Original Article

Preliminary Report on Drilling the Endplate during Posterior Lumbar Interbody Fusion

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Objective: To evaluate the results of drilling the endplate while performing posterior lumbar interbody fusion (PLIF).

Method: From June 2007 to August 2009, 69 patients (108 motion segments) received nerve decompression and PLIF in our hospital. We used transpedicle screws and unilateral polyetheretherketone (PEEK) cage for lumbar fusion. After the disc tissue and cartilaginous endplates were removed, we drilled the bony endplate with a 3 mm Kirschner wire under C-arm guidance. The morselized bone was packed, and the PEEK cage was inserted into the interbody space. Radiographs and clinical outcome were assessed, and collected data included union time, radiographic parameters, clinical outcome, and patient demographics.

Results: The overall successful treatment rate was 91.3% (63/69), and the failure rate was 8.7% (6/69). There were no nerve injuries during surgery and no postoperative infections. There were 106 interspaces (98.1%) fused in 67 patients. The delayed union rate was 14.8%. Eighteen (16.7%) interbody spaces collapsed by more than 3 mm. The postoperative anterior and posterior disc heights increased by 34.2% (2.6/7.6) and 36.4% (2.28/6.27) compared to preoperative disc height, respectively. Six patients had postoperative complications.

Conclusions: The technique of drilling the endplate while performing PLIF provided a successful clinical outcome and an excellent union rate.

Key words: PLIF, PEEK cage, endplate

Introduction

Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) with pedicle screws fixation have been reported to enhance osteosynthesis and increase successful fusion rates for treating lumbar degenerative disease.[1,2] Interbody devices (spacers or cages) are inserted

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to support the anterior column without using a tricortical or bicortical strut bone graft.[3] Entire excision of the right and left facet joints, including the inferior portion of the superior lamina, is frequently performed to achieve adequate decompression and to increase the space available for interbody insertion.[3]

Many authors have described the clinical efficacy and high fusion rates of PLIF with local bone graft and cages combined with pedicle screw fixation.[2] Unilateral single cage seems sufficient in PLIF; the clinical success rate and fusion rate with a single cage were similar to those with bilateral cages.[4] TLIF, a unilateral approach to the disc space and a variant of PLIF, is often performed. The radiographic fusion rates of TLIF are reported to be 89% to 94%.[5-7] Since the the union rate of PLIF and TLIF are similar and the unilateral cage has similar fusion rate with bilateral cages, we chose unilateral cage PLIF for easier operation with less blood loss.

Endplate preparation is critical for the success of interbody fusion.[8] Many surgeons suggest removal of cartilaginous endplates with specially designed shavers and curettes. They also suggest that the bony endplates be preserved to prevent graft subsidence.[9] To enable fusion, bleeding bone placed next to the graft is necessary to offer a sufficient number of potentially osteogenic cells.[10] In this study, we propose to drill the endplates to enhance endplate bleeding while performing PLIF with a unilateral single interbody device. Herein, we report the surgical technique and clinical results of our series.

Materials and Methods

From June 2007 to August 2009, 91 consecutive patients with grade I or grade II spinal spondylolisthesis (Fig. 1A and 1B), spinal spondylosis with spinal stenosis, or degenerative disc disease received nerve decompression and PLIF in our hospital. The surgical indications included disabling radicular pain and/or back pain refractory to conservative management. We offered conservative treatment including rest, bracing and medications for at least 6 weeks for non-urgent patients while those with severe cord compression, cauda equina syndrome or with progressive neurologic deficits received urgent surgeries. The surgical levels were determined by the clinical level of radiculopathy and correlating magnetic resonance imaging (MRI) findings. The exclusion criteria were lumbar posterolateral fusion with pedicle screw fixation, recurrent herniated disc disease, failed back surgery, and adjacent level disease. The remaining 69 patients (108 motion segments) who met the criteria were retrospectively reviewed. There were 26 men and 43 women with a mean age of 58.7 years (range, 23 to 80 years). The minimal clinical follow-up time was 12 months.

We used transpedicle screws and unilateral polyetheretherketone (PEEK) cage (Synthes, USA) for the lumbar fusions. Neurological decompression was performed by removing the inferior one-half of lamina in the cephalad vertebra, superior one-half of lamina in the caudal vertebra, and bilateral total medial facetectomy. The local bone graft was harvested by removing cartilage and fibrous tissue on the excised bone. Next, the bone was morselized and packed into the PEEK cage. The residual bone was inserted into the anterior portions of the interbody space and was impacted with an impactor to form a hard wall at the anterior disc space.

The disc was usually excised at the right side or at the area of the herniated intervertebral disc. The disc tissue and cartilaginous endplates were removed with special shavers, curved curettes, and disc clamps. Afterwards, the protective sheath was inserted into the disc space. We drilled the bony endplate with a 3 mm Kirschner wire for at least 4 to 5 holes through the protecting sheath under C-arm guidance (Fig. 2A and 2B). After the interver-

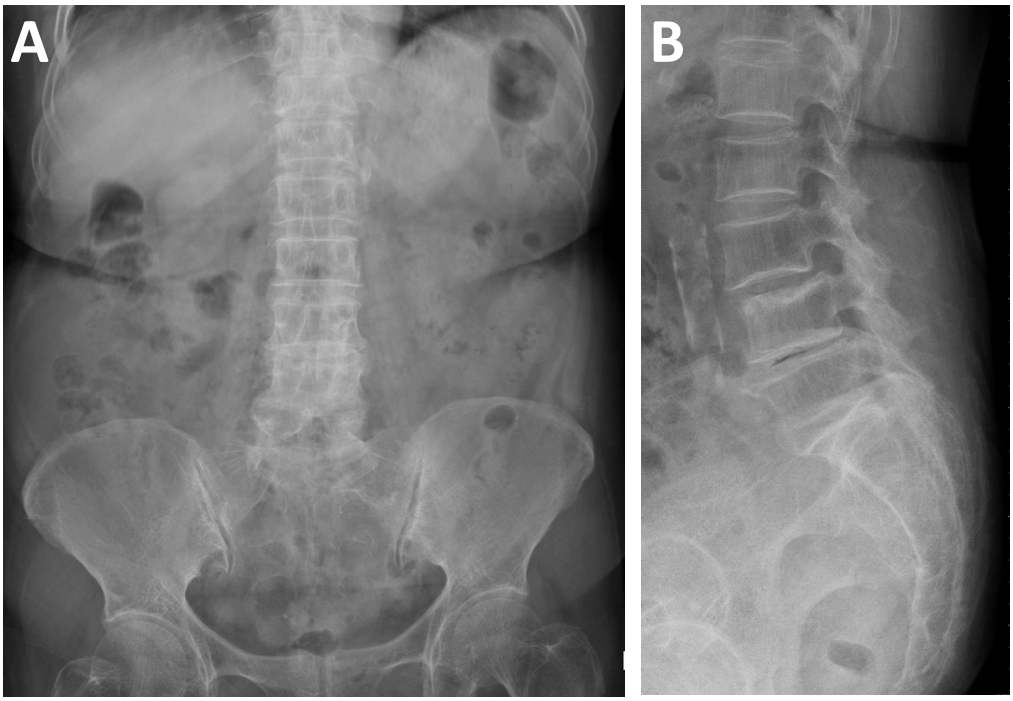

Fig. 1 (A) and (B): An 80-year-old woman suffered from spinal stenotic syndrome. The AP and lateral lumbar spine radiographs revealed L3-4 spondylosis.

tebral space was well prepared, the morselized bone was packed and the PEEK cage was inserted into the interbody space. Finally, the transpedicle screws were inserted (Fig. 2C and 2D).

After surgery, all patients wore a chair-back brace or Taylor's brace for 3 months. Patients were regularly followed up at 6 weeks, 3 months, 6 months, 9 months, and 12 months after the operation. Radiographs of the lateral lumbar spine and kidney-ureter-bladder (KUB) were obtained at each visit. Radiographs were used to assess anterior and posterior heights, status of fusion at each interval, and segmental sagittal alignment of fusion levels. The segmental sagittal alignment was measured

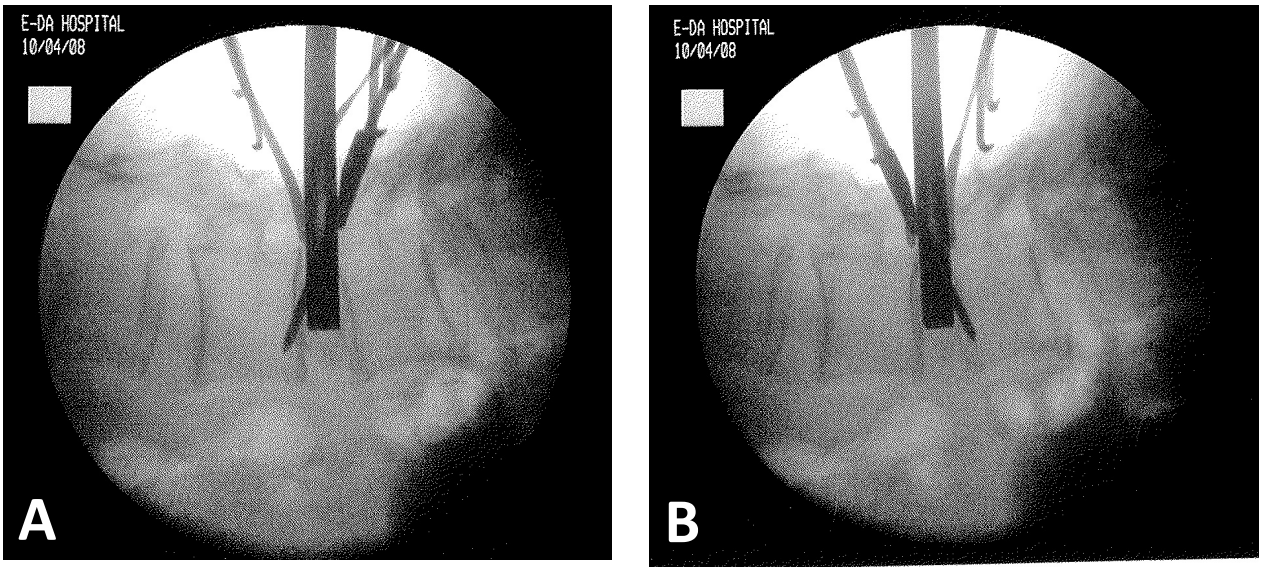

Fig. 2 (A)and(B): The bony endplates were drilled with a 3 mm Kirschner wire inserted through the protective sheath under C-arm guidance at the L4-5 disc space.

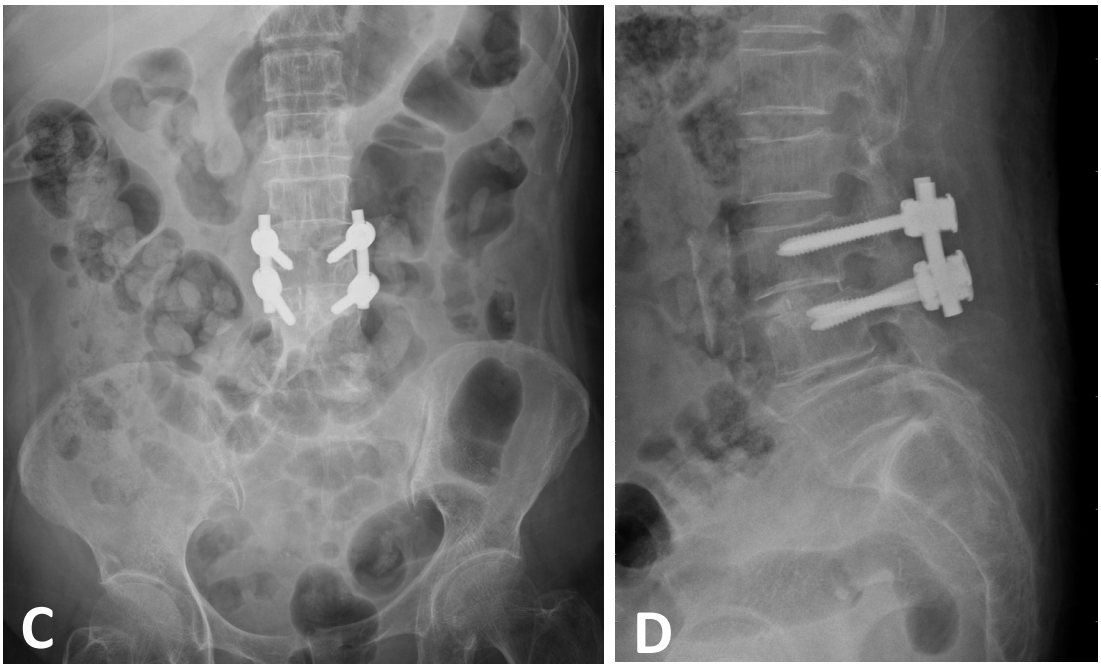

Fig. 3 (C) and (D): Postoperative AP and lateral lumbar spine radiographs revealed that the L3-4 vertebrae were fixed with PEEK cage and transpedicle screws.

as the angle between the cranial and caudal endplates of the upper and lower vertebrae in the motion segment subjected to fusion. Union was defined as the presence of cross trabeculations over the upper and lower endplates of the fusion segment (Fig. 2E and 2F). Delayed union was defined as a lack of cross trabeculations over the intervertebral space and a linear lucency on the radiograph obtained at the 6 months follow-up. The computer tomography was not applied in our series for high dose of radiation and the plain radiography was easier

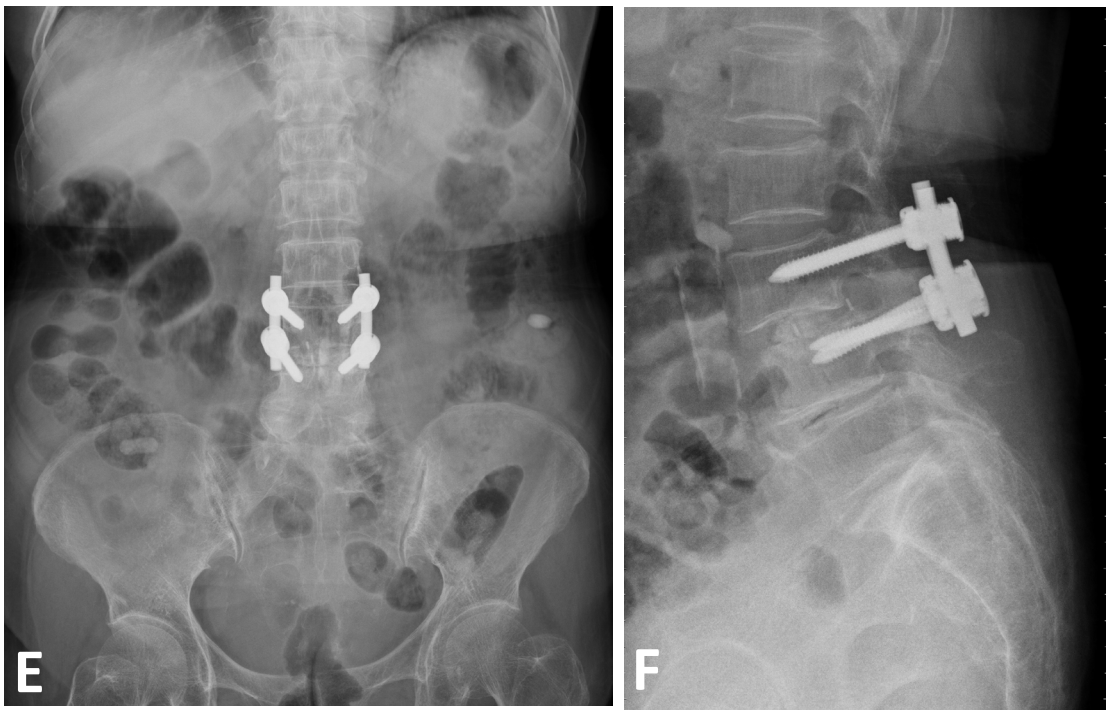

Fig. 4 (E) and (F): The final AP and lateral lumbar spine radiographs showed bony union at the L3-4 interbody space.

to identify in most cases. Non-union was defined using the same radiographic criteria at the 12 months follow-up. Further surgery was indicated if the patients suffered from intractable back pain or severe and progressive neurological symptoms.

Clinical outcomes were graded by comparing the preoperative and postoperative neurological states using the criteria proposed by Odom et al.[11] An excellent outcome was obtained if all preoperative symptoms were relieved and abnormal findings improved. A good outcome was obtained if there was minimal persistence of preoperative symptoms and abnormal findings were either unchanged or alleviated. Fair outcome was obtained if there was definite relief of some preoperative symptoms and other symptoms were unchanged or slightly alleviated. Poor outcome was obtained when symptoms and signs were unchanged or exacerbated. Successful treatment was defined as an excellent or good outcome, and failed treatment was defined as a fair or poor outcome. Collected data included union time, radiographic parameters, clinical outcome, and patient demographics.

Results

The characteristic data of 69 patients (108 motion segments) and levels of interbody fusions are listed in Table 1. The mean follow-up time was 29.5 months (range, 16 to 43 months). The mean hospital stay was 7.3 days. There were 30 excellent outcomes, 34 good outcomes, 4 fair outcomes, and 2 poor outcomes, according to Odom's criteria. The overall success rate of the treatment was 91.3% (63/69), with a failure rate of 8.7% (6/69). There were no postoperative infections in any of our cases.

The radiographic data are listed in Tables 2 and 3. There were 106 interspaces (98.1%) fused in 67 patients. The delayed union rate was 14.8%, and 18 (16.7%) interbody spaces collapsed by more than 3 mm. The postoperative anterior disc height increased by 34.2% (2.6/7.6) compared to the preoperative disc height. The postoperative posterior disc height increased by 36.4% (2.28/6.27) compared to preoperative disc height.

Six patients had postoperative complications. Two male patients had non-unions at

Table 1. Patient demographic data

Characteristic	Cases n (%)
Total patients	69 (100)
Sex	
Male	26 (37.7)
Female	43 (62.3)
Etiology	
Spondylolisthesis	33 (47.8)
Spondylosis	30 (43.5)
Degenerative disc disease	6 (8.7)
Motion segments	
1	37 (53.6)
2	26 (37.7)
3	5 (7.2)
4	1 (1.5)
Level	
L2,3	7 (6.5)
L3,4	18 (16.7)
L4,5	48 (44.4)
L5S1	35 (32.4)

Table 2. Results of Surgery

Characteristic	Cases (total, 69) n (%)
Union	67 (97.1)
Nonunion	2 (2.9)
Complications	6 (8.7)
Segmental coronal angle (degree)	
Preoperative	0.19
Postoperative	0.94
Final	0.43
Loss of correction	-0.51 (-8 – 8)
Segmental saggital angle (degree)	
Preoperative	-14.6
Postoperative	-15.3
Final	-15.2
Loss of correction	0.73 (-10 – 12)

Table 3. Radiologic Results of Surgery

Characteristic	levels (total, 108) n (%)
Fusion Time(Months)	5.04 (3 – 12)
Nonunion level	2 (1.9)
Delayed union(> 6 Months)	16 (14.8)
Collapse ≥ 3 mm	18 (16.7)
Anterior disc height (mm)	
Preoperative	7.60 (1.3 – 14.6)
Postoperative	10.2 (4.5 – 15.5)
Final	9.3 (4.2 – 15)
Loss of correction	1.44 (0 – 5.5)
Posterior disc height (mm)	
Preoperative	6.27 (0.9 – 15.7)
Postoperative	8.55 (3.5 – 16.3)
Final	7.73 (3 – 13.8)
Loss of correction	1.68 (0 – 5.3)

the L5/S1 level. They received secondary surgery to remove the broken screws and posterolateral fusion with bone graft. Two days after the operation, one female patient had a cerebrovascular attack that resulted in right-side paraplegia. This patient was regularly treated at our neurologic department. One female patient had persistent postoperative left lower limb radiculopathy. MRI showed epidural fibrosis, and local steroid injection was administered. The final patient with a complication received L2 to L5 spinal fusion surgery and developed persistent buttock pain. The radiographs revealed L5/S1 adjacent instability. The patient refused further surgical treatment, and the symptom persisted without improvement.

Discussion

Capener[12] proposed PLIF for lumbar degenerative disease in 1932. Cloward[13] started to treat painful intervertebral disc with PLIF and autologous bone in the 1940s. In the 1980s, Steffee and Sitkowski[14] stated that PLIF in conjunction with pedicle screw fixation was biomechanically ideal and that it enhanced the fusion and success rate of spinal fusion in lumbar degenerative disease. Thereafter, PLIF was generally accepted as the gold standard surgical procedure for lumbar spinal arthrodesis. However, the problem of grafted bone collapse remains even when PLIF with pedicle screw fixation is performed using autograft or allograft bone.[15] Several types of interbody devices (spaces or cages) with solid anterior column support have been used for lumbar arthrodesis in recent years.[16] These devices have greatly improved the biomechanical stability of PLIF with pedicle screw fixation and are used in the standard procedure for lumbar spinal fusion surgery. Fogel et al.[4] reported that the fusion and clinical success rates were not significantly different between unilateral interbody cages and recommended the use of one cage based on the results of a retrospective comparative study. Therefore, in the present study, we used unilateral PEEK cage with pedicle screws for PLIF surgery.

Several different clinical success rates have been reported for PLIF, ranging from 79% to 86%.[17-18] In our study, the clinical successful rate obtained was 91.3%. Some studies reported a method of PLIF with total laminectomy.[19,20] In the present study, we used bilateral total medial facetectomy to achieve complete nerve decompression. This procedure can effectively improve radicular symptoms and decrease the risk of nerve injury during surgery;[3] however, the extent of laminectomy after pedicle screw fixation may increase adjacent instability.[21] In the current series, 2.9% of our patients developed adjacent instability after PLIF. We followed up for the patients for an average of 29.5 months which was long enough for evaluation of fusion rate, and the period of 29.5 months could be accepted by most journals.

The goal of PLIF is to achieve neurologic decompression and a stable construct. The higher union rate results in fewer cases of residual back pain due to pseudoarthrosis and

broken transpedicle screws. Hashimoto et al.[22] and Miura et al.[23] reported 100% bone union rate after PLIF with a carbon cage. However, Miura et al.[23] stated that only 29% of fixed segments achieved bone union. Okuyama et al.[3] reported that the fusion rate of PLIF with cages filled with excised facet joint bone was 93.5%. Fogel et al.[4] reported a fusion rate of 88% after PLIF; this rate was not affected by the use of either a single cage or bilateral cages. Some studies report fusion rates of TLIF from 89% to 94%.[5-7] In our series, the fusion rate was 97.1% (2/69) for all cases and 98.1% (2/108) for all fixed segments. Radiographs revealed increased anterior and posterior disc heights in our series. The final losses of anterior and posterior disc heights were 1.44 mm and 1.68 mm, respectively.

Endplate management is critical to achieve bone union and is important when the interbody space is the only fusion site. Some authors recommend partial removal of the endplate to increase the likelihood of successful fusion,[24-27] and some surgeons even suggest total removal of the bony endplate to allow the graft to rest on the cancellous bone for enhancing the bone union rate.[25,28] However, preservation of the bony endplate is desirable for prevention of interbody device subsidence.[24,25,29] Our technique involves preservation of the bony endplate and drilling the endplate; this can increase the bleeding area in contact with the bone graft. Furthermore, bone grafting of the available surface area of the interbody space is important for fusion.[4] Prolo, Oklund and Butcher[30] reported that filling up to 77% of the available disc space with bone could result in successful fusion. We used morselized local bone graft to fill the anterior disc space for increasing the contact area of the endplate and bone graft. The bone filling disc space could be up to 80% in our series. These two reasons might explain the high fusion rate (98.1%) we achieved in our series. In our series, we were in lack of control group which did not receive drilling endplate preparation but we had higher fusion rate in comparison to historical series in the literature.

In summary, we present the clinical results of drilling the endplate while performing PLIF. Our results showed that drilling the endplate during PLIF provided a successful clinical outcome and an excellent union rate.

Acknowledgment

We do not have a financial relationship with the organization that sponsored this research. We have full control of all primary data and agree to allow the journal to review the data if requested.

Ethical Approval

The studies were performed in accordance with the ethical standards specified in the 1964 Declaration of Helsinki. All persons gave their informed consent prior to their inclusion in the study.

References

1. Steffee AD, Sitkowski DJ: Posterior lumbar interbody fusion and plates. Clin Orthop Relat Res 1988;227:99-102.
2. Lee JH, Jeon DW, Lee SJ, et al: Fusion rates and subsidence of morselized local bone grafted in titanium cages in posterior lumbar interbody fusion using quantitative three-dimensional computed tomography scans. Spine 2010;35:1460-5.
3. Okuyama K, Kido T, Unoki E, et al: PLIF with a titanium cage and excised facet joint bone for degenerative spondylolisthesis – in augmentation with a pedicle screw. J Spinal Disord Tech 2007;20:53-9.
4. Fogel GR, Toohey JS, Neidre A, et al: Is one cage enough in posterior lumbar interbody fusion: a comparison of unilateral single cage interbody fusion to bilateral cages. J Spinal Disord Tech 2007;20:60-5.
5. Hackenberg L, Halm H, Bullmann V, et al: Transforaminal lumbar interbody fusion: a safe technique with satisfactory three to five year results. Eur Spine J 2005;14:551-8.
6. Lauber S, Schulte TL, Liljenqvist U, et al: Clinical

and radiologic 2–4-year results of transforaminal lumbar interbody fusion in degenerative and isthmic spondylolisthesis grade 1 and 2. Spine 2006;31:1693-8.
7. Lowe TG, Tahernia AD: Unilateral transforaminal posterior lumbar interbody fusion. Clin Orthop Relat Res 2002;394:64-72.
8. Philips FM, Wetzel FT, Lieberman I, et al: An in vivo comparison of the potential for extravertebral cement leak after vertebroplasty and kyphoplasty. Spine 2002;27:2173-9.
9. Dipaola CP, Molinarin RW: Posterior lumbar interbody fusion. J Am Acad Orthop Surg 2008;16:130-9.
10. Polikeit A, Ferguson SJ, Nolte LP, et al:The importance of the endplate for interbody cages in the lumbar spine. Eur Spine J 2003;12:556-61.
11. Odom GL, Finney W, Woodhall B: Cervical disc lesions. J Am Med Assoc. 1958;166:23-8.
12. Capener N: Spondylolisthesis. Br J Surg 1932;19:374-86.
13. Cloward RB: The treatment of ruptured lumbar intervertebral disc by vertebral body fusion. I. Indications, operative technique, after care. J Neurosurg 1953;10:154-68.
14. Steffee AD, Sitowski DJ: Posterior lumbar interbody fusion and plates. Clin Orthop Relat Res 1988;227:99-102.
15. Brantigan JW, Steffee AD, Lewis ML, et al: Lumbar interbody fusion using the Brantigan I/F cage for posterior lumbar interbody fusion and variable pedicle screw placement system. Two-year results from a Food and Drug Administration investigational device exemption clinical trial. Spine 2000;25:1437-46.
16. Kanayama M, Cunningham BW, Haggerty CJ, et al: In vitro biomechanical investigation of the stability and stress-shielding effect of lumbar interbody fusion devices. J Neurosurg 2000;93:259-65.
17. Lowe TG, Tahernia AD, O'Brien MF, et al:Unilateral transforaminal posterior lumbar interbody fusion (TLIF): indications, technique, and 2-year results. J Spinal Disord Tech 2002;15:31-8.
18. Potter BK, Freedman BA, Verwiebe EG, et al: Transforaminal lumbar interbody fusion: clinical and radiographic results and complications in 100 consecutive patients. J Spinal Disord Tech 2005;18:337-46.
19. Csécsei GI, Kliekner AP, Dobai J, et al: Posterior interbody fusion using laminectomy bone and transpedicular screw fixatioin in the treatment of lumbar spondylolisthesis. Surg Neurol 2000;53:2-7.
20. Ido K, Asada Y, Sakamoto T, et al: Use of autologenous cortical bonegraft sandwiched between two intervertebral spacers in posterior lumbar interbody fusion. Neurosurg Rev 2001;24:119-22.
21. Lai PL, Chen LH, Niu CC, et al: Relationship between laminectomy and development of adjacent segment instability after lumbar fusion with pedicle fixation. Spine 2004;29:2527-32.
22. Hashimoto T, Shigenobu K, kanayama M, et al: Clinical results of single-level posterior lumbar interbody fusion using the Branigan I/F carbon cage filled with mixture of local morselized bone and bioactive ceramic granules. Spine. 2002;27:258-62.
23. Miura Y, Imagama S, Yoda M, et al: Is local bone viable as a source of bone graft in posterior lumbar interbody fusion? Spine 2003;28:1386-9.
24. Kozak JA, Heilman AE, O'Brien JP: Anterior lumbar fusion options: technique and graft materials. Clin Orthop Relat Res 1994;300:45-51.
25. Steffen T, Tsantrizos A, Aebi M: Effect of implant design and endplate preparation on the compressive strength of interbody fusion constructs. Spine 2000;25:1077-84.
26. Boden SD, Sumner DR: Biologic factors affecting spinal fusion and bone regeneration. Spine 1995;20:102-12.
27. Prolo DJ: Biology of bone fusion. Clin Neurosurg 1990;36:135-46.
28. Lin PM: Posterior lumbar interbody fusiontechnique: complications and pitfalls. Clin Orthop Relat Res 1985;193:90-102.
29. Grant PJ, Oxand TR, Dvorak MF: Mapping the structural properties of the lumbasacral vertebral endplates. Spine 2001;26:889-96.
30. Prolo DJ, Oklund SA, Butcher M: Toward uniformity in evaluating results of lumbar spine operations. A paradigm applied to posterior lumbar interbody fusions. Spine 1986;11:601-6.