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Posterior Lumbar Interbody Fusion for Degenerative Lumbar Spine Disease: A Prospective Study of One-Year Clinical and Radiological Outcomes in a Resource-Limited Rural Setting

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Abstract

Study Design: *We prospectively analysed the clinic-radiological outcomes of instrumented posterior lumbar interbody fusion (PLIF) using local morselised bone in degenerative lumbar spine disease.*

Purpose: *To evaluate the clinical and radiological outcomes of PLIF in degenerative lumbar spine disease.*

Overview: *The degenerative lumbar spinal disease treatment is very diffuse, including conservative and operative approaches. Moreover, there is no current, concrete, gold-standard treatment approach to the diverse range of patient presentations despite substantial research efforts.*

Methods: *Thirty patients who underwent posterior lumbar interbody fusion using local morselised bone were included in the study with a minimum follow-up of 12 months. Clinical outcomes were evaluated using the Visual Analogue Scale (VAS) for pain and Oswestry Disability Index (ODI) for disability preoperatively and at 3 months, 6 months, and 12 months postoperatively and modified Kirkaldy-Willis criteria for functional outcomes at the last follow-up. Plain radiographs taken 3, 6, and 12 months after surgery were evaluated for fusion using Brantigan-Steffee criteria. A CT scan at 12 months after surgery was evaluated for fusion using our criteria. SPSS version 21 was used for the analysis of data. The significance threshold of the p-value was set at <0.05.*

Results: *Clinical outcomes were good to excellent in 70% of our patients, fair in 23 %, and poor in 7 % of patients. 90% of our patients demonstrated plain radiographic fusion. One patient among the fused group demonstrated pseudoarthrosis on a CT scan, which gave the actual radiologic fusion rate of 86.7%. No major complication demanding surgical attention was seen in our study group.*

Conclusions: *PLIF using has the advantage of shorter operative time, less blood loss, and a requirement of a single posterior incision, avoiding risks inherent to the anterior approach, and in adequately selected patients of degenerative lumbar spine disease yields good clinical and radiological outcomes.*

Keywords: *PLIF, Degenerative lumbar spine, spine fusion*

1. Introduction

Degenerative lumbar spine disease is a common ailment in the ageing population, representing a significant burden for the health care system. Degenerative lumbar spinal disease is a broad term that includes degenerative disc disease, degenerative spinal scoliosis, spinal stenosis, facet joint arthritis and spondylolisthesis. Symptoms associated with degenerative lumbar spine disease vary in severity and show a relatively low correlation with the severity of anatomic and radiological changes. Patients may present with chronic lumbar axial pain, radicular pain, spasms, neurogenic claudication and neurologic deficits.

The degenerative lumbar spinal disease treatment is very diffuse, including conservative and operative approaches. Moreover, there is no current, concrete, gold-standard treatment approach to the diverse range of patient presentations despite substantial research efforts [1]. Only a tiny section of patients seeks surgical intervention. Surgical options consist of decompression and spinal fusion surgeries such as anterior lumbar interbody fusion, posterior lumbar interbody fusion and posterolateral fusion.

Posterior lumbar interbody fusion (PLIF) was initially described by Ralph Cloward in 1953 [2] and has grown in popularity since then, becoming one of the most commonly performed procedure for degenerative lumbar spine disease. PLIF has the advantages of a purely dorsal approach, spinal cord decompression, reduction of sagittal slips, and the possibility of reaching and stabilising the anterior spinal column while avoiding the risks inherent to the anterior approach (Figure 1 and 2). The availability of pedicle screw instrumentation and intervertebral cages contributed to progressively greater acceptance of this procedure. Better alignment and higher fusion rates are routinely achieved using these devices. PLIF has evolved. There have been changes in the technique and type of bone grafting. Many recent reports showed comparable fusion rates of local bone graft and cage with those of iliac crest bone graft, with definite advantages [3]. The practice of using double cages has evolved to single cages with comparable results and fewer complications [4]. The evolution of construct design from femoral ring allograft to threaded cortical bone dowels, to cylindrical metal fusion cages, and ultimately to tapered fusion cages (metal and composite) proceeded with the knowledge that fusion success requires, in part, both mechanical stability and adequate graft material to provide a favourable biologic environment in which fusion can occur [5]. The two most extensively used include a titanium cage and a PEEK (Polyetheretherketone) cage. We used a PEEK cage in our study. It has been seen that titanium implants affect the diagnostic value of imaging studies and are responsible for artefacts. Our study aimed to evaluate the outcome of PLIF in degenerative lumbar spine disease. Analysis focused on clinical outcome, radiological fusion, and complications associated with the procedure.

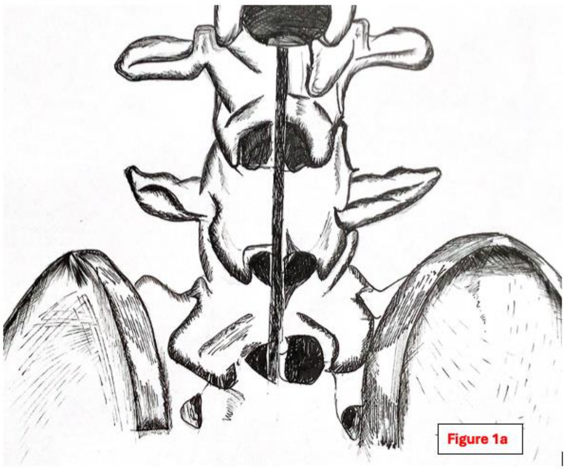

Figure 1a. *Midline incision*

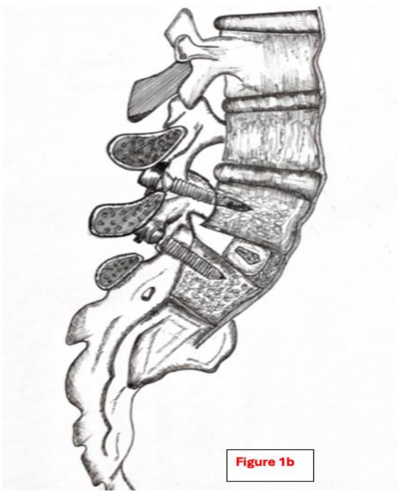

Figure 1b. *Polyaxial screws and cage placed as seen from side*

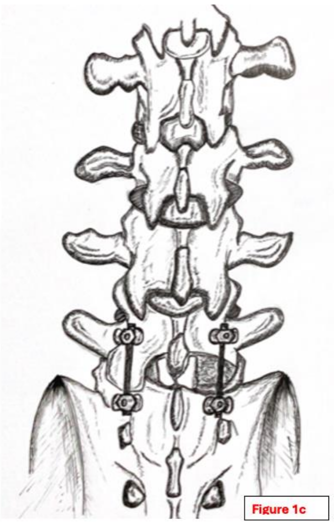

Figure 1c. *Posterior view showing rods connected*

Figure 1. *Posterior instrumented fusion with interbody cage*

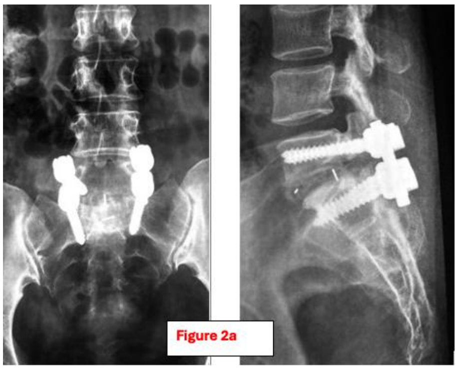

Figure 2a. *Radiograph showing interbody fusion*

Figure 2b. *Radiograph showing pseudoarthrosis*

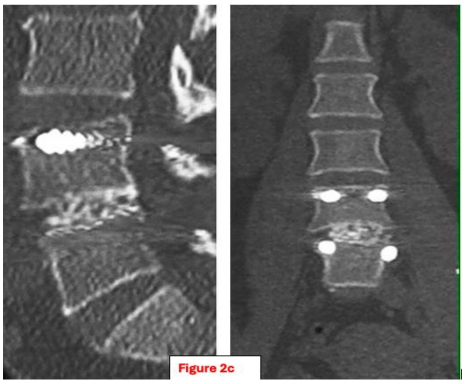

Figure 2c. *CT scan showing union*

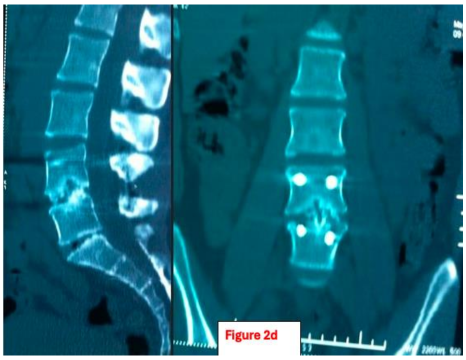

Figure 2d. *CT scan showing pseudoarthrosis*

Figure 2. *Radiographs on follow-up*

2. Methods

Ethics: Institutional ethics committee approval was obtained before beginning the study. Written informed consent was obtained from the included patients. Study design: It was a prospective observational study conducted in the orthopaedic surgery unit of our hospital between March 2021 to June 2023. Thirty patients were included in our study. Baseline parameters were noted, including age at presentation, gender, symptoms, presence or absence of neurology, diagnosis, and level of spinal involvement (Table 1). Revision cases, patients with more than one level of involvement and infective cases were excluded from the study. These patients were followed up for a minimum of 12 months from surgery.

Table 1. *Baseline parameters*

Parameter	Values
Age (years)	60.46 ± 10.91
Gender	Male:10 Female:20
Symptoms	Only Backpain: 1(3.33%) Back pain with associated symptoms: 28 (93.33%) Only Neurogenic claudication: 1 (3.33%)
Neurological involvement	Yes: 1 (3.33%) No: 29 (96.66%)
Diagnosis	Chronic PID[1]: 3 (10%) Degenerative listhesis: 18 (60%) Degenerative stenosis: 4 (13.33%) Lytic listhesis: 5 (16.67%)
Level of spinal involvement	L2-L3:1 (3.33%) L4-L5:25 (83.33%) L5-S1:4 (13.33%)

1-prolapsed intervertebral disc

3. Assessment

Clinical assessment was done using Visual Analogue Scale (VAS) for pain and Oswestry Disability Index (ODI) for disability. VAS and ODI scores were recorded during preoperative assessment and postoperatively at 3 months, 6 months, and 12 months after surgery.

At the last follow-up, modified Kirkaldy-Willis criteria (Table 2) was employed to grade the clinical outcomes as excellent, good, fair, and poor [6]. Plain radiographs were taken as part of pre-operative work-up and postoperatively to study fusion and rule out any complications at 3, 6, and 12 months after surgery. Fusion was assessed on plain anteroposterior and Lateral radiographs using Brantigan-Steffee criteria [7]. A computed tomography (CT) scan was taken at 12 months' follow-up to confirm radiological fusion.

Table 2. *Modified kirkaldy-Willis criteria of functional outcome*

Grade	Description
Excellent	The patient has returned to his normal work and other activities with little or no complaint
Good	The patient has returned to his normal work but may have some restriction in other activities and may on occasions after heavy work have recurrent back pain requiring a rest for a few days

Fair	The patient has to reduce his working capacity, taking a lighter job or work part-time, and may occasionally have recurrence of pain requiring absence from work for one to two weeks, once or twice a year
Poor	The patient does not return to work.

Brantigan-Steffee classification of fusion on plain radiograph

Fusion is said to be present when the following criteria are met:

- Bone in the fusion area is more dense and more mature than originally achieved during surgery.
- No interspace between the cage and vertebral body.
- Mature bony trabeculae bridging the fusion area.

CT criteria of interbody fusion used in our study

Fusion is said to be present when the following criteria are met:

- Dense bridging trabecular bone is seen lateral to the implant and sometimes within the implant.
- Absence of cystic lucencies adjacent to the implant and no linear defects through the bridging bone.

Statistical methods

SPSS version 21 was used for the analysis of data. The significance threshold of the p-value was set at <0.05.

4. Results

Clinical outcomes: Statistically significant improvement was noted in both VAS and ODI scores at each postoperative follow-up (Table 3). According to modified Kirkaldy-Willis criteria, functional outcomes were excellent in 9 (30%), good in 12 (40%), fair in 7 (23%), & poor in 2 (7%). Intra-operative complications were dural tear in 2 (6.7%) patients which was sutured immediately with no significant postoperative problems.

Post-operatively, 1 (3.3%) patient had worsening of neurology, and 4 (13.3%) patients had early signs of adjacent segment degeneration (Table 4).

Table 3. *Clinical and radiographic Outcomes*

Parameter	Preop	3 month post op	6 month post op	12 month post op	Statistical test applied	P value and its interpretation
VAS	7.23 ± 1.52	3.60 ± 1.56	3.30 ± 2.02	2.86 ± 2.04	Kruskal Wallis test with post hoc Dunn's multiple comparison test	<0.0001. <0.05. The VAS score 3 months post op is significantly lower as compared to preop VAS score. <0.05. The VAS score 6 months post op is significantly lower as compared to preop VAS score. <0.05. The VAS score 12 months post op is significantly lower as compared to preop VAS score.
ODI	22.77 ± 7.25	10.30 ± 3.94	9.23 ± 4.91	9.50 ± 5.03	Kruskal Wallis test with post hoc Dunn's multiple comparison test	<0.0001. <0.05. The ODI score 3 months post op is significantly lower as compared to preop VAS score. <0.05. The ODI score 6 months post op is significantly lower as compared to preop VAS score. <0.05. The ODI score 12 months post op is significantly lower as compared to preop ODI score.
Fusion		Fusion present:3 Fusion absent:27	Fusion present:21 Fusion absent: 9	Fusion present:27 Fusion absent:3	Chi square test	<0.0001. The occurrence of fusion is significantly higher at 6 month and 12 month post op evaluation

Table 4. *Functional outcomes and complications*

Parameters	Values
Intra-op complications	Nil: 26 Dural tear:2 Screw malpositioning: 1
Post-op complications	Nil:25 Neurology worsened: 1 Early ASD: 4
Clinical outcome (Kirkaldy-Willis criteria)	Poor: 2(6.7%) Fair: 7(23.3%) Good:12(40%) Excellent: 9(30%)

Radiographic outcomes: Fusion was observed in 27 (90%) patients on plain radiography at 6-month & 12-month follow-up. 3 (10%) patients had pseudoarthrosis on plain radiography at 6 & 12-month follow-up. No case of delayed union was observed. CT scan at last follow-up confirmed fusion in 26 (86.7%) patients, as one patient from the plain radiographic fused group had pseudoarthrosis on CT films (Table 3). On follow-up CT scan, one patient was noted to have asymptomatic pedicle screw malposition.

5. Discussion

Surgical management of degenerative disease of the spine is perhaps the most controversial issue in spine surgery. Interbody fusion has gained broader usage in the treatment of degenerative disease of the lumbar spine. 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. Various techniques have been developed for lumbar interbody fusion. PLIF has been the most popular posterior technique.

The technique requires generous bone resection, judicious nerve root retraction, and meticulous haemostasis. Excessive bleeding impairs visualisation, places the dura and nerve roots at further risk, and may even predispose to epidural fibrosis. Interbody support, however, restores disc space height, foraminal height, facilitates correction of alignment and balance, prevents progression of subluxation, and provides load sharing to prolong the life of instrumentation. The addition of posterior instrumentation adds to the operating time, blood loss, and cost, and potentially increases the risk of nerve root injury. Nevertheless, posterior instrumentation allows compression of the disc space, 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. Although posterior instrumentation enhances the stability and fusion [8], a biomechanically stable spine is achieved only when solid fusion is achieved [9].

Patients included in our study fulfilled the inclusion criteria. For all patients, non-surgical therapy had failed for at least 6 months. All 30 patients were available for 12 12-month follow-up. To assess clinical outcomes, we used standard outcome instruments. For pain, VAS was used while disability was evaluated using ODI. Clinical outcomes were graded as excellent, good, fair and poor based on Kirkaldy-Willis criteria. Radiological assessment was done using Brantigan and Steffee classification of fusion on plain radiographs and a fixed protocol for fusion assessment on CT scan. Evaluation and diagnosis, and treatment planning and execution were done by the single operating surgeon in all our patients using the same surgical technique.

At 12-month follow-up, 70% of our patients reported good to excellent outcomes with improvements in pain and disability. Outcomes were fair in 23% and poor in 7% of patients using Kirkaldy-Willis criteria.

90% of our patients had a plain radiographic fusion at 12-month follow-up. However, one patient in that group showed pseudoarthrosis on CT scan, giving the actual fusion rate of 86.66%.

No major complications demanding a second surgical procedure were seen in our study group. Two patients (6.7%) of severe degenerative disease in our group had intraoperative complications in the form of dural tears, which were repaired with sutures and had no postoperative problems related to the tear. Retrospectively on CT scan, one patient had a screw malposition (3.3%) which was asymptomatic, however. No patient in our group had any significant wound complications requiring a second surgical procedure. At 12-month follow-up, 3 patients developed radicular leg pain, and 1 patient complained of neurogenic claudication for which an MRI was advised. MRI of these patients revealed degeneration of the disc one level above the operated level (Adjacent segment degeneration-13.33%). However, these patients were given a trial of conservative treatment. One patient (3.3%) in our study with a preoperative neurological deficit (unilateral ADF/EHL-grade 3) worsened postoperatively (ADF/EHL-grade 1) and didn't recover till the last follow-up, leaving the affected side weak. None of the patients in our study group had hardware failure (screw migration, screw breakage, cage breakage, cage migration or cage subsidence) seen in earlier studies. Okuda S et al [10] in a large study reported one or more PLIF complications in 25% of their cases, and that 8% of the cases underwent a second operation.

Our study had several shortcomings. A short follow-up of 12 months with a small sample size was the most notable one. Our study was not randomized, and we compared our outcomes with those in other, similar series. The decision on fusion and/or pseudoarthrosis was taken by the operating surgeon and the principal investigator after reading the radiographs and CT scan. This may have introduced a bias in the radiographic outcomes as neither of the interpreters was blinded to the patient. We did not study the demographic predictors of surgical success, like level of education, tobacco use, alcohol intake, and workers' compensation claims. The impact of associated medical comorbidities like diabetes and morbid obesity on clinical outcomes was not evaluated.

The PLIF still holds a role in modern-day spine surgery, despite advances in minimally invasive surgery, robotics, and endoscopic techniques. PLIF has established efficacy in complex cases, delivers high fusion rates and stability, allows for direct visualisation of bilateral nerve roots, and the learning curve is less steep, making it a reliable option when newer technologies are less accessible, or the surgeon is less experienced in minimally invasive techniques.

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