ASIAN SPINE JOURNAL
Clinical Study
Asian Spine J 2016;10(1):85-92 • http://dx.doi.org/10.4184/asj.2016.10.1.85

Efficacy of Titanium Mesh Cages for Anterior Column Reconstruction after Thoracolumbar Corpectomy

Khaled Abdeen

Department of Neurosurgery, Faculty of Medicine, Alexandria University, Alexandria, Egypt

Study Design: This retrospective study was conducted to determine the safety and efficacy of titanium cage reconstruction and anterior plating after thoracolumbar corpectomy.

Purpose: To study the clinical and radiological outcome of anterior column reconstruction after thoracolumbar corpectomy.

Overview of Literature: Anterior column reconstruction aims to optimize neural decompression with adequate stabilization.

Methods: A series of 16 patients underwent reconstruction after thoracolumbar corpectomy to treat injury due to trauma (n=10), tuberculosis (n=3), and tumor (n=3). The average duration of follow-up was 18 months (range, 8–58 months). The degree of kyphosis, construct height, and the subsidence of the cage in relation to the vertebral endplates were measured. The approach was thoracoabdominal in 10 cases and retroperitoneal in 6 cases.

Results: Four patients were neurologically intact with Frankel grade E on admission, and all remained intact postoperatively. Of the 6 patients with Frankel grade D, all fully recovered full motor and sensory functions. Of the 6 patients with Frankel grade C, three improved one grade and the other three improved two grades. The mean height of the vertebra before surgery was 41 mm and the mean construct height immediately after surgery and at follow-up was 47 mm and 44 mm, respectively. Solid fusion was observed in all patients. The sagittal alignment of the fractured segment was restored immediately after surgery as a significant decrease in the local kyphotic angle.

Conclusions: Anterior instrumentation is an effective and safe treatment for thoracolumbar instability with satisfactory clinical and radiological outcomes.

Keywords: Thoracolumbar; Anterior column; Reconstruction

Introduction

The optimal treatment of unstable thoracolumbar spine due to trauma, tumors, and tuberculous spondylitis remains controversial. Primary goals in management of thoracolumbar instability are preservation of remaining spinal cord function, restoring spinal alignment, maximizing neurological recovery and early rehabilitation. This can be achieved by optimizing neural decompression, while providing stable internal fixation over the least number of spinal segments [1].

Of the anterior, posterior and combined approaches, it remains debatable which is best [2]. Decompression and stabilization of the thoracolumbar spine can be done

Received May 7, 2015; Revised Jun 4, 2015; Accepted Jun 4, 2015
Corresponding author: Khaled Abdeen
Department of Neurosurgery, Faculty of Medicine, Alexandria University, Alexandria, Ramal Station 11534- Egypt
Tel: +00966 1462200, Fax: +966-11464-0506, E-mail: khaledabdeen@hotmail.com

through the anterolateral or posterior approach. Posterior stabilization generally requires the instrumentation be placed two levels above and below the site of the injury [3,4]. The anterolateral and posterior approaches produce favorable results [3,5] and complications [6]. The main intent of the anterior approach is to enable decompression by corpectomy while allowing reconstruction of the anterior spine [7].

Anterior decompression and reconstruction supplemented with instrumentation is generally believed to be superior to fixation with posterior pedicle screw instrumentation for highly unstable thoracolumbar spine. However, the indications and methods for the anterior approach have not been fully documented [8,9].

This study evaluated the clinical and radiological results of anterior reconstruction and instrumentation using titanium mesh cages after thoracolumbar corpectomy.

Materials and Methods

1. Patients

Sixteen patients (10 males, 6 females) underwent reconstruction using cylinderical titanium mesh cages and plating after thoracolumbar corpectomy performed to treat trauma (n=10), tuberculosis (n=3), metastatic deposit (n=2) and myeloma (n=1). The mean age of the patients was 43.5 years. Clinical assessment was performed preoperatively, during the early postoperative period, before discharge of the patient and at follow-up at least one year after surgery. Neurological status was assessed using Frankel motor score system. Inclusion criteria included patients with incomplete paraplegia, radiologi-cal evidence of mechanical instability, canal compromise >40% and 50% loss of vertebral body height depending on Load Sharing Classification (Fig.1). The aver-age duration of follow-up was 18 months (range, 8–58 months) following single-level reconstruction in trauma and tumor cases and two-level corpectomy in tuberculous spondylitis cases.

2. Operative techniques

The surgical approach was thoracoabdominal in 10 cases and retroperitoneal in 6 cases. A left-sided approach was preferred to avoid retraction of the liver and inferior vena cava. In the thoracolumbar approach, exposure above and below the diaphragm was needed to obtain an adequate working area for decompression and instrument placement. All patients underwent corpectomy and decompression of the spinal canal with anterior column reconstruction using a cylinderical titanium mesh cage. Great care was taken to preserve the bony endplates as much as possible while preparing the endplates after corpectomy. The inferior and superior ends of the cage were trimmed

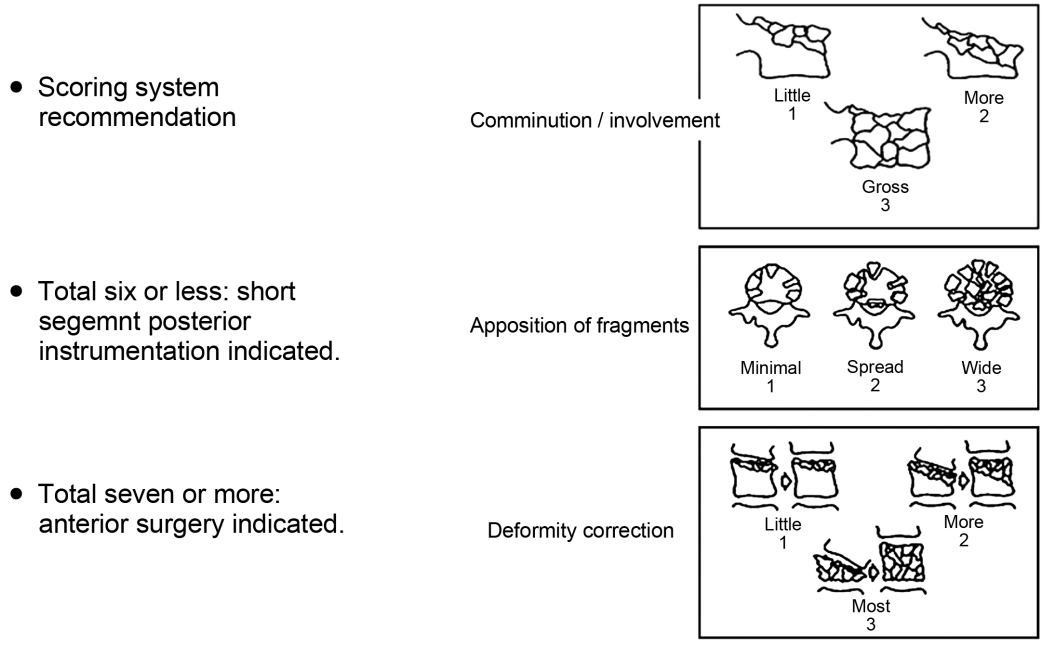

Fig. 1. Load sharing classification.

to match the sagittal alignment of the vertebral endplates. Each cage was filled and surrounded laterally and anteriorly with bone chips mixed with demineralized bone matrix and synthetic bone as allograft especially in metastatic spine (Fig. 2). Autograft was harvested from iliac bone and the fractured vertebral body in traumatic cases. In neoplastic and tuberculous cases, iliac bone graft was used to fill the cage. In traumatic cases, the corpectomy was subtotal leaving a small rim of the vertebral cortex on the contralateral side of the approach, to avoid injury to the contralateral segmental vessels. The plate device was placed, and distractive forces were applied to reduce the kyphotic deformity.

3. Radiological evaluation

All patients were assessed preoperatively, early postoperatively (before discharge) and 3, 6, and 12 months postoperatively. Serial radiographs of the involved segment were obtained to evaluate the fusion status and stability of the operated segment. Postoperative computed tomography (CT) scans of the operated segment were done to document the position of the cage and screws, and to assess spinal decompression and state of fusion. Kyphotic deformity was assessed on lateral radiographs of the thoracolumbar spine using the Cobb method. The Cobb angle was measured between the superior endplate of the upper level vertebra to the corpectomy and the inferior endplate of the lower level to the corpectomy. The kyphotic angle was measured preoperatively, early postoperatively, at one month follow-up and at the latest follow-up. The construct height was measured as the distance between the inferior endplate of the superior vertebra to corpectomy and the inferior vertebra to the corpectomy on lateral X-ray. In all patients, dynamic X-ray and CT scan were performed 3 months postoperatively to document stability, fusion, subsidence and possible hardware displacement. Determination of fusion can be difficult with anterior thoracolumbar instrumentation. A construct was deemed stable in the absence of motion on flexion-extension films, lack of significant radiolucency at the interbody graft vertebral body junction and no evidence of interval change in angulation in a one-year period. Average patient radiographic and clinical follow-up was 18 months (range, 8–28 months).

Results

This study included 16 patients: 10 with traumatic thoracolumbar instability (Figs. 3, 4), 3 with tuberculous spondylitis, 2 with metastatic deposits (Fig. 5) and one case with myeloma (Fig. 6). The level was L1 in 6 cases, D12

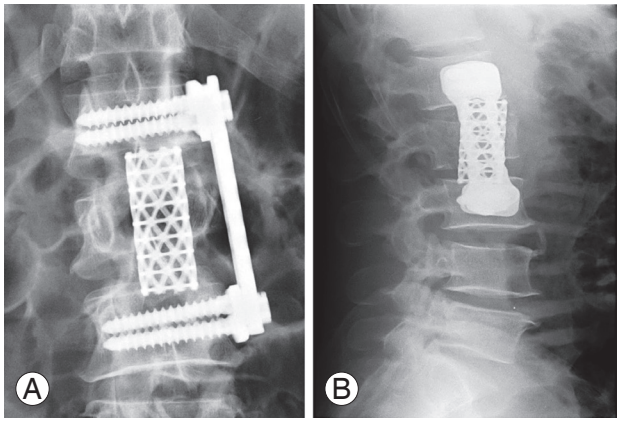

Fig. 3. (A, B) Postoperative X-ray of the retroperitoneal approach for L2 fracture.

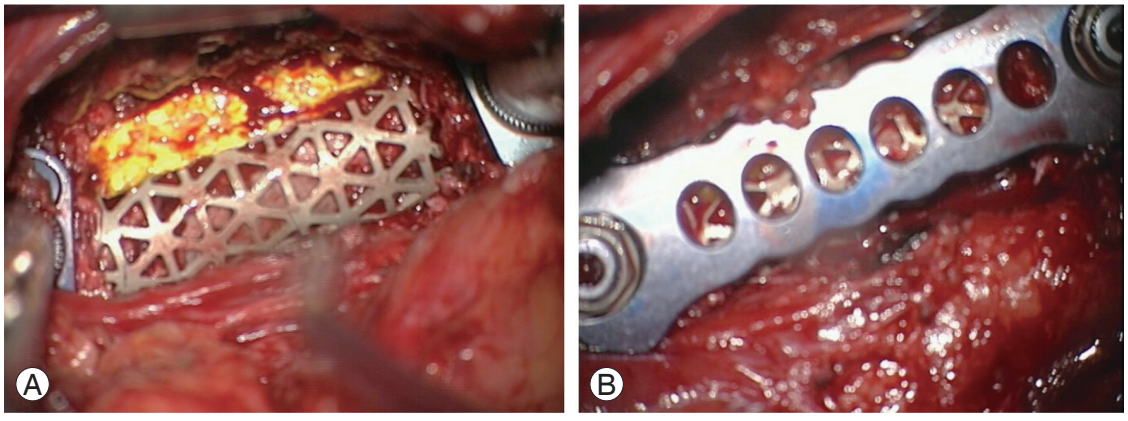

Fig. 2. (A, B) Intraoperative photos of the cage placed at the corpectomy site. The canal and dura are covered with hemostatic patch and plate.

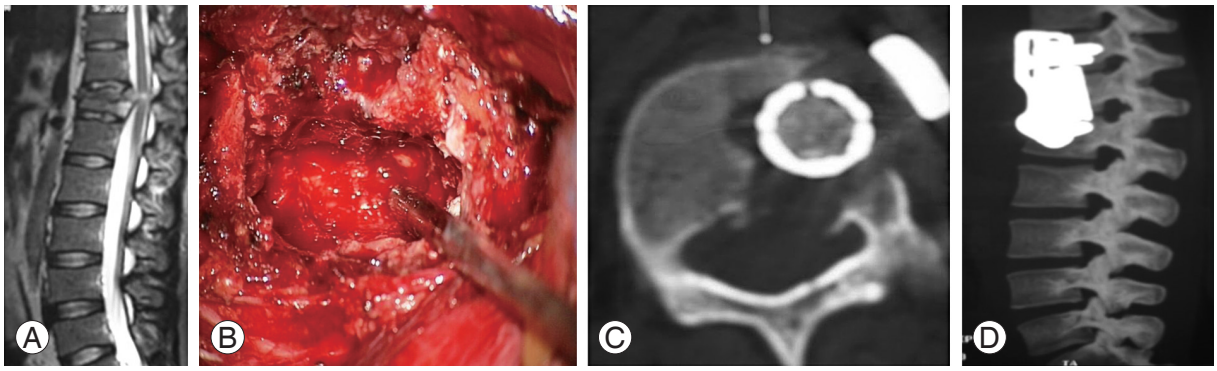

Fig. 4. (A) Preoperative sagittal magnetic resonance imaging showing D12 fracture with retropulsed fragment. **(B)** Operative area of the corpectomy. **(C)** Axial computed tomography (CT) showing adequate removal after anterior column reconstruction. **(D)** Sagittal CT reconstruction after anterior column reconstruction.

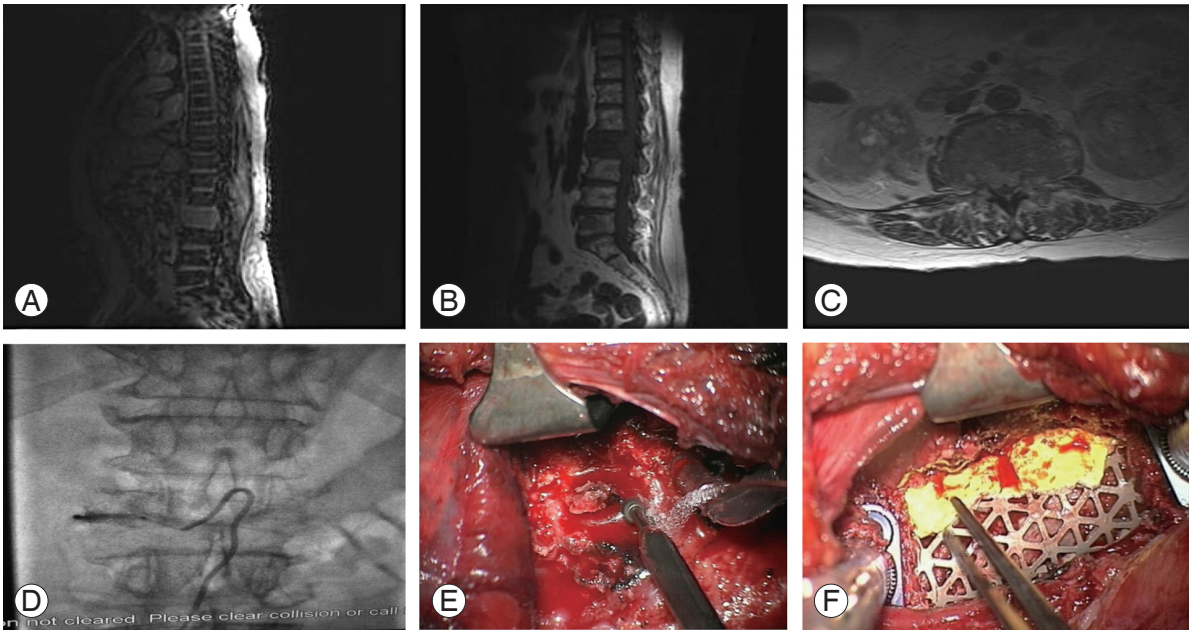

Fig. 5. (A–F) Case of metastatic L2, with preoperative embolization of the segmental vessels, retroperitoneal approach, corpectomy and anterior column reconstruction.

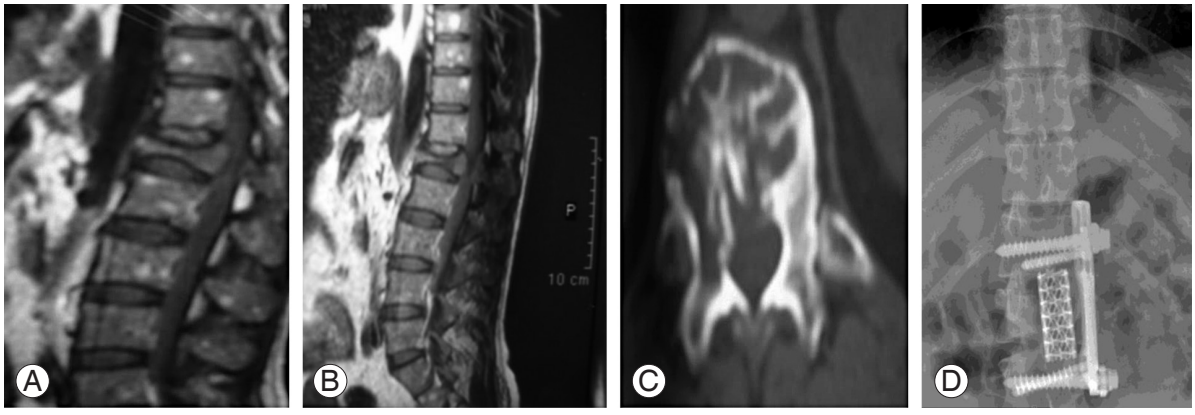

Fig. 6. (A–D) A case of multiple myeloma, featuring preoperative sagittal magnetic resonance imaging with collapsed L1. Axial computed tomography of the same vertebra, with postoperative X-ray showing titanium mesh cage.

Table 1. Clinical outcome according to Frankel grade

Postoperative Frankel grade	No. of patients	Preoperative Frankel grade				
		A	B	C	D	E
A						
B						
C	6				3	3
D	6					6
E	4					4

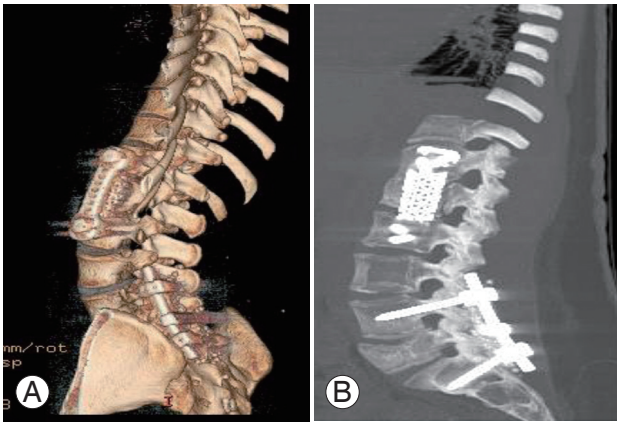

Fig. 7. (A, B) Thoracoabominal approach for L1 fracture and posterior apprach for L5 fracture .

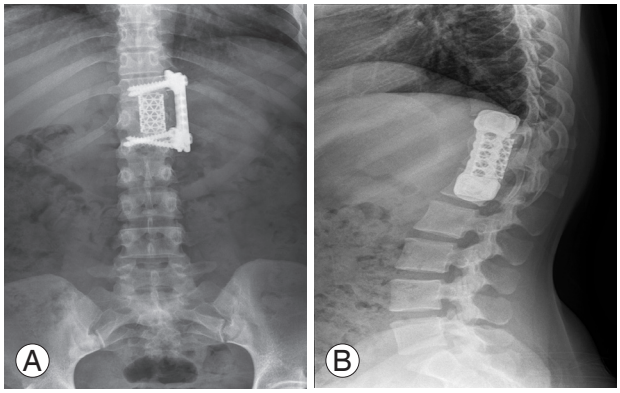

Fig. 8. (A, B) Anterior column reconstruction after L1 fracture.

in 4 cases and L2 in 6 cases. The average extent of canal encroachment was 55% (range, 40%–75%) according to axial CT measurements of the compromised vertebra. The mean preoperative kyphotic deformity was 13 degrees (range, 5–16 degrees). Four patients were neurologically intact, with Frankel grade E on admission. All these patients remained intact postoperatively. Of the six patients with Frankel D on admission, all recovered full motor and sensory functions. Of the six patients with Frankel C on admission, three improved one grade and the other three improved two grades (Table 1). The mean±standard deviation preoperative kyphosis was 2.0±13.5 degrees. The mean kyphosis immediately after surgery was –2.6±14.5 degrees. The mean kyphosis at final follow-up was 3.4±13.5 degrees. There was no significant difference between the postoperative and final kyphosis measurements. The mean height of the involved vertebra before surgery was 41 mm and the mean construct height immediate after surgery and at follow-up was 47 mm and 44 mm, respectively (Figs. 7, 8). No case of severe collapse or signifi-cant recurrence of the deformity was evident. All patients achieved solid fusion with significant neurological im-provement and no significant correction loss. Two pa-tients developed intercostal neuralgia that was improved after intercostal nerve block and medical treatment, postoperative pneumonia (n=1) and superficial wound infection (n=4) (Table 2). There were no intraoperative or late vascular injuries. No case displayed a complication directly attributable to the use of titanium mesh cage.

Discussion

The vertebral body plays a significant role in maintaining the biomechanical stability of the spine and is responsible for transmitting up to 80% of the axial load applied to the spine [3]. Pathological processes like trauma, maligngnancy and infection can involve the vertebral bodies, resulting in incapability of maintaining anterior column support and stability [2,8-10]. Vertebral body destruction can result in ventral compression of the neural elements and compromise of neurologic stability. In these circumstances, indirect decompression of neural elements through ligamentotaxis alone is not as effective as direct anterior decompression. The patient may need to undergo

Table 2. Postoperative complications

Variable	No.
Intercostal neuralgia	2
Superficial wound infection	2 at operative site, 2 graft site
Deep vein thrombosis	1
Screw misplacement	1
Meralgia parasethetica	1
Postoperative graft pain and tenderness	3

vertebrectomy and anterior reconstruction [7,11].

Anterior approaches can achieve sufficient decompression and immediate stabilization of the spinal column [5]. The ideal reconstruction device of anterior column should provide a mechanical stability and spinal alignment maintenance while facilitating stable fusion. The anterolateral approach provides a more direct and complete decompression of the spinal canal. Bone fragments can be removed from the canal under direct vision potentially allowing a better neurological outcome. This approach protects the integrity of the posterior column and is associated with a sustained correction of angular deformity. Disadvantages of anterior surgery include the more extensive approach required, lack of familiarity to many spinal surgeons, the potential for thoracic pain and the potential for pulmonary complications [8,12,13].

The tricortical iliac graft and rib graft have been used extensively to construct corpectomy defects. Disadvantages include a less than ideal shape for corpectomy reconstruction and lack of intrinsic stability. Resorption of the graft during fusion will leads to graft collapse, which creates increased bending moment at the screw-plate interface and can produces fatigue and subsequent failure of the construct [3,14-16].

The anterior approaches in patients with vertebral fractures requires fixation of only one level rostral and caudal to the fractured vertebral body, whereas in the posterior approach instrumentation may span five or more levels with the the anterion column disrupted with secondary deformity [17,18]. The anterior approach facilitates complete removal of the injured vertebral disc, which may prevent chronic post-traumatic back pressure [17].

To optimize fusion, bone grafts are better maintained under compression. This is achieved more effectively using an anterior approach and plating with bicortical screws [17,18]. There is little evidence in the literature concerning the efficacy of outcome using the cylinderical mesh titanium cage for postcorpectomy reconstruction. McAfee [6] reported on complications associated with the anterior approach when used in patients with thoracolumbar fractures undergoing decompression and stabilization. The failure rate was 96% (2 of 35 patients).

The primary function of the titanium mesh cage is to provide structural support to the anterior column [10,17]. The cage can be filled with an autogenous graft, which also enables maintenance of osteoinductivity and osteoconductivity [2]. The largest endplate is selected to reduce the incidence of subsidence and telescoping of the graft within the vertebral body adjacent to the fracture. With the advent of newer instrumentation techniques and use of anterior approaches, the degree of neurological recovery appears favorable than an earlier report [18].

Multiple cages with varying diameters and heights are available. These can be filled with autogenous bone graft, which also enables maintenance of osteoinductivity and osteoconductivity [17,19]. A titanium mesh cage with cancellous bone after corpectomy provides immediate structural support to the anterior column, while the cancellous bone inside the cage promotes fusion. Traditional stability can be achieved with anterior stabilization device. The cages confer resistance to axial compression, lateral flexion and axial rotation. Additional stability can be achieved with an anterior stabilization device.

Spinal metastasis often requires corpectomy through an anterior approach followed by posterior column reconstruction and subsequent instrumentation. This circumferential reconstruction is often associated with significant risks [3,13,20,21]. In this study, 2 patients with spinal metastasis underwent preoperative embolization followed by stand -alone anterior column reconstruction with neurological improvement.

The fusion rate in our study was 100%, which is con-

sistent with the literature [6,7,10,12,22-24]. Proper fit of the cage and gentle axial loading may create biomechanically—and biologically—favorable conditions for fusion. Bony fusion at the implant-vertebral body interface is sufficient for solid fusion. We have not closely evaluated radiological fusion, but rather accepted radiological stability when the clinical results were acceptable. The radiologic method of fusion assessment is not completely reliable. So, we depended on the fusion mass outside and surrounding the cage to more easily and accurately assess with plain radiography than the fusion within the cage. We filled the bone chips around the cage to help the later assessment. The 1-mm slice CT scans with sagittal reconstruction is superior to plain radiographs for assessment of fusion within and around the cage.

Dvorak et al. [8] recommended anterior and posterior in thoracolumbar vertebral reconstruction to avoid mechanical failure. As a result of biomechanical improvements in anterior instrumentation, several investigators reported good results with anterior decompression and stand alone instrumentation [5,6,9,19,24,25]. Wang and Liu [26] concluded that the anterior approach or combined anterior and posterior approach is a better option in managing unstable thoracolumbar burst fractures, while the latter should be used only for the burst fracture with a significant posterior column injury.

Verlaan et al. [27] conducted a literature review of 132 papers involving 5,648 patients with thoracic and lumbar fractures treated with posterior, anterior or combined approaches. They concluded that evidence -based guidelines for the treatment of these fractures are lacking and suggested that for a better comparison of surgical techniques, randomized controlled trials are necessary .

Our data agree with these previous studies that suggest titanium mesh cages provide durable biomechanical stability.

This study demonstrates that the titanium mesh cage is effective at maintaining sagittal alignment over a postoperative period of 28 months. The clinical outcomes are compatible with published reports using titanium cages.

Conclusions

Titanium mesh cages with cancellous autograft bone after corpectomy of the thoracolumbar spine provides immediate structural support to the anterior column and offers biomechenical stability without any evidence or any significant recurrence of the deformity. Anterior instrumentation is an effective and safe treatment for thoracolumbar instability, with satisfactory clinical and radiological outcomes.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

References

1. McDonough PW, Davis R, Tribus C, Zdeblick TA. The management of acute thoracolumbar burst fractures with anterior corpectomy and Z-plate fixation. Spine (Phila Pa 1976) 2004;29:1901-8.
2. Jun DS, Yu CH, Ahn BG. Posterior direct decompression and fusion of the lower thoracic and lumbar fractures with neurological deficit. Asian Spine J 2011; 5:146-54.
3. Danisa OA, Shaffrey CI, Jane JA, et al. Surgical approaches for the correction of unstable thoracolumbar burst fractures: a retrospective analysis of treatment outcomes. J Neurosurg 1995;83:977-83.
4. Lemons VR, Wagner FC Jr, Montesano PX. Management of thoracolumbar fractures with accompanying neurological injury. Neurosurgery 1992;30:667-71.
5. Esses SI, Botsford DJ, Kostuik JP. Evaluation of surgical treatment for burst fractures. Spine (Phila Pa 1976) 1990;15:667-73.
6. McAfee PC. Complications of anterior approaches to the thoracolumbar spine. Emphasis on Kaneda instrumentation. Clin Orthop Relat Res 1994;(306): 110-9.
7. Allain J. Anterior spine surgery in recent thoracolumbar fractures: an update. Orthop Traumatol Surg Res 2011;97:541-54.
8. Dvorak MF, Kwon BK, Fisher CG, Eiserloh HL 3rd, Boyd M, Wing PC. Effectiveness of titanium mesh cylindrical cages in anterior column reconstruction after thoracic and lumbar vertebral body resection. Spine (Phila Pa 1976) 2003;28:902-8.
9. McGuire RA Jr. The role of anterior surgery in the treatment of thoracolumbar fractures. Orthopedics 1997;20:959-62.
10. Bradford DS, McBride GG. Surgical management of thoracolumbar spine fractures with incomplete neu-

rologic deficits. Clin Orthop Relat Res 1987;(218):201-16.
11. Dunn HK. Anterior stabilization of thoracolumbar injuries. Clin Orthop Relat Res 1984;(189):116-24.
12. Hitchon PW, Torner JC, Haddad SF, Follett KA. Management options in thoracolumbar burst fractures. Surg Neurol 1998;49:619-26.
13. Tomita K, Kawahara N, Kobayashi T, Yoshida A, Murakami H, Akamaru T. Surgical strategy for spinal metastases. Spine (Phila Pa 1976) 2001;26:298-306.
14. Kaneda K, Taneichi H, Abumi K, Hashimoto T, Satoh S, Fujiya M. Anterior decompression and stabilization with the Kaneda device for thoracolumbar burst fractures associated with neurological deficits. J Bone Joint Surg Am 1997;79:69-83.
15. Regine WF, Tibbs PA, Young A, et al. Metastatic spinal cord compression: a randomized trial of direct decompressive surgical resection plus radiotherapy vs. radiotherapy alone. Int J Radiat Oncol Biol Phys 2003;57(2 Suppl):S125.
16. Lee SW, Lim TH, You JW, An HS. Biomechanical effect of anterior grafting devices on the rotational stability of spinal constructs. J Spinal Disord 2000;13:150-5.
17. Aebli N, Timm K, Patrick M, Krebs J. Short-segment posterior instrumentation combined with anterior spondylodesis using an autologous rib graft in thoracolumbar burst fractures. Acta Orthop 2014;85:84-90.
18. Kostuik JP. Anterior fixation for fractures of the thoracic and lumbar spine with or without neurologic involvement. Clin Orthop Relat Res 1984;(189):103-15.
19. Sasso RC, Renkens K, Hanson D, Reilly T, McGuire RA Jr, Best NM. Unstable thoracolumbar burst fractures: anterior-only versus short-segment posterior fixation. J Spinal Disord Tech 2006;19:242-8.
20. Pascal-Moussellard H, Broc G, Pointillart V, Simeon F, Vital JM, Senegas J. Complications of vertebral metastasis surgery. Eur Spine J 1998;7:438-44.
21. Robertson PA, Rawlinson HJ, Hadlow AT. Radiologic stability of titanium mesh cages for anterior spinal reconstruction following thoracolumbar corpectomy. J Spinal Disord Tech 2004;17:44-52.
22. Harms J. Screw threaded rod system in spinal fusion surgery. Spine (Phila Pa 1976) 1992;6:541-75.
23. Sasso RC, Best NM, Reilly TM, McGuire RA Jr. Anterior-only stabilization of three-column thoracolumbar injuries. J Spinal Disord Tech 2005;18 Suppl:S7-14.
24. Schnee CL, Ansell LV. Selection criteria and outcome of operative approaches for thoracolumbar burst fractures with and without neurological deficit. J Neurosurg 1997;86:48-55.
25. Vahldiek MJ, Panjabi MM. Stability potential of spinal instrumentations in tumor vertebral body replacement surgery. Spine (Phila Pa 1976) 1998;23:543-50.
26. Wang J, Liu P. Analysis of surgical approaches for unstable thoracolumbar burst fracture: minimum of five year follow-up. J Pak Med Assoc 2015;65:201-5.
27. Verlaan JJ, Diekerhof CH, Buskens E, et al. Surgical treatment of traumatic fractures of the thoracic and lumbar spine: a systematic review of the literature on techniques, complications, and outcome. Spine (Phila Pa 1976) 2004;29:803-14.