs, return to light work, moderate back pain necessitating regular analgesia
Poor	Mild or no motor improvement, severe disabling back pain

thoracotomy was done at the level of the rib corresponding to the level of the herniation. The appropriate caudad rib was followed to its base and excised subperiosteally. Identification of the appropriate operative level for excision of the disc was confirmed with a needle and X-ray. The segmental vessels were usually ligated one level above and below the disc space away from the foramen. Following adequate exposure, the majority of the disc (except the posterior annulus and herniation) and cartilaginous endplate was removed with curettes and pituitary rongeurs. A partial vertebrectomy was performed by creating a trough in the lateral portion of the caudal vertebral body and, if necessary, in the cephalad body as well. The extent of bone resection was dependent upon the size and location of the disc herniation, and enough bone was removed to visualize the spinal canal above and below the site of compression. A high-speed burr was used to deepen the trough and resect the cancellous bone of the posterior portion of each vertebral body, leaving the posterior cortex and the protruding disc intact. The remaining posterior vertebral cortices, herniated disc material, and posterior longitudinal ligament were then carefully dissected away from the dura with a curette, thereby completing the decompression.

Two patients in this series had strut grafting with autogenous tricortical iliac crest and rib bone without instrumentation. Seven patients had insertion of Moss cages (DePuy AcroMed, UK) packed with autogenous iliac crest cancellous grafts, and one patient had a Syncage & Ventrofix (AO Synthes, Switzerland) inserted, packed with cancellous bone graft. All patients with a cage had supplemental anterior instrumentation with vertebral body screws and single-rod construct (Mehdian anterior spinal system – Corin Spinal systems, Gloucestershire, UK). Following adequate haemostasis, a chest tube was inserted, followed by closure of the surgical wound. One patient developed complete paraplegia immediately after surgery, underwent re-exploration within 1 h, received a complete vertebrectomy with further decompression, and a larger Moss cage was reinserted with substantial recovery. All patients wore a TLSO brace for 10–12 weeks until interbody fusion was apparent on plain radiographs.

Clinical outcomes were rated according to the classification in Table 2.

Results

Overall clinical outcomes demonstrated six excellent or good results, three fair and one poor.

One of the three patients who had a good result still had a persistent left foot drop, though there was improvement by two grades compared to the preoperative level of motor weakness and the patient walked without assistive devices. Another patient in this group, who had history of back pain going back 10 years and paraparesis of gradual

onset (2 months) had improved motor function by three grades in the lower limbs and had occasional back pain following surgery.

A young woman presenting with monoparesis had a fair result. She complained of persistent back pain necessitating regular analgesia. She had two grades of motor improvement in her left leg, with no residual weakness. Another patient who had back pain with subjective neurological symptoms had a fair result following two-level discectomy and fusion with autogenous bone grafts. He complained of persistent severe back pain. The patient who had the poor result had undergone a previous T9/10 discectomy and autogenous grafting 10 years earlier through an antero-lateral approach. He had few complaints after the first surgery, and presented with right leg weakness (same side as the previous operation) of 1-week duration due to new herniation at the T10/11 level. His thoracic discectomy, hemivertebrectomy and fusion with Moss cage was uncomplicated, and although his neurologic deficit improved he continued to experience lower extremity spasticity and severe back pain.

Complications

One elderly patient with a T9/10 disc herniation developed postoperative atelectasis requiring 2 days of assisted ventilation, and made an unremarkable recovery thereafter.

Fig. 1 Radiograph (lateral view) of a 48-year-old woman with MRC (Medical Research Council) grade 3 weakness in the lower limbs and moderate mid-thoracic back pain showing calcified thoracic disc at T7/8

Fig.2 Magnetic resonance imaging (MRI) scan (T2-weighted) showing thoracic disc herniation at T7/8 with spinal cord compression

A 48-year-old woman with a calcified disc herniation at T7/8 (Fig. 1, Fig. 2) and grade 3 pre-operative motor weakness developed significant spinal cord monitoring changes intra-operatively. Upon awakening, she was noted to have complete paraplegia. A chest radiograph (Fig. 3A) followed

by an emergency MRI scan showed a remnant of calcified disc compressing the spinal cord (Fig. 3B). She underwent emergency re-exploration with additional T7 and T8 corpectomy to facilitate decompression of the residual disc material that had displaced into the spinal cord. A larger Moss cage was placed and fusion and instrumentation was extended an additional two levels (Fig. 4). She subsequently recovered her motor function to grade 4 power in both lower limbs and was ambulatory with support at 2 years.

Discussion

As demonstrated in other studies, the distribution of symptomatic disc herniations in our patients tended to be in the lower region of the thoracic spine [1, 6, 7, 18, 24]. The presenting symptoms and neurologic deficits experienced in our patient group were also similar to those reported in the literature [2, 3, 4, 5, 7, 8, 12]. The spinal cord dysfunction and neurologic deficits associated with thoracic disc herniations are the result of anterior spinal cord compression and vascular compromise [2, 4, 8, 14, 26]. All the patients in this study had central or centro-lateral herniations. Dystrophic calcification is reported to occur in 30–70% of cases of thoracic disc herniations, and is often associated with more severe neurologic dysfunction [19]. Fifty percent of the patients in this study had calcification of the herniated disc material. Calcified discs are also more likely to be adherent to the dura, making their removal more difficult [13, 17, 30].

The primary goals of surgical treatment for thoracic disc herniations are to achieve complete decompression of the spinal cord and/or nerve root, avoid iatrogenic spinal

Fig.3 **A** Immediate post-operative chest radiograph demonstrating Moss cage and anterior instrumentation. **B** Emergent post-operative MRI scan (T2-weighted) showing further displacement of residual calcified disc material with increased spinal cord compression

Fig. 4 A Post-revision MRI scan (T2-weighted) demonstrating excellent decompression of the spinal canal.

B Two-year follow-up radiograph (anteroposterior view) after emergency revision surgery, showing larger Moss cage in situ with antero-lateral instrumentation

Table 3 Incidence of mortality and neurological deterioration based on surgical approach

Approach	No. of patients	Total mortality (%)	Postoperative neurological deterioration (%)
Laminectomy	63	8 (13)	22 (35)
Transpedicular	41	0	0
Transfacet pedicle sparing	23	0	0
Costotransversectomy	55	0	3 (5.5)
Lateral extracavitary	72	1 (1.4)	1 (1.4)
Transthoracic	140	0	1 (0.7)

cord injury, prevent spinal instability and deformity, and prevent further disc herniation.

A number of surgical approaches have been described to treat symptomatic thoracic disc herniation, and each approach is associated with variable rates of clinical success and potential morbidity (Table 3) [22]. Laminectomy for the treatment of thoracic disc herniations has been largely abandoned owing to poor results and post-operative complications [21, 22]. Transpedicular and transfacet pedicle sparing approaches have the advantage of being less extensive procedures; however, visibility of the anterior spinal canal is very limited and removal of centrally located discs can be problematic [12].

The lateral extracavitary and costotransversectomy approaches can provide a larger area of access and visibility to the posterior and lateral aspect of the vertebrae and disc, but still provide relatively limited exposure of the anterior aspect of the spinal canal. These two procedures increase the risk of potential morbidity [30].

Crafoord et al., in 1958, reported the first transthoracic removal of a T10/11 disc herniation in a patient with spastic paraparesis, and achieved complete neurologic recovery [10]. In 1960, Hulme reported an additional six patients treated via a transthoracic approach, four of whom achieved a good outcome [16].

Transthoracic approaches to the thoracic spine can be performed using a transpleural or extrapleural technique. Otani et al. [24] highlighted the advantages of the extrapleural approach, including the elimination of routine postoperative chest tube drainage and fewer respiratory complications. The transthoracic approach requires some resection of the vertebral endplates and vertebral body for adequate visualisation of the spinal canal and safe removal of the herniated disc [22]. Stillerman and Weiss and others have reported the technical advantages of transthoracic transpleural dissection and partial vertebrectomy to obtain access to the anterolateral dural surface [4, 6, 29, 30].

Thoracoscopic discectomy is associated with a steep learning curve, and is best indicated for small, lateral, uncalcified herniated discs or in patients who are at high medical risk [15, 30]. It is much more technically demanding to perform vertebral corpectomy and instrumented fusion with the video-assisted thoracoscopic approach [27].

Most symptomatic thoracic disc herniations causing spinal cord compression are located in a central or centro-lateral position, are often calcified and may be adherent to the dura. They are therefore probably best treated via a direct anterior transthoracic approach [12, 14]. Guidelines for choosing the most appropriate surgical approach to a thoracic disc herniation have been proposed by Stillerman et al. [30], and include consideration of the patient's gen-

eral health, symptoms and signs, location of the disc herniation and surgeon experience.

Mulier and Debois reviewed 324 patients from the literature with seven of their own who had undergone transthoracic discectomy. Transient pulmonary complications occurred in 7% of cases [23]. The results were compared with cases where a postero-lateral approach was used, and they found that neurologic outcomes were better when the transthoracic approach was used. Bohlman and Zdeblick reported excellent or good outcomes in 16 out of 19 patients after transthoracic approach, partial vertebral endplate and body resection and anterior decompression with or without fusion [6].

Arthrodesis of the segment involved, following discectomy with strut rib grafts and autogenous cancellous iliac grafts, has been in practice for quite some time, with variable success rates of fusion [8, 23, 28].

Based on the experience of our ten patients, we feel that a more extensive hemivertebrectomy through a transthoracic approach for removal of herniated thoracic discs offers several advantages over a more limited approach. These include better exposure and direct visualization of the site of cord compression, greater ease and safety when removing the posterior vertebral cortex and herniated disc, enhanced ability to dissect adherent calcified disc from the dura by developing normal tissue planes cephalad and caudad to the lesion, and the ability to deal with two contiguous herniated discs by one-level vertebrectomy.

Interbody arthrodesis following thoracic discectomy is recommended by many authors to address potential instability, deformity and pain associated with hemivertebrec-

tomy [11, 23, 30]. All our patients had an interbody fusion to reconstruct the anterior column defect. Eight of our patients had an interbody fusion with a cage supplemented by anterior instrumentation. Cages were found to have advantages over autogenous strut grafts in the following ways:

1. They provide immediate stability at the level of the vertebrectomy
2. They maintain height and sagittal alignment of the segment
3. They eliminate the additional morbidity associated with harvesting a structural iliac crest graft, and
4. They hold the cancellous bone in place until bony union occurs.

Anterolateral instrumentation was utilized in all the patients with a cage to enhance stability of the construct, prevent cage dislodgement and minimize the need for post-operative brace immobilisation.

Conclusion

Large calcified central or centro-lateral thoracic disc herniation with or without neurological compromise may be best approached by a transthoracic transpleural hemivertebrectomy. Following discectomy and spinal decompression, the combination of interbody cage with autologous graft plus antero-lateral instrumentation provides immediate spinal stability and reliable fusion, eliminates harvesting large tricortical iliac strut grafts, and prevents late spinal instability, neurologic deterioration and pain.

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