



## Posterior lumbar interbody fusion using cages, combined with instrumented posterolateral fusion : A study of 75 cases

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Posterior lumbar interbody fusion (PLIF) with cages can be combined with decompression of the spinal canal and with instrumented posterolateral fusion (IPLF) with pedicle screws, through a single posterior incision.

The authors wanted to assess retrospectively the clinical and radiological outcome of PLIF + IPLF performed by the senior author. Between July 1997 and December 2003, 75 patients underwent PLIF with cages and IPLF with transpedicular instrumentation, for either degenerative disc disease, stenosis, spondylolisthesis or post-discectomy syndrome. The clinical outcome was evaluated according to the criteria of Kirkaldy-Willis. Flexion/extension radiographs and CT-scans were obtained in cases where there was any doubt about the fixation/fusion status. The mean age was 48.7 years (range : 30 to 75). The mean duration of follow-up was 29.17 months (range : 12 to 67). The clinical outcome was excellent or good in 85.3% of the patients. There were 4/75 patients (5.3%) who failed to return to their original occupation. Four posterolateral fusions were uncertain, but all anterior fusions succeeded : thus circumferential fusion was obtained in 71 out of 75 cases, or 94.6%. Three patients sustained a neurological complication, but only one was left with a partial drop foot. The results were comparable with similar studies. Therefore the authors recommend further use of PLIF + IPLF in painful lumbar degenerative spinal disease where conservative management has failed.

**Keywords** : posterior lumbar interbody fusion ; cages ; instrumented posterolateral fusion.

### INTRODUCTION

Circumferential fusion of the lumbar spine, which is a combination of anterior and posterior arthrodesis, commonly referred to as 360-degree fusion, has become popular since the mid-1980s (21,23). Since Cloward's (6) initial description of the posterior lumbar interbody fusion (PLIF) for degenerative disorders of the lumbar spine, the procedure has seen varying degrees of acceptance and there have been numerous adaptations and innovations. The basic principle, however, still remains the same, i.e. to decompress the entrapped neural elements, enlarge the intervertebral foramina through disc space elevation, remove anterior discal tissue, and provide immediate motion segment stability.

It is the ideal procedure in a patient with severe low back pain with an objective radiculopathy from

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canal or foraminal stenosis. Currently, the PLIF procedure and its modifications are used successfully in various disorders, including degenerative disc disease, spinal stenosis, low-grade spondylolisthesis, and post-discectomy syndrome.

PLIF may be supplemented with posterior instrumentation : either standard transpedicular fixation or translaminar screws. The addition of a posterolateral fusion to provide a truly circumferential fusion has been associated with superior outcomes in selected series (2-4,10,12,22,28,38,41), but increases operation time, cost and neurological complications.

The advantage of PLIF over ALIF (Anterior lumbar interbody fusion) is that the former, if supplemented with a posterolateral fusion, accomplishes a 360-degree fusion via a single-stage approach. This decreases the operative time and spares the patient from the complications associated with a transabdominal approach, in particular, damage to the great vessels and to the presacral plexus. Moreover, obesity may be a relative contraindication for anterior spinal surgery.

Those less enthusiastic about PLIF cite its steep learning curve (11), technical difficulty and high complication rate, in particular graft migration and neural injury (37,42,44).

The graft material in PLIF can be autologous iliac crest bone, local autograft from lamina or facet, allograft spacer, or a structural spacer cage filled with osteoinductive graft material. There are also some reports about the use of bone substitutes like rh-BMP2 (Bone Morphogenic Protein) and calcium carbonate or phosphate derivatives.

This study is looking at the results of PLIF using cages filled with autogenous cancellous bone grafts from the iliac crest, combined with IPLF, in 75 patients.

### SURGICAL TECHNIQUE

The senior author (EFW) has refined the technique of PLIF with experience, and would emphasise the key points as follows. The patient is placed prone on a Wilson/Codman frame. The abdomen is free from external pressure, to ensure minimal epidural bleeding.

A routine midline approach is made. Bone autografts are harvested via subcutaneous dissection from the midline wound to the right or left posterior iliac crest.

After securing adequate haemostasis, the iliac wound is closed in layers without a suction drain. Subperiosteal dissection exposes the intended segmental levels and the transverse processes on both sides. The facet joints of the involved segments are identified and the joint surfaces excised. A posterior decortication is performed at this stage. Pedicle screws are inserted under fluoroscopic control in the lateral plane, using a standard "free hand targeting" technique. Decompression is commenced via the midline, removing adjacent borders of the spinous processes of the vertebrae above and below.

Interspinous ligaments and ligamenta flava are excised to enter the neural canal. The spinal fenestration is enlarged with sufficient decompressive laminotomy superiorly and inferiorly to expose and mobilise the nerve roots on both sides. These are then retracted to expose the disc space. A cruciate incision is made on both sides of the annulus and the disc material is removed with pituitary rongeurs. Disc space fenestration is then performed, utilising reamer/distractor instrumentation, first on one side, then on the other side. Neural elements are protected throughout this procedure. Disc space preparation is the next step, utilising reamer/distractor instrumentation, starting from one side, then on the other side. Again, due care is taken to protect the neural elements. End plates are removed above and below. A cage sizer is used to determine the cage size and is checked with image intensification. Appropriate size cages (PEEK = polyethyletherketone, or Titanium cages) are packed with cancellous autografts and are bilaterally inserted. The final position of the cages is confirmed fluoroscopically. A visual check ensures that there is no persistent nerve root compression following the insertion of the cages. Cancellous bone grafts are applied to the prepared posterolateral decorticated beds.

Two rods are then cut to length following templating. After rod contouring, both rods are applied to the pedicle screw heads, with nut application.

Final tightening of the nuts is performed under compression with the torque wrench. Free fat grafts are applied over the exposed dura and nerve roots. Haemostasis is secured and the wound is closed in layers. The patient is mobilised the next day, with a lumbar orthosis for 12 weeks.

## MATERIALS AND METHODS

The combination PLIF + IPLF is being offered in this institution since 1996. The authors decided to check the results retrospectively. The inclusion criteria were : severe low back or leg pain, or both, not responding to medication, rehabilitation and conservative treatment ; low back pain for at least 2 years ; degenerative disc disease, spinal stenosis, spondylolisthesis (all grades and all types), and post-discectomy syndrome. Exclusion criteria were : fusions performed after revision surgery, tumours, trauma, infection, fusion of more than 3 levels, and patients with obvious psychological problems or on long-term health-benefits.

All acceptable cases seen between January 1997 and December 2003 were included, in order to obtain a follow-up period of at least 3 years. They were identified from the records in the operating room. Eighty-four patients who fulfilled the inclusion criteria were so identified and contacted. Of these 84, 4 patients had moved to another address and could not be contacted, while 5 patients declined the offer. Thus, 75 patients were available for follow-up. All procedures were performed by the senior author (EFW).

Preoperative assessment consisted of plain radiographs, discography, myelography, CT-scan, MRI-scan, dependent on the patient's complaints and available imaging. The graft material used was autogenous cancellous bone harvested from the posterior iliac crest combined with PEEK or titanium interbody cages in all patients.

The data of all 75 patients were collected from their clinical notes and periodic follow-up : radiographs, duration of symptoms, investigations performed, post-operative complications, time to radiological fusion, time to resume work, revision surgery if any, and time to discharge from clinic review. All patients had a clinical and radiological assessment at 4, 6 and 12 months post-operatively. Those who had relief of symptoms, were pleased with the results or were able to resume work, and had evidence of radiological fusion, were discharged at that time. Those who had partial relief of symptoms, were not able to resume work, or had doubt-

Table I. — Clinical results\*

	No
Excellent	48 (64%)
Good	16 (21.3%)
Fair	9 (12%)
Poor	2 (2.7%)

\*Kirkaldy-Willis criteria (20) in brief :

Excellent = return to normal work with little or no complaint

Good = return to normal work with some restriction

Fair = reduced working capacity

Poor = unable to return to work.

ful evidence of radiological fusion were followed-up further. All 75 patients were invited to a final review for a full physical and radiological assessment. The physical assessment involved a record of any residual back/leg pain, any change in neurological condition, and any complications. Overall clinical results were determined by the Kirkaldy-Willis criteria (table I) (20).

## Radiologic evaluation

The radiological examination focused on fusion status and complications related to the procedure or the metalwork. Union was defined as solid when there was bony trabecular continuity and less than 4 degrees of mobility between the segments on flexion-extension radiographs. Union was "probable" when the bony trabecular continuity was not clear but there was less than 4 degrees mobility between the adjacent fused segments. Non-union was defined as a visible gap, graft collapse, and motion greater than 4 degrees.

The posterolateral fusion was evaluated separately from the PLIF. Consolidation of the posterior bone graft was graded as probably fused, indeterminate or probably pseudarthrotic on both sides at each level.

Both the interbody fusion (PLIF) and the instrumented posterolateral fusion (IPLF) were taken into account when assessing whether a level was in fact solidly fused.

If doubt existed regarding the status of fusion, flexion/extension radiographs and CT-scans were obtained for further assessment.

## RESULTS

The group consisted of 45 men and 30 women (mean age : 48.7 years, range : 30 to 75). The mean



*Fig. 1.* — Lateral view : PLIF plus IPLF

duration of symptoms prior to surgery was 4.2 years (range : 2 to 6.5). Preoperatively, 45 patients (60%) complained predominantly of low back pain, 15 (20%) predominantly of leg pain and another 15 (20%) of equal back and leg pain.

The indications for surgery were degenerative disc disease in 37 (49.3%), spinal stenosis in 14 (18.7%), degenerative spondylolisthesis of all grades in 11 (14.7%), isthmic spondylolisthesis in 9 or 12%, and post-discectomy syndrome in 4 (5.3%). Fifty-four patients (72 %) had a single level fusion (32% at L4/L5, and 40% at L5/S1), 20 (26.7%) had a two-level fusion (the majority from L4 to S1), and 1 patient (1.3%) had a three-level fusion. Titanium cages were used in 42 patients, and PEEK cages in 33 patients.

The mean duration of surgery was 2.4 hours. The average intraoperative blood loss was 1.3 l (range : 0.6 to 2.0). The mean hospital stay was 6.5 days (range : 4 to 12).

The mean duration of follow-up was 29.17 months (range : 12 to 67).

### **Back pain**

Thirty-six out of 60 patients with back pain (60%) had complete relief of back pain following surgery ; 18/60 patients (30%) had occasional back pain and 6/60 patients (10%) had persistent back pain in spite of surgery.

### **Leg pain**

Twenty-one out of 30 patients with leg pain (70%) had complete relief of leg pain, 7/30 patients (23.3%) had occasional leg pain, and 2/30 patients (6.7%) had persistent leg pain and were referred to the pain clinic for pain management.

### **Return to work**

Overall 48/75 patients (64%) returned to their original occupation, with a further 12/75 (16%) working at least part-time. There were 12/75 other patients who were either housewives or retired, of whom 11 patients (14.7%) were able to return to normal household work ; the twelfth patient was a housewife who was not able to return to normal household work due to leg pain. Finally, 3/75 patients (4%) were unable to return to their original job : two switched to a lighter job due to persistent back pain at the same level, while the third patient was unable to return to work due to persistent back pain because of degenerative changes at one level above the site of fusion ; this patient was offered but declined further surgery. All these three patients were considered to have failed to return to work after surgery. Thus, there were 4/75 patients (5.3%) who failed to return to their original occupation.

### **Clinical results**

Considering the excellent and good results as satisfactory, according to the Kirkaldy-Willis scale (20), the success rate in the current study was 85.3% (table I).



Fig. 2. — Anteroposterior view : PLIF plus IPLF

## Fusion

In three patients, concern regarding the state of *anterior* fusion prompted the clinician to perform flexion/extension radiographs and a CT-scan. No significant movement was detected on the dynamic films, and the CT-scans confirmed the presence of a bridging fusion mass.

Seventy out of 75 patients had bilateral solid fusion *posterolaterally*. There was frank pseudoarthrosis on one side in one patient (but fusion on the opposite side); fusion was less clear in four other patients, but all four had solid interbody fusion, were asymptomatic and returned to work.

On the whole, 71 out of 75 (94.6%) patients were shown to have, by definition, a stable circumferential fixation.

## Complications

All four dural tears were encountered in patients with severe degenerative disease.

All were repaired with either dural clips or sutures. Two patients had cerebrospinal fluid leak

post-operatively (headache, postural hypotension). One of them had CSF leak from the wound in the early postoperative period; a fat patch was applied, while the other patient went on to spontaneous resolution without any intervention. Three patients had wound haematoma, which settled after aseptic aspiration. Two patients had superficial infection of the bone graft donor area, which settled with a short course of oral antibiotics. One patient unfortunately developed severe leg pain postoperatively; the MRI scan showed a new disc prolapse at the level above the fusion, but pain resolved after a limited discectomy on the fourth post-operative day.

Radiographs showed one asymptomatic extrapedicular screw. One case of screw pull-out was resolved by switching from a 6.5 mm to a 7.5 mm screw. There were no cases of graft dislodgement. There was one case where the follow-up radiographs at 12 weeks showed that the cage had displaced posteriorly by about 25%. However, this patient did not have any symptoms, and went on to achieve full radiological union. One patient had a fractured titanium cage, one year following surgery, but without symptoms; he went on to radiological fusion, and returned to normal activities. Donor site pain lasted for four months in four patients despite a variety of conservative measures, and one of them remained on Gabapentin until eight months post-surgery. One patient with an L4/L5 fusion developed disc degeneration at a level above the fused segment, which caused pressure on the L4 nerve root. This patient had a second operation to fuse the L2/L3 and L3/L4 segments, which relieved all the symptoms.

Three patients had neurological complications. Of these, two experienced transient extensor hallucis longus weakness (both patients having undergone a two-level PLIF); both recovered within a period of 6 weeks. One patient suffered unilateral foot drop, which recovered only partially, leaving the affected side weak. Thus a permanent neurological deficit occurred in 1.3% (1/75) of the cases.

## DISCUSSION

Advocates of posterior lumbar interbody fusion (PLIF) report superior results compared to other

lumbar fusion techniques (2-4,6,7,10,12,14,22,28,34,38,40,41), while opponents cite its technical difficulty and high complication rate, particularly with regard to neural injury (11,37,42). The technique requires generous bone resection, judicious nerve root retraction, and meticulous haemostasis. Vigorous nerve root retraction or disc space distraction may lead to neural injury. Excessive bleeding impairs visualisation, places the dura and nerve roots at further risk, and may even predispose to epidural fibrosis.

However, from a biomechanical, anatomic, and physiologic standpoint, the theoretical advantages of interbody fusion seem obvious. Interbody support restores disc space height, facilitates correction of alignment and balance, prevents progression of spondylolisthesis, and provides load sharing to prolong the life of instrumentation.

Interbody fusion has gained broader usage in the treatment of motion segment instability pain since its introduction by Cloward (6). As the anterior and middle spinal columns support 80% of the spinal load, placing the bone graft in this load-bearing position subjects it to compressive forces that enhance bony fusion, as predicted by Wolff's law.

In addition, the vertebral body represents 90% of the osseous surface area and receives a more generous vascular supply than the posterolateral elements, factors which further improve fusion potential. Interbody fusion can be achieved by an anterior transabdominal approach, but this has the risk of damage to the great vessels and to the presacral plexus; obesity also can be a relative contraindication for anterior spinal surgery. The advantage of PLIF over ALIF (Anterior Lumbar Interbody Fusion) is that the former accomplishes a 360° fusion via a single-stage approach. This decreases the operative time and spares the patient from the complications associated with a transabdominal approach.

The addition of IPLF to PLIF, however, is not universally accepted. It adds to cost, operating time and blood loss, and potentially increases the risk of nerve root injury.

Nevertheless posterior implants allow compression of the interspace, reducing graft or cage migration. Posterior pedicular constructs provide

load sharing with the anterior column and enhancement of the posterior tension band, thereby more closely resembling physiological loading. The addition of such instrumentation has been shown to increase initial stiffness (5) and stabilisation of the lumbar spine segments after PLIF with cages (25). Brodke *et al* (5) and Lund *et al* (26) found that the combination of cage and posterior pedicle screw instrumentation was the stiffest on biomechanical testing, as compared to a standalone PLIF procedure. As the motion segment is a three-joint complex, consisting of a disc and two facet joints, the highest rate of fusion is obtained from supplementary fixation of the facet joints behind the anterior graft used for posterior lumbar interbody fusion (28,32). Supplementing this interbody graft with a posterolateral bone graft will further improve the fusion rate. Jutte and Castelein (18) supported this thesis. They analysed 105 consecutive instrumentation-assisted lumbar fusions and reported 13 patients with broken screws. Eight of these patients experienced screw breakage after surgical reduction of spondylolisthesis L5-S1 combined with transpedicle fixation without anterior load sharing. However, none of the 28 patients who underwent additional interbody support (via ALIF or PLIF) had instrumentation failure. As a result, they recommended using interbody fusion to supplement instrumentation-assisted arthrodesis in patients with L5-S1 spondylolisthesis.

Similarly, Enker and Steffee (10) concluded that restoring the anterior column prolongs the life of instrumentation used to augment lumbar arthrodesis. The use of a pedicle screws/rod system in the Gertzbein study about circumferential fusion (13) was associated with a high fusion rate, and it was believed that compression of the anterior graft by the posterior fixation device facilitated the fusion.

Many authors (16,27,29,33,36,38,45) have reported a fusion rate of 100% with circumferential fusion, confirming that, indeed, reliable fusion can be achieved with this technique. However, a number of retrospective studies have reported a certain but not absolute association between achieving a solid fusion and a successful clinical outcome in adults with acquired lytic spondylolisthesis (1,8,15,19,31,35). In other words, obtaining 100% circumferential

fusion will not provide 100% clinical success because of the psychosocial, socio-economic and other factors, which are yet to be elucidated.

Appropriate patient selection and screening in these areas will improve clinical success rates.

Many systems have been used for interbody fusion: autografts, allografts, calcium carbonate and phosphate derivatives, besides hybrid spacers, such as metallic or carbon fibre ramps, or circular cages filled with osteoinductive materials.

Recently synthetic and metallic interbody spacers (carbon and titanium cages) have gained popularity because of unlimited choice of shapes and sizes and the absence or reduction of bone graft harvest morbidity. The use of tricortical graft from the iliac crest allows easy radiographic follow-up of the fusion and is inexpensive. However, some series report significant donor site pain in up to 25% of patients (39). Moreover, in elderly patients with osteoporosis, the relatively weak tricortical iliac crest grafts are too fragile to restore and maintain disc height. Graft fracture, collapse and resorption are the main factors contributing to nonunion and failure. The use of allograft, whilst reducing donor site morbidity, has been associated with increased rates of pseudarthrosis, higher incidence of graft collapse (4), and an increased time to fusion (4,6). Thus, some authors have suggested that interbody fusions are less successful if strong structural support is not provided in the intervertebral space (9,24,30,43). There remains also the theoretical risk of disease transmission from allografts. Interbody cages were introduced to tackle some of these problems. Their design provides structural support while the inside cancellous graft incorporates, so that graft collapse is avoided (3). Human cadaveric models of PLIF have shown adequate and equal mechanical strength when comparing tricortical bone grafts and titanium fibre mesh implants (17).

Interbody cages obviate the need for tricortical iliac crest grafts and possibly reduce donor site morbidity. Carbon cages packed with autologous bone are claimed by some to achieve a quicker and more reliable fusion when compared to allograft alone (4). The disadvantage of cages is that titanium cages may obscure the disc space on radiographs

making the assessment of interbody fusion difficult. The cost of these implants should also be taken into account. Nevertheless, using titanium or PEEK cages in our study has shown good results, both radiologically and clinically.

There is a paucity of literature assessing clinical outcome for PLIF combined with IPLF using pedicular fixation. Only two of 68 papers reviewed by Boos and Webb (2) discussed the outcome of such surgery. The results were excellent (fusion rate 94%, satisfactory clinical outcome 87%) when compared to other forms of fusion. The authors obtained a stable circumferential fixation in all patients, with a satisfactory clinical outcome in 85%.

Complications often cited in association with PLIF include neural injury, dural laceration, excessive bleeding, graft migration and graft collapse. These are predominantly associated with the exposure and retraction required for disc clearance and graft insertion. The neural injury rate in the current series (2.6% temporary, 1.3% permanent) was comparable to that reported in the literature.

## CONCLUSION

These 75 combined posterior lumbar interbody fusions and instrumented posterolateral fusions, performed by a single surgeon, using a single incision, demonstrated clinical success in 85.3%, a circumferential fusion in 94.6%, and a low complication rate (permanent neurological deficit in 1.3%). This study, in spite of its retrospective character, supports circumferential fusion of the lumbar spine using a particular technique, and adds to the limited number of studies in the literature which show good clinical results after a successful circumferential fusion. The authors hope that this study will help the spine surgeon in making therapeutic decisions in properly selected patients.

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