Technical Note doi: 10.2176/jns-nmc.2021-0395

Neurol Med Chir (Tokyo) 62, 342-346, 2022 Online May 25, 2022

Lateral Lumbar Interbody Fusion Using Bone Graft Substitute for Lumbar Vertebral Fracture Associated Radiculopathy

Manabu Sasaki,[1,2] Takanori Fukunaga,[2] Koshi Ninomiya,[2] Masao Umegaki,[1,3] Katsumi Matsumoto,[2] and Haruhiko Kishima[1]

[1]*Department of Neurosurgery and Spine Surgery, Iseikai Hospital, Osaka, Osaka, Japan*
[2]*Department of Neurosurgery, Osaka University Graduate School of Medicine, Suita, Osaka, Japan*
[3]*Department of Neurosurgery, Suita Municipal Hospital, Suita, Osaka, Japan*

Abstract

This study aims to present our surgical technique of lateral lumbar interbody fusion (LLIF) without corpectomy for lumbar vertebral fracture (LVF) associated radiculopathy. This study includes three patients treated with LLIF (mean age of 77.3 years, Group L) and three patients treated with PLIF (mean age of 75.7 years, Group P) to compare the surgical outcomes. The cartilage on the fractured vertebrae was aggressively resected with attention to avoid injury to the ring apophysis. The central cavity of the fractured endplate was filled with a bone graft substitute made of hydroxyapatite and collagen composite, followed by interbody fusion achieved by utilizing of a cage with sufficient length spanning the bilateral edges of the fractured vertebra. PLIF was performed with a standard technique using two interbody cages, and vertebroplasty was combined in one patient. Comparing to PLIF, LLIF could be performed with less estimated blood loss in shorter surgical time. Local kyphotic angle improved in all cases of Group L immediately after the surgery, but correction loss was observed at the final examination. The lordotic angle was lost in Group P postoperatively. Arthrodesis was achieved in all the cases. The mean VAS score for leg pain was 85.3 mm in Group L and 82.0 mm in Group P at preoperation and decreased to 8.7 mm and 11.3 mm, respectively, at postoperation. LLIF is an effective surgical option that enables stabilization of the fractured vertebra and reduces radicular pain by indirect neural decompression.

Keywords: lumbar vertebral fracture, lateral lumbar interbody fusion, radiculopathy, surgical outcome, concave deformity

Introduction

Lumbar vertebral fracture (LVF) is a frequent complication of osteoporosis in elderly patients. Back pain is the most common symptom of LVF and is usually managed with conservative treatments, such analgesics and spinal orthosis. Although relatively rare, LVF occasionally causes radiculopathy due to lateral recess stenosis (LRS) or foraminal stenosis (FS) secondary to vertebral deformity,[1-6] and patients often suffer from radicular pain even after fracture healing. This is attributed to the instability or loss of intervertebral height at the affected spinal segments, including the fractured vertebrae.

In 2011, we reported on surgical treatments for radiculopathy following LVFs,[2] a subject that had been rarely discussed until then. This study included two cases treated with posterior lumbar interbody fusion (PLIF). Improvement of the clinical scores was preserved during follow-up; however, the scores gradually worsened in patients treated with posterior decompression alone. Although PLIF is a useful technique for treating radiculopathy caused by LVF, it has a few disadvantages. First, in PLIF, the posterior supporting elements of the spine need to be sacrificed. Second, it is difficult to perform surgical intervention for a concave endplate from the narrow posterior space surrounded by neural tissues.

Lateral lumbar interbody fusion (LLIF) is a minimally invasive method that provides direct approach to the lat-

Received December 1, 2021; Accepted March 31, 2022

Table 1 Summary of the six cases treated with LLIF or PLIF for radiculopathy following LVF

Case	Age (year)	Fracture level (type)	Method of fusion (method of PI)	OP time (min)	EBL (mL)	F/U (mo)	Local kyphotic angle (°)			VAS for leg pain (mm)	
							Pre	Day 0	Final	Pre	Post
LLIF											
1	66	L4 (bi-concave)	L3/4/5 XLIF (L3–L5, PPI)	227	50	36	6	1	4	87	6
2	79	L2 (concave)	L2/3 XLIF (L1–L4, open)	221	280	36	19	9	10	88	0
3	87	L4 (concave)	L3/4/5 XLIF (L3–L5, PPI)	281	70	27	−16	−22	−12	81	20
PLIF											
4	70	L5 (bi-concave)	L4/5/S1 PLIF (L4–S1, open)	467	770	72	−30	−26	−22	97	0
5	77	L4, L5 (concave)	L4/5 PLIF (L4–S1, open)	461	859	120	−18	−15	−13	49	13
6	80	L5 (concave)	L4/5 PLIF, L5VP (L4–5, open)	260	150	64	−19	−18	−10	100	21

* LVF, lumbar vertebral fracture; LLIF, lateral lumbar interbody fusion; XLIF, extreme lateral interbody fusion; PLIF, posterior lumbar interbody fusion; VP, vertebroplasty; OP, surgical operation; VAS, visual analog scale; EBL, estimated blood loss; F/U, follow-up periods

eral aspect of the intervertebral disc through the psoas muscle without manipulation of the major abdominal vessels. It enables achievement of anterior stability without injury to the posterior spine supporting tissues, anterior longitudinal ligament (ALL) or posterior longitudinal ligament (PLL). The effect of this technique on indirect neural decompression is expected to improve radiculopathy.[7-9] In this study, we utilized LLIF for surgical treatment of radiculopathy-causing LVFs with the aim to underline the surgical procedures and preliminary surgical outcomes. This study was approved by the local Institutional Review Board of our hospital (No. 2021-23) and informed patient consent was obtained for the use of their data in this retrospective study.

Case Reports

1) Patients

This retrospective study included three women (Cases 1-3, Group L) with a mean age of 77.3 years (range: 66-87 years), who suffered from radiculopathy following LVFs from 2018 to 2019 (Table 1). Case 1 had suffered an L4 vertebral fracture due to a traffic accident 27 years ago (Fig. 1), while Cases 2 and 3 had LVFs related to osteoporosis (Fig. 2). Case 1 had an LVF with bi-concave deformity, and Cases 2 and 3 had fractures of the caudal endplate of the L2 and L4 vertebrae, respectively (Table 1). The patients were administered conservative treatment for radicular leg pain after more than 3 months of onset. Cases 2 and 3 received additional medication of teriparatide for osteoporosis simultaneously.

To compare the surgical outcomes, we also reviewed three patients (Cases 4-6, Group P) with a mean age of 75.7 years (range: 70-80 years) treated with PLIF for radiculopathy secondary to L4- or L5- LVF before 2018 (Table 1).

2) Surgical methods

LLIF was performed using the XLIF system (NuVasive, Inc., San Diego, CA, USA) following the standard surgical technique. The patient was placed in the right lateral position with the waist bent to the right side. A 5-cm transverse skin incision was made just above the affected spinal segment. The psoas muscle was exposed via the retroperitoneal approach and split just above the affected intervertebral discs under the guidance of NVM5 nerve monitoring system (NuVasive, Inc., San Diego, CA, USA) to prevent injury to the lumbar nerve plexus. The retractor, prepared exclusively for XLIF, was placed at the center of the intervertebral disc under fluoroscopy. The disk material was resected until the contralateral annulus fibrosus was fenestrated. Thereafter, cartilage on the non-fractured endplate was carefully removed to avoid injuring the osseous endplate, whereas that on the fractured vertebrae was aggressively resected using a curved Cobb elevator without concern of causing a slight injury to the central endplate. However, caution was practiced to avoid injury to the ring apophysis. The center of the concave osseous endplate was lightly decorticated using a rasp, followed by interbody fusion achieved by utilizing of a cage (CoRoent XL; NuVasive

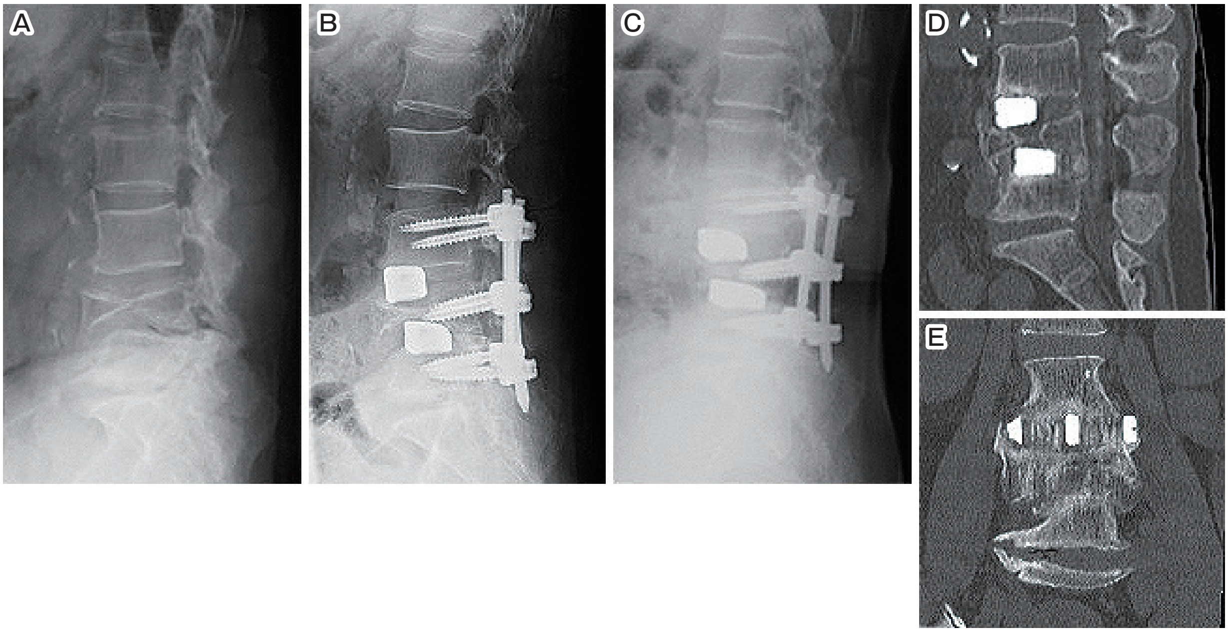

Fig. 1 Plain radiography and CT scans of a 66-year-old female with bi-concave L4 vertebral fracture.
Preoperative plain radiography shows severe bi-concave deformity of the L4 vertebra and local kyphosis (A). Plain radiography at the 1 month shows correction of the local kyphosis with large XLIF cages situated in the intervertebral spaces (B), and the sagittal alignment is maintained at the 36 months (C). CT scans at the 2-year follow-up show that arthrodesis was obtain ed inside and/or outside the cages at the affected spinal levels (D, E).

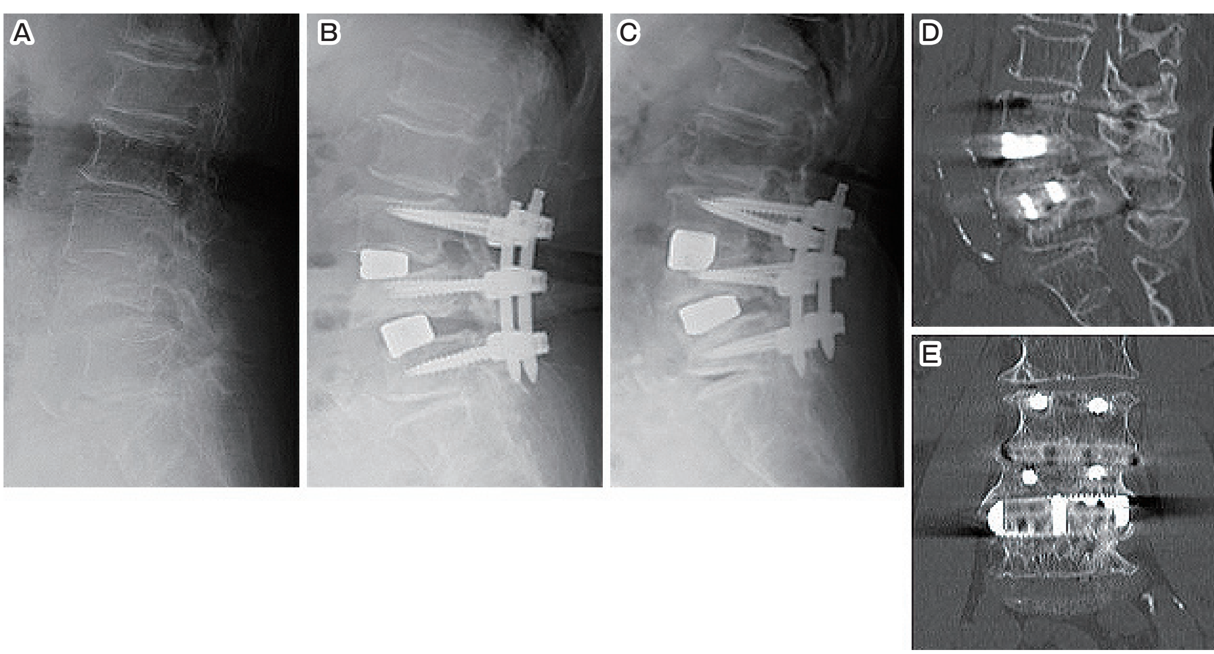

Fig. 2 Plain radiography and CT scans of an 87-year-old female with L4 vertebral fracture.
Preoperative plain radiography shows L4 vertebral fracture (A). Plain radiographies at the 1 month (B) and the 12 months (C) show good anterior stabilization with XLIF. CT scans at the 26 months (D, E) show successful arthrodesis.

Inc., San Diego, CA, USA) with sufficient length spanning the bilateral edges of the fractured vertebra. The appropriate length and height of the cage were determined by test insertion of the trials into the intervertebral space under fluoroscopy. Ahead of the cage insertion, the central cavity of the fractured endplate was filled with a bone graft substitute made of hydroxyapatite and collagen composite (HOYA Technosurgical Corporation, Tokyo, Japan), which was then covered by a spatula used for cage insertion in order to prevent its removal from the cavity. Thereafter, the cage filled with the bone graft substitute was inserted into the intervertebral space under fluoroscopic guidance until it wedged against the bilateral ring apophysis of the concave endplate. Case 2 underwent single-level LLIF at the L2-3 level for FS and open posterior instrumentation on the same day. Cases 1 and 3 with L4 LVF were managed with a two-stage surgery. They initially underwent two-level LLIF at two points adjacent to the LVF. As pain reduction was achieved in all cases after the initial surgery, percutaneous posterior instrumentation without posterior decompression was performed a week later.

PLIF was performed with a standard technique using two interbody cages and local bone graft harvested during laminectomy. Vertebroplasty of the fractured vertebra was combined in one case (Case 6). These surgical techniques were previously described.[2] All patients wore a soft lumbar orthosis for 3 months postsurgery.

3) Assessment of radiological and clinical outcomes

Radiological outcomes were assessed using CT images taken preoperatively, on day 0, and every 6 months until arthrodesis was visible. Arthrodesis was defined as the continuity of the cortical bone formed inside or outside the interbody cage. The local kyphotic angle (LKA) was defined as the angle of kyphosis between the cranial endplate of the top vertebra and the caudal endplate of the bottom vertebra at the affected spinal segment.

Clinical outcomes were assessed using a visual analog scale (VAS) for leg pain (worst possible length: 100 mm) recorded preoperatively and 3 months postoperatively.

4) Surgical outcomes

The mean surgical time (ST) was 243.0 min (range, 221-281 min) in Group L and 396.0 min (range, 260-467 min) in Group P, and mean estimated blood loss (EBL) was 133.3 mL (range, 50-280 mL) in Group L and 593.0 min (range, 150-859 min) in Group P (Table 1). Arthrodesis was observed in all the cases (Figs. 1 and 2). The mean preoperative LKA was 3.0° (range, −16°-19°) in Group L and −22.3° (range, −30°-18°) in Group P. The postoperative LKA improved in all cases of Group L with a mean angle of −4.0° (range, −22°-9°) immediately after the surgery, but correction loss was observed at the final examination with mean angles of 0.7° (range, −12°-10°) (Table 1). The lordotic angle was lost in all cases of Group P postoperatively; the mean postoperative LKA was −19.7° (range, −26°-−15°) on day 0 and decreased to −15.0° (range, −22°-10°) at the final examination. The mean VAS score for leg pain was 85.3 mm (range, 81-88 mm) in Group L and 82.0 mm (range, 49-100 mm) in Group P before surgery and decreased to 8.7 mm (range, 0-20 mm) in Group L and 11.3 mm (range, 0-21 mm) in Group P at the final examination.

Discussion

Neurological compromise following LVF is relatively rare. According to a recent multicenter cohort study,[6] number of the thoracolumbar junction fractures causing neurological deficits was five times that of lower lumbar fractures causing radiculopathy. Thoracolumbar junction fractures commonly cause anterior-wedge vertebral deformity, while LVF commonly develops a concave deformity.[3,10] This deformity causes radiculopathy due to FS or LRS in the adjacent spinal segment. Although radiculopathy usually lacks severe neurological deficits, it is often resistant to conservative therapies and so severe that it negatively impacts patient's daily activities.[1-6]

Recently, an increasing number of studies have focused on radiculopathy following LVF. Yamashita et al. attempted to identify disturbed nerve roots using selective nerve root infiltration.[3] According to their results, caudal endplate fracture and subsequent slippage of the fractured vertebra are likely to induce FS with impingement of the exiting nerve roots, whereas cranial endplate fracture and slippage of the cranial vertebra tend to cause LRS with impingement of the traversing nerve roots. Multiple existing reports state that FS following LVF frequently causes radiculopathy.[3,5,6]

Studies have been conducted lately, analyzing the surgical outcomes for osteoporotic LVF causing radiculopathy. Spinal fusion had been used in most surgical treatments, but the authors reported high rates of instrumentation and/or implant failure.[4-6] Since the incidence of failure was frequent in posterior fusion without anterior support,[6] it can be concluded that anterior reconstruction should be included in the surgical strategies. PLIF with/without vertebroplasty is the most popular surgical method for LVFs causing radiculopathy.[6] However, the major problem in its application to fractured vertebrae is the inadequate anterior support obtained by this procedure as the PLIF cages are not fit for the concave endplate.

LLIF has some advantages over PLIF for interbody fusion, including fractured vertebra. Although the XLIF cages are also not designed to fit to the concave deformity, a large XLIF cage can be placed across the bilateral ring apophysis of the concave endplate, resulting in a stable anterior reconstruction. In some previous studies, the cage was fixed in the intervertebral space using the ALL and PLL, which were preserved through the surgical procedure of LLIF. The large cage restored intervertebral height and subsequently provided indirect neural decompression.[7,8] The recent study reported excellent surgical outcomes of oblique lateral interbody fusion (OLIF) for LVFs causing back and leg pain.[9] The authors used an OLIF cage filled with autologous cancellous bone harvested from the iliac crest. The present result suggests that interbody fusion can be obtained with our surgical method. A bone graft substitute made of hydroxyapatite and collagen composite was utilized for LLIF in this study, to prevent an iliac bone fracture due to harvesting bone graft enough to fulfill the concave cavity. The sponge-like bone graft substitute is easily adapted to the deformity of the fractured endplate. As a result, successful arthrodesis was obtained without instrumentation failure, even in patients with poor bone quality or severe vertebral deformity.

In this study, LLIF resulted in good surgical outcomes. LLIF was performed in a shorter operation time and with a smaller blood loss, comparing to PLIF (Table 1). LLA increased in all case of Group L immediately after the surgery, but not in any case of Group P. The postoperative VAS score for leg pain decreased to approximately 1/10th of the preoperative values in all cases (Table 1). These results suggest that LLIF is effective both clinically and radiologically for LVF associated radiculopathy.

Patient selection is vital for positive surgical outcomes in LLIF. This technique cannot be applied to an unstable vertebra before fracture healing as attaining anterior stability with LLIF alone is challenging. Treatment of osteoporosis should start from the onset of LVF to promote early healing of the fracture. LLIF also seems to be ineffective in cases with severely deformed vertebrae, including destruction of the ring apophysis, due to inadequate intervertebral height restoration for effective indirect neural decompression. In addition, it is prudent to determine the indication for LLIF in patients with LCS. The effect of indirect decompression is often insufficient in patients with severe LCS or bony LRS.[10-12] To avoid unplanned additional surgeries, we performed two-staged surgical treatment for two cases with LCS, as recommended by a previous report.[10] LLIF was performed as the primary surgery followed by thorough clinical examination, which led to the consideration of posterior direct decompression in addition to posterior instrumentation as a secondary surgery.

This study has a few limitations. First, this is an observational study with a very small sample size (three cases at a single hospital). In addition, we are unable to derive a definitive conclusion from the study findings. However, we believe that the preliminary results of this study in combination with future large-scale studies in this area will be helpful in determining a suitable surgical method for radiculopathy arising secondary to LVF.

Abbreviations

LRS, lateral recess stenosis; FS, foraminal stenosis; PLIF, posterior lumbar interbody fusion; LLIF, lateral lumbar interbody fusion; ALL, anterior longitudinal ligament; PLL, posterior longitudinal ligament; LVF, lumbar vertebral fracture; CT, computed tomography; ST, surgical time; EBL, estimated blood loss; LKA, local kyphotic angle; JOA, Japanese Orthopedic Association; VAS, visual analog scale; LCS, lumbar canal stenosis

Conflicts of Interest Disclosure

The authors declare no conflict of interest. We received no financial support.

References

1) Chung SK, Lee SH, Kim DY, Lee HY: Treatment of lower lumbar radiculopathy caused by osteoporotic compression fracture: the role of vertebroplasty. *J Spinal Disord Tech* 15: 461-468, 2002
2) Sasaki M, Aoki M, Nishioka K, Yoshimine T: Radiculopathy caused by osteoporotic vertebral fractures in the lumbar spine. *Neurol Med Chir (Tokyo)* 51: 484-489, 2011
3) Yamashita T, Sakaura H, Miwa T, Ohwada T: Modified posterior lumbar interbody fusion for radiculopathy following healed vertebral collapse of the middle-lower lumbar spine. *Global Spine J* 4: 255-262, 2014
4) Nakajima H, Uchida K, Honjoh K, Sakamoto T, Kitade M, Baba H: Surgical treatment of low lumbar osteoporotic vertebral collapse: a single-institution experience. *J Neurosurg Spine* 24: 39-47, 2016
5) Kohno M, Iwamura Y, Inasaka R, et al.: Surgical intervention for osteoporotic vertebral burst fractures in middle-low lumbar spine with special reference to postoperative complications affecting surgical outcomes. *Neurol Med Chir (Tokyo)* 59: 98-105, 2019
6) Isogai N, Hosogane N, Funao H, et al.: The surgical outcomes of spinal fusion for osteoporotic vertebral fractures in the lower lumbar spine with a neurological deficit. *Spine Surg Relat Res* 4: 199-207, 2020
7) Fujibayashi S, Hynes RA, Otsuki B, Kimura H, Takemoto M, Matsuda S: Effect of indirect neural decompression through oblique lateral interbody fusion for degenerative lumbar disease. *Spine (Phila Pa 1976)* 40: E175-E182, 2015
8) Lang G, Perrech M, Navarro-Ramirez R, et al.: Potential and limitations of neural decompression in extreme lateral interbody fusion- a systematic review. *World Neurosurg* 101: 99-113, 2017
9) Fukuda K, Katoh H, Takahashi Y, Kitamura K, Ikeda D: Minimally invasive anteroposterior combined surgery using lateral lumbar interbody fusion without corpectomy for treatment of lumbar spinal canal stenosis associated with osteoporotic vertebral collapse. *J Neurosurg Spine* 28: 1-9, 2021
10) Oliveira L, Marchi L, Coutinho E, Pimenta L: A radiographic assessment of the ability of the extreme lateral interbody fusion procedure to indirectly decompress the neural elements. *Spine (Phila Pa 1976)* 35: S331-S337, 2010
11) Kirnaz S, Navarro-Ramirez R, Gu J, et al.: Indirect decompression failure after lateral lumbar interbody fusion-reported failures and predictive factors: systematic review. *Global Spine J* 10: 8S-16S, 2020
12) Nakashima H, Kanemura T, Satake K, et al.: Unplanned second-stage decompression for neurological deterioration caused by central canal stenosis after indirect lumbar decompression surgery. *Asian Spine J* 13: 584-591, 2019

Corresponding author: Manabu Sasaki, MD, PhD
Department of Neurosurgery, Osaka University Graduate School of Medicine, 2-2 Yamadaoka, Suita, Osaka 565-0871, Japan.
e-mail: m-sasaki@nsurg.med.osaka-u.ac.jp