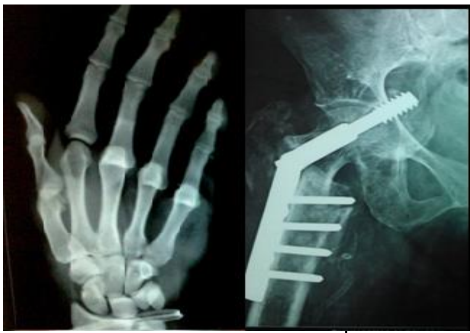

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Evaluation of the clinico-radiological outcome of lumbar interbody fusion using cage and local bone graft in management of lumbar spondylolisthesis

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Abstract

Background: Pain in the lower lumbar spine is a socioeconomically serious medical illness. The main reason from physiological perspective was micro and macro instability of spine. Posterior lumbar interbody fusion (PLIF) is a reliable treatment option for patients with spondylolisthesis; providing spinal stabilization in a balanced alignment with the disc space height being restored and with the neural elements being decompressed mechanically.

Aims: To study clinical and radiological outcomes of Posterior lumbar interbody fusion with cage and local bone graft from laminectomy bone chips in lumbar spondylolisthesis.

Material and Method: Our study includes 4 males and 8 females, aging 35-64 years. As per the Meyerding-evaluating system, 11 cases were classified as degree I, 1 cases as degree II, and 0 cases as degree III. The average follow-up duration was 18 months. The clinical outcomes were evaluated using the Oswestry Disability Index preoperatively and at 4th, 8th 12th, 18th month and the Kim & Kim criteria at last follow up. The radiological outcomes were evaluated as per the Modified Lee's criteria for fusion.

Results: There were 7 cases of definitive fusion, 4 cases of probable fusion and 1 case of pseudoarthrosis, with a fusion rate of 91.67% (definitive 58.3 % + probable 33.3 %). The mean time for fusion was 16 months. There were no implant failures. According to Kim & Kim clinical criteria for scoring, the results were excellent in 9 cases, good in 2 cases, and fair in 1 case. The excellent and good rate was 91.66 %.

Conclusion: PLIF with cage and bone graft from local laminectomy chips serves as a solid internal fixation and has the advantages of shorter operative time and less blood loss. This technique also provides excellent outcomes according to the clinical and radiological evaluation.

Keywords: spondylolisthesis, laminectomy, pseudoarthrosis

Introduction

Pain in the lower lumbar spine is a socioeconomically serious medical illness. The probability in a life cycle to develop lower lumbar discomfort is 50-80% [1-3]. The main reason from physiological perspective was micro and macro instability of spine [3, 4] Clinical spinal instability is controversial and not well understood. White and Panjabi defined clinical instability of the spine as the loss of the spine's ability to maintain its patterns of displacement under physiologic loads so there is no initial or additional neurologic deficit, no major deformity, and no incapacitating pain [3, 5].

The lumbar spine checklist uses several elements, such as biomechanical parameters, neurologic damage and anticipated loading on the spine (Table 1).

Table 1: Check list for diagnosis of clinical instability in lumbar spine. A point total of 5 or more indicates clinical instability

Element	Point value
Anterior elements destroyed or unable to function	2
Posterior elements destroyed or unable to function	2
Radiographic criteria	
Flexion- extension radiographs	4
Saggital plane translation>4.5mm or 15%	2
Saggital plane rotation	
15deg at L1-2,L2-3 and L3-4	2
20 deg at L4-5	2
25 deg at L5-S1	2
Resting Radiographs	
Saggital displacement >4.5mm or 15%	2
Relative saggital plane angulation >22 deg	2
Cauda equina damage	3
Dangerous loading anticipated	1

The instability hypothesis assumes a relationship between abnormal intervertebral motion and LBP. The corollary to this hypothesis is that a decrease in the intervertebral motion in a patient with LBP may result in reduced pain. In fact, this is the basis for low back treatments involving surgical fusion, muscle strengthening and muscle control training [6, 3]

Posterior lumbar interbody fusion (PLIF) is a reliable treatment option for patients with spondylolisthesis; providing spinal stabilization in a balanced alignment with the disc space height restored and with the neural elements being decompressed mechanically. PLIF was first described as an effective technique by Cloward in 1945 [7]. However it was not widely adopted at that time because of the high complication rate associated with pseudarthrosis and the nerve root irritation caused by postoperative collapse or displacement of the grafted bone. The technique was later modified by Steffee and Sitkowski, using pedicle screw fixation [8]. This resulted in an increased rate of arthrodesis and a reduced rate of graft migration. With the prevalent use of titanium inter-body cages in the 1980s, the problems arising from autograft harvesting were resolved. The titanium cages provided immediate stability to spinal levels, restoration of the disc space and neuroforaminal area, and an increased surface area leading to successful fusion [9].

In practice, several kinds of bone grafts have been used for interbody fusion. Autologous iliac bone graft is a suitable choice with good biological healing ability but may cause considerable donor site morbidity, such as local pain, increased operation time and blood loss, and infection [10]. Local lamina bone and facet joint auto graft obtained from the decompression procedure are also good sources of bone grafts in PLIF [11, 12] and have the advantage of not increasing morbidity. Allografts alone may have less potential for bony union and carry a higher risk of disease transmission if not properly screened [13] The literature supports use of local autograft from the posterior elements in PLIF, with a 90% fusion rate and 79% good results [14-16, 11, 12].

Additional use of cages in PLIF would provide better bio-mechanical advantages, including restoration of disc space height [17], better sagittal alignment, good initial anterior column weight bearing [18], and better fusion rates [11, 16, 19, 20].

Accordingly, we have performed PLIF with bone chips from local host bone and cage as a supplement to stability and fusion.

Aims: To study clinical and radiological outcomes of Posterior lumbar inter-body fixation with cage and local bone graft in lumbar spondylolisthesis.

Materials and Methods

The present study is a retrospective study of 12 cases of spondylolisthes. Our study includes 4 males and 8 females, aging 35-64 years. As Per the Meyerding-evaluating system, 11 cases were classified as degree I, 1 case as degree II, and 0 cases as degree III. The affected lumbar vertebrae were L3 (1 case), L4 (9 cases), and L5 (2 cases).

All the cases were examined clinically and confirmed radiologically. The patient's age, sex, symptoms, duration were noted and were examined clinically for the status of the spine. Straight leg raising test was done and neurological examination of the lower limbs performed. All the patients were subjected to the radiological examination of the lumbosacral spine by taking antero-posterior, lateral (flexion and extension views), oblique views to demonstrate spondylolysis and spondylolisthesis. MRI/ X-rays studies were done in all the cases to facilitate evaluation of the root compression disc changes, spinal cord changes.

Selection of the patients for surgery

Inclusion criteria: Patients with grade 1 & 2 spondylolisthesis, who had severe low backache or severe symptoms of root compression or restricted straight leg raising test or those who did not have alleviation of the symptom with conservative methods were subjected to surgery.

Exclusion criteria: Patients with grade 3 and grade 4 spondylolisthesis and patients with listhesis but with no clinical symptoms, spondylolisthesis patients with severe comorbidities and infection and local incision site.

Indications for surgery

1. Persistent or recurrent back and/or leg pain or neurogenic claudication, with significant reduction of quality of life, despite a reasonable trial of non-operative treatment (a minimum of 6 months).
2. Progressive neurologic deficit.
3. Bladder or bowel symptoms.

Surgical details

All cases were operated under general anaesthesia in prone position on operating table on two bolsters, allowing the abdomen to have free respiratory movements.

Through posterior approach, skin incision about 10 to 12 cm centring L5 vertebra was given, deep fascia incised in line of skin incision. The spinous process and laminae were exposed sub periosteally, paraspinal muscles retracted on either side up to the tips of transverse processes on either side. Hemostasis was secured with bipolar diathermy. The freely moving spinous process and lamina of L5vertibra in cases of L5-S1 spondylolisthesis, L4 lamina and spinous process in cases of L4-L5 spondylolisthesis was removed enblock and fashioned for grafting. Other loose fibrocartilaginous materials and thickened ligamentum flavum was incised and removed-thus spinal canal decompression acheived. Nerve root canal decompression was specifically addressed.

Spinal nerve roots were gently retracted towards cord and L5-S1 disc space (in cases of L4-L5 the L4-L5 disc space) was approached, with a sharp knife annular ligament incised and disc material was extracted using disc punch. On either side of the vertebral end plates scooping was done.

Under C-ARM control pedicle screws were placed into vertebral body. In L4-L5 listhesis, pedicle screws placed through L4 and L5 vertebral pedicles. Screws on either side

were connected with connecting rods and nuts.
Banana cage packed with slivers of bone graft from spinous process and lamina was placed after checking the size with a trial cage. Part of the prepared graft was placed anterior and lateral to cage as sentinel graft. Compression was achieved between the pedicle screws of adjacent bodies and the rods were tightened.
Position was confirmed under C' arm imaging in both planes. Hemostasis was secured with diathermy. The surgical wound was sutured in layers over suction drain. Recovery from anesthesia and immediate post-operative period were uneventful.

Note

1. The degenerated disc materials were removed and the cartilagenous end plates curetted thoroughly;
2. The cage was inserted without damaging the bony end plates;
3. Cages of appropriate sizes selected; and,
4. Adequate compressive force was applied to the disc space by the pedicle screws.
5. Thorough root decompression was achieved.

Our construct to achieve stability was of 4 polyaxial pedicle screws with two in upper vertebral body and two in lower one with connecting rods between them. Cage was used to aid interbody fusion. The titanium cages used were of various sizes (width: 11 mm, angulation: 0°, 4°, 8°, height: 9-13 mm, length: 20, 25 mm) and they were rectangular and radiopaque.

Post-operative management: From the 3rd postoperative day, a lumbo-sacral orthosis was used for 12 weeks postoperatively. The patient was encouraged to walk from 3rd week.
Most of the patients were relieved of the symptoms on the third day and sutures removed on the 10th day. Log rolling was employed in the initial mobilization of the patient, which is started on the day after surgery. Pharmacological deep vein thrombosis prophylaxis was not routinely used. A bladder catheter was retained until the patient could get to a bedside commode or to the bathroom with assistance, usually till 15 to 18 days. Diet was advanced as tolerated, walking encouraged, and the patient was discharged when independent ambulation was possible and only oral pain medication required.
The patients were discharged with the advice not to lift heavy weights for six months. Climbing stairs, lifting heavy objects, sitting cross legged and using Indian latrines were discouraged for 6 months.

Follow UP: Patients were followed up for a mean duration of 18 months, noting at each visit, the clinical outcome by oswestry disability index, Prolo functional outcome.
The radiological outcome was assessed by Modified Lee's criteria for fusion. Kim and kim criteria was used at last follow up for grading the result.

Assesment of Results: The clinical evaluation was based on the Oswestry Disability index and Prolo functional outcome (table 2) for the preoperative back pain and pain at the 4th, 8th, 12th, and 18th postoperative month. At the last follow up the Kim & Kim criteria were also used (Tables 3). The lateral plain radiographs taken preoperatively, immediately postoperatively and at the last follow-up were compared for the radiological assessment. Although the radiopaque titanium cage made it difficult to assess whether bony union was achieved, the local morselized bone graft impacted anterior to the cage allowed for directly evaluating the bony union. In other words, we carefully looked for bone bridging and radiolucency around the cage and the metal screws, and any evidence of instability on the flexion-extension lateral radiographs for assessing the bony union.
The bony union status was classified into solid union, delayed union and non-union. Solid union was considered to be obtained when the endplates observed immediately postoperatively on the radiographs became invisible during the follow-up examinations and there was bony trabecular continuity and bone bridging from the graft to the adjacent vertebral bodies in the intervertebral space, the bone graft that appeared as granules on the lateral radiographs became a radiopaque mass after union and any instability on the flexion-extension radiographs and radiolucencey around the cage and screws were not observed. Non-union was defined as disruption of the trabecular continuity, the appearance of instability on the flexion-extension radiographs and > 1 mm radiolucency around the screws and cage. Delayed union was diagnosed when all of the definitions of solid union were met despite that disruption of the trabecular continuity and evidence of non-union was not observable. Instability was considered present when > 3 of posterior angular formation was observed on the lateral radiographs and > 2 mm of displacement of the vertebral body and cage movement occurred. Radiological union was graded as per Modified Lee criteria (table 4).

Oswestry low back pain disability questionnaire/ oswestry disability index: It is designed to tell us how your back pain affects your ability to function in everyday life. www.rehab.msu.edu/_files/_docs/Oswestry_Low_Back_Disability.pdf

Table 2: The Prolo Functional and Economic Outcome Rating Scale

Status	Criteria
Economic status	• Complete invalid • No gainful occupation, including ability to do homework or retirement activities • Ability to work but not at the previous occupation • Working at the previous occupation part time or w/ limited status • Able to work at the previous occupation w/ no restrictions
Functional status	• Total incapacity (worse than preop) • A mild to moderate level of low-back pain or sciatica • A low level of pain & able to perform all activities except sports • No pain, but 1 or more recurrences of low-back pain Or sciatica Complete recovery

Assessment: Excellent (10–9), good (8–7), fair (6–5) and poor (4–2).

Table 3: Criteria for the Clinical Results by Kim and Kim

Status	Criteria
Excellent	Complete relief of the pain in the back and lower limbs No limitation of physical activity Analgesics not used able to squat on the floor
Good	Relief of most pain in the back and lower limbs Able to return to the accustomed employment Physical activities are slightly limited Analgesics used only infrequently Able to squat on the floor
Fair	Partial relief of pain in the back and lower limbs Able to return to the accustomed employment Able to return to the accustomed employment with limitation, or return to lighter work Physical activities definitely limited Mild analgesics used frequently Mild limitation to squat on the floor
Poor	Little or no relief of pain in the back and lower limbs Unable to return to the accustomed employment Physical activities greatly limited
	Analgesics used regularly Unable to squat on the floor without support

Table 4: Modified Lee's criteria of fusion

Definitive fusion	Definitive bony trabeculae bridging across the graft host interface. No movement (less than 3°) on dynamic radiographs and no gap at interface.
Probable fusion	No definitive trabeculae crossing the graft host interface, but no detectable movement and identifiable gap at the interface.
Possible pseudoarthrosis	No definitive trabeculae crossing the graft host interface, but no detectable movement but identifiable gap at the interface
Definitive pseudoarthrosis	No definitive trabecular bone, definitive gap, and movement more than 3° at the interface.

Results

Table 5: Results using Oswestry Disability index at last follow up

Oswestry Disability index	No. of Patients
0% to 20% (minimal disability):	8
21%-40% (moderate disability):	4
41%-60% (severe disability):	0
61%-80% (crippled):	0
81%-100%:	0

Table 6: Results by Kim and Kim criteria

Grade	Number of Patients
Excellent	9
Good	2
Fair	1
poor	0

Table 7: The Prolo Functional and Economic Outcome Rating Scale

Sl. No.	Preoperative	4th mnth	8th mnth	12th	18th
1	E2+F2= 4	E3+F2= 5	E3+F3= 6	E5+F4= 9	E5+F4= 9
2	E1+F2= 3	E2+F2= 4	E4+F2= 6	E5+F4= 9	E5+F4= 9
3	E2+F2= 4	E3+F2= 5	E3+F3= 6	E5+F4= 9	E5+F4= 9
4	E2+F2= 4	E2+F2=4	E3+F3=6	E4+F3= 7	E4+F3=7
5	E2+F2= 4	E3+F2= 5	E3+F3= 6	E5+F4= 9	E5+F4= 9
6	E2+F2= 4	E3+F2= 5	E3+F3= 6	E5+F4= 9	E5+F4= 9
7	E2+F2= 4	E3+F2= 5	E3+F3= 6	E5+F4= 9	E5+F4= 9
8	E2+F1= 3	E2+F2=4	E3+F3=6	E4+F3= 7	E4+F3=7
9	E2+F2= 4	E3+F2= 5	E3+F3= 6	E5+F4= 9	E5+F4= 9
10	E2+F2= 4	E3+F2= 5	E3+F3= 6	E5+F4= 9	E5+F4= 9
11	E1+F1= 2	E2+2=4	E2+2=4	E2+2=4	E3+F2= 5
12	E2+F2= 4	E3+F2= 5	E3+F3= 6	E5+F4= 9	E5+F4= 9
	3.67	4.67	5.83	8.25	8.34

E= Economic Status, **F=** Functional Status

Assessment: Excellent (10–9), good (8–7), fair (6–5) and poor (4–2).

Table 8: Prolo Functional Outcome at the end of 18 Months

Sl. No.	Assessment	No. of patients
1	Excellent (10–9)	9
2	Good (8-7)	2
3	Fair (6-5)	1
4	POOR (4-2)	0

Table 9: Modified Lee's criteria for fusion

Fusion status:	Number of patients:
Defnitive fusion	7
Probable fusion	4
Possible pseudoarthrosis	1
Definitive pseudoarthrosis	0

Clinical Outcome: No intraoperative complications occurred, there was one case of infection. The late clinical outcome is summarized in the Table (7, 8). The mean follow up period was 18 months. The rate of excellent and good outcome was 91.66 % (excellent: 75 %) The results are comparable to the studies reported in literature by Csescei *et al*, [21] Zhao *et al*, [22] and Sears. [23]

Radiological outcome: There were 7 cases of definitive fusion, 4 cases of probable fusion and 1 case of pseudoarthrosis, with a fusion rate of 91.67% (definitive 58.3% + probable 33.3%). Radiological outcome is summarized in the table (9). Our fusion result was comparable to those of other published studies. The average reported fusion rate ranges from 90% to 100% in patients with cage PLIF. 22, 23, 24, 25, 26.

Table 10: Comparing the literature, showing similar results in our study

Study	year	No. of patients	Grafting material	Follow up	Fusion rate	Clinical outcome
Simmons	1985	113	Posterior elements bone chips	NR	NR	79% good
Csecsei [1]. 1	2000	46	Laminectomy bone chips	27.3 months	95.70%	87% good or Excellent
La Rosa *et al*	2001	17	Titanium cage+AIC	24 months	100.00%	76.5 successful
Chen *et al*.[11]	2003	118	BAK cage+local graft	33 months	95.00%	NR
Zhao *et al*.[22]	2003	27	BAK Cage+AIC	>24months	100.00%	92.5% Good or excellent
Sears.[23]	2005	34	Interbody cages	21.2 months	NR	91% good or excellent
Our study	2016-2019	12	Interbodycage+ local bone graft	18 months	91.6% (def+probable)	91.6%excellent or good

AIC: Autogenous iliac crest graft, BAK: Bagby and Kuslich cage, NR: not reported

Discussion: Several operative solutions to treat lumbar spondylolisthesis caused by different etiologies have been reported in the literature [27-31]. Branch, [32] suggested the use of laminectomy bone for interbody fusion, together with iliac chips or banked bone. Steffee, [33, 34] completed posterior interbody fusion with transpedicular plate fixation. Advocates of posterior lumbar interbody fusion (PLIF) report superior results compared to other lumbar fusion techniques, [33, 35, 36] while opponents cite its technical difficulty and high complication rate, particularly with regard to neural injury [16, 34, 37]. Brodke *et al*, [18] and Lund *et al*, [27] found that the combination of cage and posterior pedicle screw instrumentation was the stiffest on biomechanical testing, as compared to a standalone PLIF procedure.

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 subluxation, and provides load sharing to prolong the life of instrumentation [18, 20].

Reviewing the literature, Fraser, [37] found that clinical outcome was better after anterior interbody fusion than after posterolateral, although the fusion rate was much higher in the latter group. Both techniques carry the risk of complications, primarily vascular and neural damage. No complications were found in our patients; this could be the result of the relatively simply technique. The addition of IPLF (inter transverse posterior lumbar fusion to PLIF is not universally accepted. It adds to cost, operating time and blood loss, and potentially increases the risk of nerve root injury [20]. Posterolateral fusion involves the risk of muscle fibrosis caused by the extensive release of muscles adjacent to the transverse process, and the loss of blood and postoperative wound infection due to a lengthened operative time. In contrast, interbody fusion was advantageous for increasing the fusion rate and reducing the extensive muscle release around the transverse process with the fusion being performed at the level of the spinal compression, and obtained early stability and a high rate of fusion following PLIF with the use of pedicle screws for fixation. [35] We have thus achieved satisfactory fusion rates and good functional outcomes by using posterior interbody fusion alone.

Interbody cages obviate the need for tricortical iliac crest grafts and possibly reduce donor site morbidity. According to Banwart *et al*, [38] in a large number of patients using the iliac crest bone graft, the rate of major complications was 10%, that of minor complications was 39%.

Infection can result in implant loosening and pseudoarthrosis through osteolysis. There are no reports in literature on management of infected cages other than anecdotal accounts. It only makes sense that infected and loose cage will need to be removed, since it will not provide any stability to spine and as a foreign body will only make it difficult to eradicate the organism. The other cage may be left in place if not loose, because it may provide enough stability to forgo a posterior stabilizing procedure [39]. We had a single case of infection with no radiological signs of instability or loosening, and the infection subsided with IV antibiotics. The follow up results of this case was satisfactory with probable union at 14 months (Mod Lee criteria).

With the use of posterior construct with interbody cage we have achieved early stability and good clinical results in most of the cases (91.6%).

Limitations of our study: First, it is not straightforward to objectively assess the radiographic fusion status, especially with implants in the grafted sites. Computed tomography and MRI are reportedly more reliable to assess the fusion status, [40, 41] but we did not use these high-cost technologies in this study. Blumenthal and Gill [42] stated the only reliable method to determine fusion rate may be reexploration which is obviously impractical on routine basis. We have done MRI studies in 2 cases where there was doubtful fusion, in the rest of cases digital radiographs were only done.

Secondly, we did not differentiate between isthemic and degenerative spondylolisthesis groups. Although these two disease groups have a different pathogenesis and clinical manifestations, we believe both represent disease conditions with an unstable spine clinically and radiographically, and the treatment principles are the same. A good arthrodesis also is mandatory for good outcomes in lytic and degenerative spondylolisthesis. [43] Numerous investigators have used the same study design we used. 27, 29, 43.

Third, relatively short-term follow up and few cases, none of the patients underwent additional surgery for adjacent degenerative disease, implant failure or cage migration but longer follow up is required to determine the rate of this complication.

Prone positioning over fixed Bolsters

Surgical position

Pedicles marked with probe under C' arm.

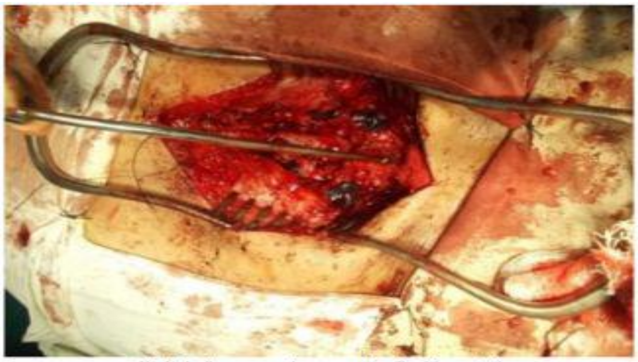
Marking of pedicles

Cages (Titanium) in our study

Radiopaque Titanium cages

Position of Pedicle screws and Cages checked under C'arm guidance

Intraoperative C'arm image

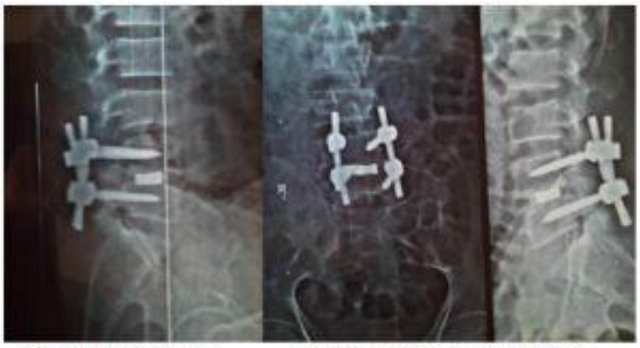


Pedicle Screws and connecting Rod inserted

Final construct

Laminectomy bone used as Graft.

Local bone graft harvested



8th month follow up 18th month follow up showing solid fusion

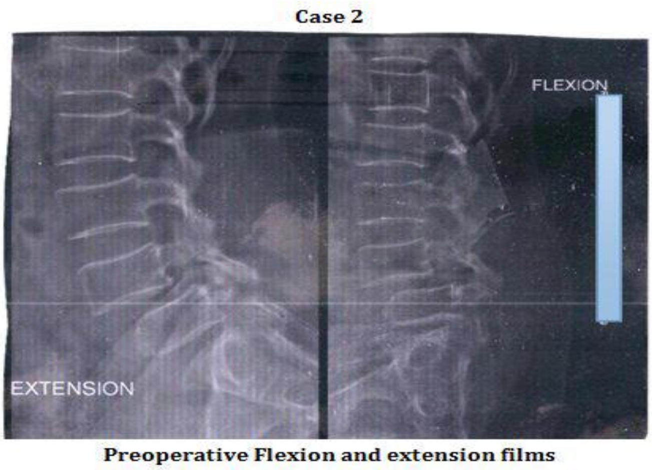
Follow-up xrays

Post op Follow up at 18th month showing normal Range of Extension, Flexion and lateral bending

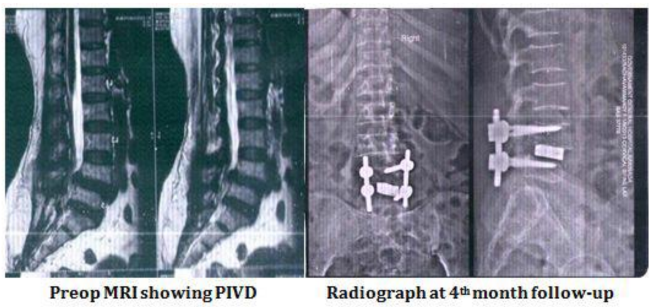
Post op ROM showing good result

Pre-op x-rays showing Grade II listhesis

Early postoperative x-ray showing cage instu



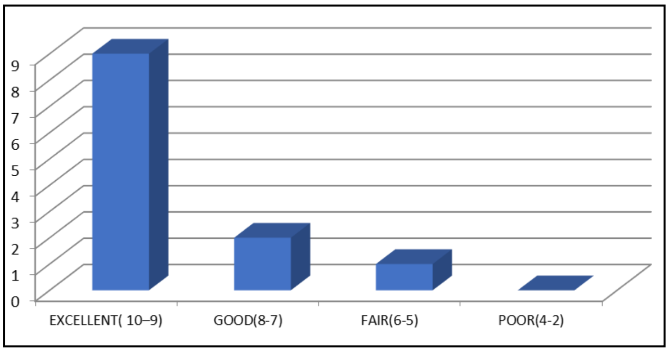
Pre-op x-rays



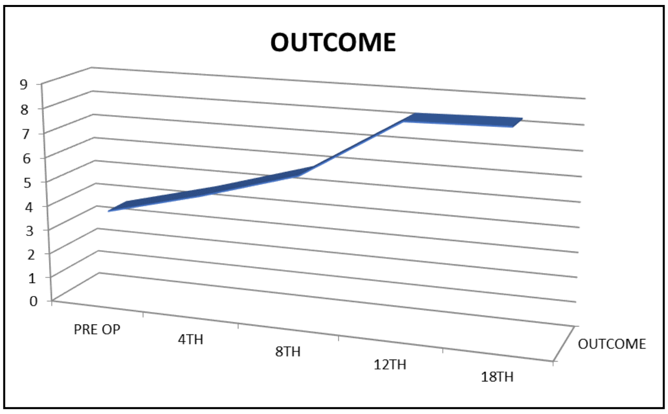
Standard pre-op evaluation with MRI and xrays

18 th month postop x-ray with Good radiological outcome

Normal ROM at 1½ year followup



Bar diagram showing results By KIM and KIM criteria



Line diagram showing improvement in Prolo Functional outcome

Conclusion

1. Interbody fusion was advantageous for increasing the fusion rate.

2. Interbody fusion reduces the extensive muscle release around the transverse process with the fusion being performed at the level of the spinal compression.
3. Obtained early stability following PLIF with the use of pedicle screws for fixation.
4. Satisfactory clinical results and solid fusion union were achieved at the last follow-up.
5. Using laminectomy bone chips minimized the operative time and morbidity of iliac crest bone grafts.
6. Cost remains the main prohibitive factor for its use.

The results of the present study indicate that the outcomes were significantly improved with surgery and the technique of Posterior lumbar interbody fusion with Local bone graft and Cage produced satisfying clinical outcomes and radiological outcomes such as maintaining the proper intervertebral disc space, good boney union, rigid stability and a high fusion rate.

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