Posterior Thoracic Cage Interbody Fusion (PTCIF) as an Alternative Fusion Technique after Laminectomy in Thoracic and Thoracolumbar Junctional Spine

Hong Kyung Shin¹, Sun Kyu Oh¹, Il Choi², Sang Ryong Jeon¹

¹Department of Neurological Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea
²Department of Neurological Surgery, Dongtan Sacred Heart Hospital, Hallym University College of Medicine, Hwaseong, Korea

Objective: Thoracic spine fusion is used to surgically treat various spine lesions. However, posterior-only thoracic fusion by using the pedicle screw system can be complicated by pseudoarthrosis or instrument failure. Moreover, when laminectomy is performed for decompression, thus exposing the spinal cord in the thoracic spine, the fusion bed where the bone chips are applied for posterolateral fusion may be insufficient. Therefore, we conducted interbody fusion in posterior thoracic approach.

Methods: All patients underwent posterior only approach. After pedicle screw insertion at the decompressed level, the cages packed with autologous bone chips were inserted into interbody disc space and fixation was performed by rod and screw system. Four patients with thoracolumbar spinal injury and three patients with degenerative disease. Bone fusion was defined as the formation of bony continuity between the upper and lower end plates and around the fusion cages in the posterior thoracic cage interbody fusion (PTCIF) level, as determined by computed tomography (CT).

Results: The average follow-up period was 15.3 (range, 8-28) months. All patients with degenerative disease exhibited neurological improvement. Successful bone fusion was confirmed with CT in all patients more than 3 months after PTCIF. Operation-associated complications did not occur and there was no revision operation.

Conclusion: PTCIF was found to be safe and achieved good outcomes for spinal cord decompression and bone fusion in the thoracic and thoracolumbar junctional spine. Therefore, this surgical method could be considered as an alternative procedure for posterior thoracic decompression and fixation surgery.

Key Words: Laminectomy • Spinal cord compression • Spinal fusion • Thoracic vertebrae

INTRODUCTION

Since the thoracolumbar junctional area is highly susceptible to injury, the majority of spinal trauma injuries affect this area, and thoracic spine is a common site for the surgical spinal diseases including infection and neoplastic disease. The pathological lesions in the thoracic or thoracolumbar area that arise from trauma, neoplasm, infection, deformity, and degenerative disease are often treated by surgical removal. However, this procedure often induces instability and deformity that must be treated by thoracic spine fusion.

Posterior thoracic fusion is difficult when posterior decompression is also conducted and the spinal cord is exposed, which can occasionally result in pseudoarthrosis or instrument failure. Therefore, the anterior thoracic approach with interbody fusion was developed. However, anterior thoracic approach may not be familiar with spine surgeons and this procedure is associated with diverse morbidities, especially pulmonary complications. For lumbar lesions, posterior lumbar interbody fusion (PLIF) with pedicle screw fixation is used. This is not only a reliable technique for inducing bone fusion, it is also a safe method that results. PLIF is particularly useful after lumbar laminectomy, which leaves a smaller fusion bed. As a result, PLIF has been widely employed in cases of lumbar spinal lesion where bone fusion is mandatory.

On the basis of these observations, we developed a novel procedure for cases of thoracic decompression and fixation surgery, namely, posterior thoracic cage interbody fusion (PTCIF). It was hypothesized that this procedure, which employs the posterior approach only, would yield good bony fusion and avoid the complications associated with the anterior thoracic approach. The purpose of the present study is to report this novel procedure and its surgical outcomes.
PTCIF was performed on four patients with thoracolumbar spinal injury and three patients with degenerative disease between 2012 and 2014 in Asan Medical Center (a tertiary care hospital) in Seoul, Korea. These patients were on average 48.1 (range, 28-67) years old and their average follow-up period was 15.3 (range, 8-28) months. Four had spinal injury and three had degenerative disease, namely, thoracic spinal stenosis with hypertrophied ligamentum flavum (n=2) and degenerative thoracic spondylolisthesis (n=1). PTCIF was performed at T11-L2 in three cases, T12-L1 in two cases, and T10-12 in one case and T12-L2 in one case (Table 1).

All patients underwent preoperative magnetic resonance imaging (MRI) and computed tomography (CT) to diagnose the lesions and to determine the levels that required operation. The preoperative and postoperative neurological status was measured by using American spinal injury association impairment scale12). Bone fusion was defined as the formation of bony continuity between the upper and lower end plates and around the fusion cages in the PTCIF level, as determined using CT21).

1. Surgical Technique

The patient lay in the prone position on the spine table after receiving general anesthesia. A midline skin incision was made and the vertebral body and lamina were exposed. Pedicle screws (SMC, Tae Yeon Medical Co., Ltd., Wonju, Korea) were inserted bilaterally at all of the segments that were to be fixed, including the upper and lower pedicles of the cage-inserting level. The spinous process and lamina were removed using rongeurs and a Kerrison punch. Bilateral facetectomies at the main lesion level were then performed with small rongeurs and a high speed air drill. Bilateral radical discectomy was performed following the incision of the annulus. The intervertebral disc was removed as much as possible by using microforceps. A shaver with a height of 8 mm was inserted horizontally into the disc space and turned 90° to remove the endplates. And then, angled curette was used to remove the remnant disc material and to clear the fusion bed site. Before cage insertion, autologous bone chips with or without hydroxypatite bone chips were placed into the disc space to enhance fusion. Thereafter, cages (Neo-IC lumbar cage; U&I Corporation, Uijeongbu, Korea) packed with local bone chips obtained from laminectomy were inserted under the guidance of C-arm while the disc space was distracted by a pedicle screw distractor. The rods were applied so that they connected the pedicle screws and were fixed bilaterally while the disc space was compressed by a pedicle screw compressor. Intraoperative evoked potential (IEP) monitoring was conducted in the patients with degenerative disease. It was not conducted in patients with trauma who showed complete paraplegia.

Table 1. Summary of demographics and surgical outcomes in 7 patients

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age/Gender</th>
<th>Diagnosis</th>
<th>Level of PTCIF</th>
<th>Characteristic of cage</th>
<th>AIS, muscle power (Gr)</th>
<th>Follow-up (months)</th>
<th>Fusion state</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49/M</td>
<td>Fracture-dislocation, T12-L1 and burst fracture, L1</td>
<td>T12-L1</td>
<td>8 mm, 0°</td>
<td>A, Gr 0</td>
<td>28</td>
<td>Well fused</td>
<td>none</td>
</tr>
<tr>
<td>2</td>
<td>57/M</td>
<td>Stenosis, T10-11, 11-12 with HLF</td>
<td>T10-11, T11-12</td>
<td>8 mm, 0°</td>
<td>C, Gr 2-3, D, Gr 4</td>
<td>18</td>
<td>Well fused</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td>49/M</td>
<td>Fracture-dislocation, T11-12 and burst fracture, T12</td>
<td>T11-12</td>
<td>10 mm, 0°</td>
<td>A, Gr 0</td>
<td>17</td>
<td>Well fused</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>67/F</td>
<td>Stenosis, T12-L1 with HLF</td>
<td>T12-L1</td>
<td>8 mm, 4°</td>
<td>D, Gr 4+</td>
<td>14</td>
<td>Well fused</td>
<td>none</td>
</tr>
<tr>
<td>5</td>
<td>54/F</td>
<td>Degenerative spondylolisthesis, T11-12</td>
<td>T11-12</td>
<td>8 mm, 4°</td>
<td>D, Gr 4</td>
<td>12</td>
<td>Well fused</td>
<td>none</td>
</tr>
<tr>
<td>6</td>
<td>33/F</td>
<td>Burst fracture, L1</td>
<td>T12-L1, L1-2</td>
<td>8 mm, 4°; 10 mm, 8°</td>
<td>D, Gr 4</td>
<td>10</td>
<td>Well fused</td>
<td>none</td>
</tr>
<tr>
<td>7</td>
<td>28/M</td>
<td>Fracture-dislocation, T11-12</td>
<td>T11-12</td>
<td>12 mm, 8°</td>
<td>A, Gr 0</td>
<td>8</td>
<td>Well fused</td>
<td>none</td>
</tr>
</tbody>
</table>

PTCIF: posterior thoracic cage interbody fusion; AIS: American spinal injury association impairment scale; Gr: grade; HLF: hypertrophied ligamentum flavum.
Fig. 1. A 49-year-old man with fracture-dislocation at T12-L1 and burst fracture at L1. Preoperative sagittal T2-weighted magnetic resonance imaging (A) shows severe spinal cord compression and bony fragments. Preoperative sagittal computed tomography (CT) (B) reveals a L1 burst fracture and anterior dislocation of the T12 vertebral body. The posterior thoracic cage interbody fusion (PTCIF) at T12-L1 is shown on the postoperative X-ray (C, D). Postoperative CT (E, F) 19 months after surgery shows bone continuity between T12 and L1, which indicates successful bone fusion of the PTCIF level. At that time point, the patient could sit on a wheelchair but his motor function did not improve due to complete cord injury.

Fig. 2. A 54-year-old woman with myelopathy. Preoperative sagittal T2-weighted magnetic resonance imaging (MRI) (A) and axial T2-weighted MRI (B) demonstrate degenerative spondylolisthesis with central canal stenosis and signal change in the spinal cord at T11-L2. Postoperative X-ray (C, D) shows the posterior thoracic cage interbody fusion (PTCIF) at T11-L2. Postoperative computed tomography (E, F) 3 months after the surgery indicate successful bony fusion of the PTCIF level. The patient had initially been admitted to the hospital because of left leg weakness (grade 4). However, 3 months after the operation, the neurological function of the patient had returned to normal.

RESULTS

PTCIF was performed at a single level in five patients and at two levels in one patient. During the operation, intraoperative complications such as dural tear or spinal cord injury did not occur and the cages could be inserted without spinal cord retraction or manipulation. The sensory and motor IEP, which was performed in the patients with degenerative disease to identify any subclinical spinal cord injury during the operation, revealed that significant changes did not occur. After the operation, all patients with degenerative disease exhibited neurological improvement. None developed surgery-related neurological complications after the operation (Table 1).

Follow-up CT revealed that all seven patients had successful bone fusion, namely, the formation of bony continuity between the upper and lower end plates and around the interbody cages in the PTCIF level (panels E, F in Figs. 1, 2). During the follow-up period, cage migration or halo formation around the cages and screws were not observed. Moreover, none of the patients reported permanent or transient complications associated with the operation or delayed complications such as postoperative delayed infection or postspinal surgery pain syndrome.

DISCUSSION

To induce bone fusion in the thoracic and thoracolumbar region after using the posterior approach, pedicle screw fixation with posterolateral fusion is used widely. However, when the spinal cord is exposed after a decompression procedure, thoracic posterolateral fusion can become complicated because the laminectomy for spinal cord decompression leaves an insufficient fusion bed for the application of bone chips. This means that lateral wide exposure to the rib head is needed to generate sufficient fusion space. This lateral wide exposure can cause muscle atrophy and chronic postoperative wound pain. Moreover, the bone chips placed on the fusion bed could migrate to the laminectomy site and cause spinal cord compression. Compared to this posterolateral fusion procedure, posterior interbody fusion has several theoretical advantages. First, interbody fusion using cages packed with bone chips may provide
the anterior spinal column with immediate load-bearing capacity and may help to maintain the intervertebral disc space. Second, interbody fusion may promote more spinal fusion than posterolateral fusion because it yields a larger fusion bed and weight loading (Wolff’s law). These theoretical advantages of cage interbody fusion in thoracic spine are supported by the many previous reports on lumbar fusion which showed that patients who underwent PLIF had better fusion rates or clinical outcomes than patients who underwent posterolateral fusion.

In the present study, the PLIF technique was adapted to be used in the thoracic and thoracolumbar junctional spine. In general, cage insertion into the intervertebral disc space through the posterior thoracic approach is more challenging because the thoracic spine has a smaller vertebral canal than the lumbar spine. Moreover, the dural sac cannot be retracted from side to side in the thoracic area, unlike in the lumbar area. For this reason, various anterior thoracic approaches or modified posterior thoracic approaches, including the costotransversectomy or lateral extracavitary approaches, were developed to procure the interbody space needed to apply the fusion materials. However, by using the techniques described in the Methods section, we could approach the intervertebral disc space and insert cages without any spinal cord retraction or manipulation. One previous study has also reported a posterior thoracic interbody fusion (PTIF) technique, although it does not employ cages. Yamashiki et al. reported the cases of 11 patients with thoracic disc herniation who were treated with the PTIF procedure. This procedure involved bilateral facetectomies and the insertion of bone chips only. The clinical outcomes of the patients were excellent, although one patient developed pseudoarthrosis. There is also a case report of T4 burst fracture that was treated by PTIF using a cage. In this case report, the unilateral pedicle and bilateral nerve roots had to be removed to acquire enough space for large cage insertion. By contrast, in our present study, an operative field that was sufficient for the insertion of the cage could be obtained by removing the lamina and facet joints only; the violation of other structures was not necessary. The method reported here is distinct from the previously reported methods in that it employs cages and spares the adjacent pedicles for insertion of the screws. It is easy to acquire sufficient space for inserting the cages by distracting the adjacent pedicle screws. It is also critical to prevent retropulsion of the cages by compressing and fixing of the pedicle screws and rods.

The average thoracic disc is smaller than the lumbar disc and the spine is also aligned differently in these two regions (i.e., kyphotic in the thoracic spine and lordotic in the lumbar spine). At present, the PLIF device is relatively challenging to use in thoracic spine, as the instruments are designed for use in the lumbar disc space. Thus, operation devices for the thoracic area (including cages and shavers) should be developed. We used PLIF cages with a 4° and 8° lordotic angle in the four patients to prevent cage retropulsion but we do not know yet whether a kyphotic angled cage would be beneficial for maintaining a normal kyphotic thoracic angle or whether a lordotic angled cage would help to prevent retropulsion. Such device-related outcomes warrant further evaluation.

This study has a few limitations. First, the number of enrolled cases was small and the follow-up period after the procedure was short. Second, PTIF was only used in patients with spinal injury and degenerative disease. There are also several other diseases that require treatment by posterior thoracic decompression and fusion, including infection, deformity, and neoplasms. Third, all seven cases involved short segment cage insertion only. Therefore, the extended indications of this novel procedure cannot be defined as yet. However, it is likely that when the surgical instruments for PTIF are developed, the indications and safety of this novel procedure will become clearer.

CONCLUSION

The present study examined the safety and fusion outcomes of a novel technique, namely, posterior interbody fusion using cages packed with autologous bone chips after posterior decompression in the thoracic and thoracolumbar junctional spine. PTIF was found to be safe and achieved good outcomes for spinal cord decompression and bone fusion. Moreover, spine surgeons might be very familiar with PTIF because this procedure has been already performed in various lumbar fusion operations. This procedure may be particularly helpful to patients who cannot be undertaken anterior thoracic approach because of comorbidity. Therefore, the authors propose that PTIF may be a good alternative procedure for posterior thoracic decompression and fusion surgery.

Disclosure

The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

REFERENCES

2. Cheng L, Nie L, Zhang L: Posterior lumbar interbody fusion

8 www.thenerve.net
versus posterolateral fusion in spondylolisthesis: a prospective controlled study in the Han nationality. Int Orthop 33:1043-1047, 2009


