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Clinical Studies

Clinical, radiological and functional results of transforaminal lumbar interbody fusion in degenerative spondylolisthesis

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ABSTRACT

Purpose: To evaluate the clinical, functional and radiographic outcomes of transforaminal lumbar interbody fusion (TLIF) in degenerative low-grade spondylolisthesis.

Materials and Methods: A prospective observational study of 120 consecutive patients (M:*F* = 24:96) with spondylolisthesis operated with TLIF. Clinical and functional outcome was assessed on Visual analogue Scale (VAS) and Oswestry Disability Index(ODI). The radiological outcome was assessed on sagittal alignment at a specific level, radiologic bony fusion/non-union, intervertebral disc heights and percentage of a slip in relation to the endplate. Clinical and radiological data were collected and analysed.

Results: The mean age was 50.97 years. The average follow-up was 14.5 months (12 to 18 months). Mean preoperative ODI was 38.73 and postoperatively 21.30. Analysing the radiological fusion with clinical scores, poorer radiological fusion grades correlated with higher VAS scores for pain. 70% of patients achieved >50% reduction in pain and 60% achieved > 30% reduction in ODI. Pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS) and lumbar lordosis (LL) were significantly greater in spondylolisthesis. PI, PT, and SS did not change statistically from the baseline postoperatively but increased LL and Segmental LL ($P < 0.001$). The results of our study showed a close relation between satisfactory clinical outcome (90%) and solid fusion (80%). There was however a significant number of patients with instrument failure that was found in association with fusion failure. There were no intra-operative complications.

Conclusion: TLIF is an effective option to achieve circumferential fusion without severe complications. An increased pelvic incidence may be an important factor predisposing to progression in developmental spondylolisthesis. TLIF increases global and segmental LL and provides a satisfactory outcome in symptomatic low-grade degenerative spondylolisthesis.

Introduction

Lumbar interbody fusion is a recognized surgical technique in the treatment of chronic low back pain in spondylolisthesis and for a range of spinal disorders including; degenerative pathologies, trauma, infection and neoplasia [1–5]. The aim is the production of a bony fusion between two vertebral bodies, decompression of neural structures, reconstitution of disc space height, and restoration of sagittal plane alignment [2,6]. Various fusion techniques have been developed using different approaches, vertebral fixation, and fusion materials [7–9]. Controversy exists in the literature regarding the need to reduce the sagittal plane translation because, in higher grade spondylolisthesis, there is the danger of damaging neural structures [10]. In lower grade spondylolisthesis, there is the possibility of correcting sagittal translation with only a low risk of neural damage [2,4,11]. Even though various management approaches have evolved over the past many years, high-level evidence of the best surgical strategy lacks so far [13,14]. One of the important reasons for this might be the numerous types of fusions, which contribute to various efficacies [15–17]. Harms and Jeszensky [18] developed the TLIF technique for spondylolisthesis. PLIF, a forerunner of TLIF, is limited to the levels of L3 to S1 as excessive retraction on the thecal sac at higher levels of risks damage to the neurological structures [19]. Additionally, TLIF only requires a unilateral approach and thus the contralateral facet joint and lamina can be preserved. This provides an additional surface for fusion. [4] Posterior interbody fusion techniques have been criticised due to the additional risks of neural structure mobilisation to facilitate cage insertion. Minimally invasive TLIF has now gained popularity due to use of the tubular retractors and percutaneous pedicle screw fixation systems. TLIF, minimally invasive or open TLIF,

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[20] is now widely used in lumbar spinal fusion because of minimal invasiveness to the spinal canal, shorter duration, and low morbidity compared with other fusion methods. Our study aims to provide local data on a consecutive series of selected patients undergoing the TLIF procedure at a Tertiary Care centre, its surgical outcome and noting the complications. In addition, the outcome in terms of radiological fusion rate and patient self-assessment questionnaires was assessed and correlated.

Aims and objectives:

1. To study the clinical outcome of patients who underwent TLIF with an interbody cage in terms of symptoms and signs
2. To assess the functional outcome in terms of objective scores
3. To study radiological outcome in terms of radiological fusion and nonunion
4. To assess the complications of TLIF

Materials and Methodology

Prospective Observational Study. After Institutional Ethics Committee approval, Study was conducted from September 2016 to August 2018 at a tertiary care Hospital. Consecutive patients with degenerative spondylolisthesis and planned for TLIF were included in the study as per inclusion and exclusion criteria. Informed written consent was taken from all the patients.

Inclusion Criteria

1. Age 40 to 65 years
2. Single-level low grade (Meyerding Grade-I and II) degenerative spondylolisthesis
3. Radicular symptoms and/or back pain consistent with the radiologic findings
4. Unsuccessful conservative therapy for at least 6 weeks
5. Patients who are willing to follow up for a minimum of 12 months

Exclusion Criteria

1. Pregnant women
2. Patients on chronic medication like sedative, opioids, antidepressants (>6 months of use)
3. Patients having employee compensation at working place
4. Patients having facetal tenderness at levels other than a level of spondylolisthesis
5. Patients who undergo simultaneous decompression at adjacent segments were excluded
6. Previous spinal surgery
7. Degenerative scoliosis or preoperative coronal imbalance
8. Vascular claudication, Diabetic neuropathy of limb

A prospective database of operated patients was maintained. Patient demographics, presenting symptoms and affected spinal level were noted. All patients underwent a complete radiological evaluation of spinopelvic parameters were also be noted by assessment of standard plain radiographs and dynamic radiographs and MRI imaging. Surgical data analysis included operative time, blood loss, technique, intraoperative complications and instrumentation used.

Surgical technique

All patients were operated by a single senior spine surgeon under general anaesthesia. Preoperative antibiotics were given 30 min before the incision. The patient was placed prone on a Jackson table and all bony parts carefully padded. The position was such that the abdomen was free to reduce epidural bleeding. The surgical site was then prepped and draped in the usual sterile fashion. A time out was performed before incision. The correct level was identified using a spinal needle with the help of a C-arm image. An incision was made in the skin over the intended surgical levels and dissection was carried down through the subcutaneous tissue down to the level of the deep fascia. Posterior elements were exposed in a standard subperiosteal fashion. Dissection was carried out from the spinous process, bilateral laminae, bilateral facet joints and transverse processes. The facet capsules were kept intact during the exposure. Self-retaining retractors were placed. An intra-operative radiograph was taken to confirm the appropriate spinal level. Pedicle screws were placed bilaterally. The TLIF procedure was performed from the side of radicular symptoms. The inferior facet of the cephalad vertebra was excised using a 10 mm osteotome. The interlaminar space was distracted using a laminar spreader. Then the superior facet of the caudad vertebra was removed up to a point where the superior and medial border of the caudad pedicle was palpable. This process resulted in a good subarticular decompression. Cancellous autograft was harvested from the posterior iliac crest. The disc was visualized without retraction of the thecal sac. A box annulotomy was performed. The disc space and the end plates were prepared by using curettes and shavers. A sizer trial was used to determine the appropriateness of the height of the banana cage to be used and was found to be stable. Autograft harvested from the iliac crest was then inserted in the cage. The disc space was adequately packed with this autograft bone. The cage was then inserted in the disc space. C-arm imaged confirmed proper placement of the cage. Central canal decompression and subarticular decompression on the side opposite the TLIF was achieved. The foramen was confirmed to be decompressed using a Murphy probe and in the end, the decompression of the exiting and traversing nerve roots was confirmed bilaterally. Diluted Betadine wash followed by copious normal saline wash was used. The cortical surfaces of remaining posterior elements (transverse processes) were gently decorticated with a high-speed burr. Following this, an appropriate size rod was captured in the screws bilaterally. Gentle compression across the screws was applied bilaterally to achieve lordosis. Cage was check and found to be stable. The foraminal decompression was again confirmed following this manoeuvre. Autograft mixture (iliac and locally harvested bone) was laid over the decorticated posterior elements and transverse processes. Closer done in layers. The patient was placed supine on a regular bed.

Clinical and radiological assessment

Preoperative radiographic assessment was done based on standing neutral, flexion, and extension plain lumbar radiographs, computed tomography (CT) imaging and magnetic resonance imaging of the lumbosacral spine. The dynamic radiography of the lumbosacral area was performed in a standing position in the lateral plane. The patient was asked to flex and extend as much as possible actively [Fig. 1,2,3,4]. We also obtained standing anteroposterior and lateral lumbosacral radiographs to calculate the spinopelvic parameters. In the follow-up, we obtained standing anteroposterior and lateral lumbosacral radiographs. We measured segmental LL (SLL) defined as lordosis measured between the lower endplate of the vertebra above the instrumented disc and the upper endplate of the vertebra below the instrumented disc; LL, the angle between the upper endplate of L1 and the upper endplate of S1; PI, the angle between the perpendicular of the sacral endplate and the line joining the middle of the sacral endplate and the midpoint of the axes of both femoral heads; pelvic tilt (PT), the angle between the vertical line and the line joining the middle of the sacral endplate and the hip axis; and sacral slope (SS), the angle between the superior plate of S1 and a horizontal line. Visual analogue scales (VASs) for back and leg pain and Oswestry Disability Index (ODI) were used for preoperative and postoperative evaluation of the clinical outcomes.

All patients completed preoperative clinical scores. The patients were called for follow up at 6 weeks, 3 months and 12 months, clinically and radiologically evaluated. The recovery rate of VAS and ODI indicates the degree of postoperative normalization. Statistical significance was assessed by Student *t*-test. All radiological assessments and measurements were done by treating surgeon using PACS software (Medsynaptic Private Limited, Pune, India). Dynamic instability defined as a translation > 4 mm standing flexion and extension radiographs or segmental

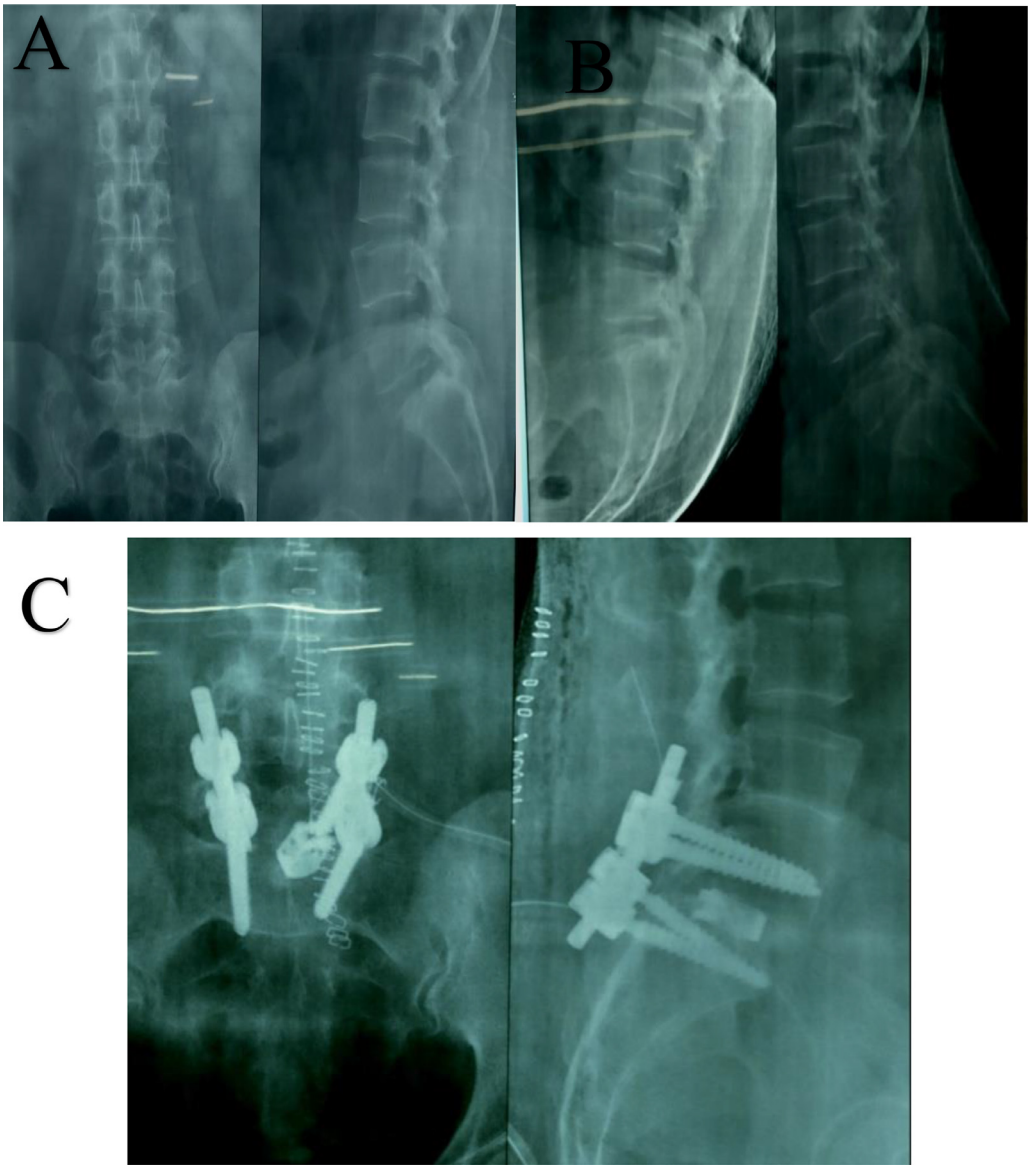

Fig. 1. (A, B) 55 Years female Radiographs of Lumbosacral spine antero-posterior and flexion-extension views demonstrating spondylolisthesis with dynamic instability at L5-S1 level (C) Postoperative radiographs showing L5-S1 single level open TLIF was done, Global and Segmental lumbar lordosis not improved significantly.

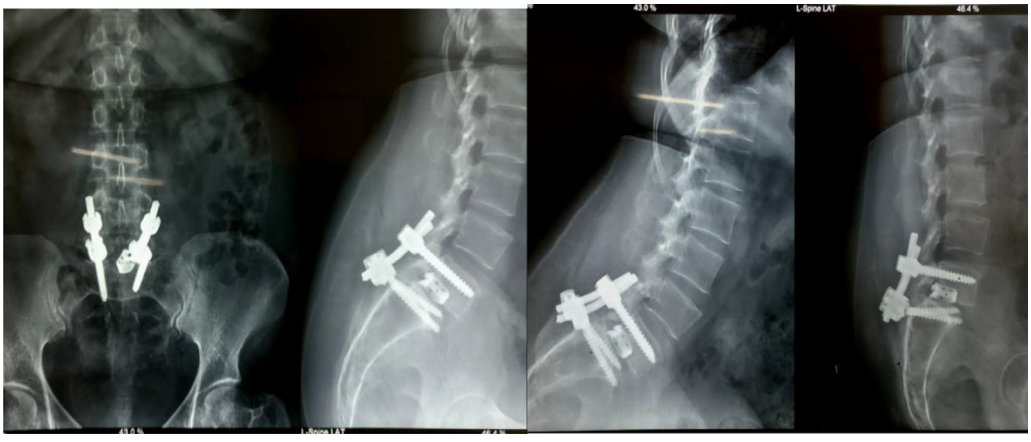

Fig. 2. Radiographs at Six months postoperative follow-up shows S1 pedicle screws breakage.

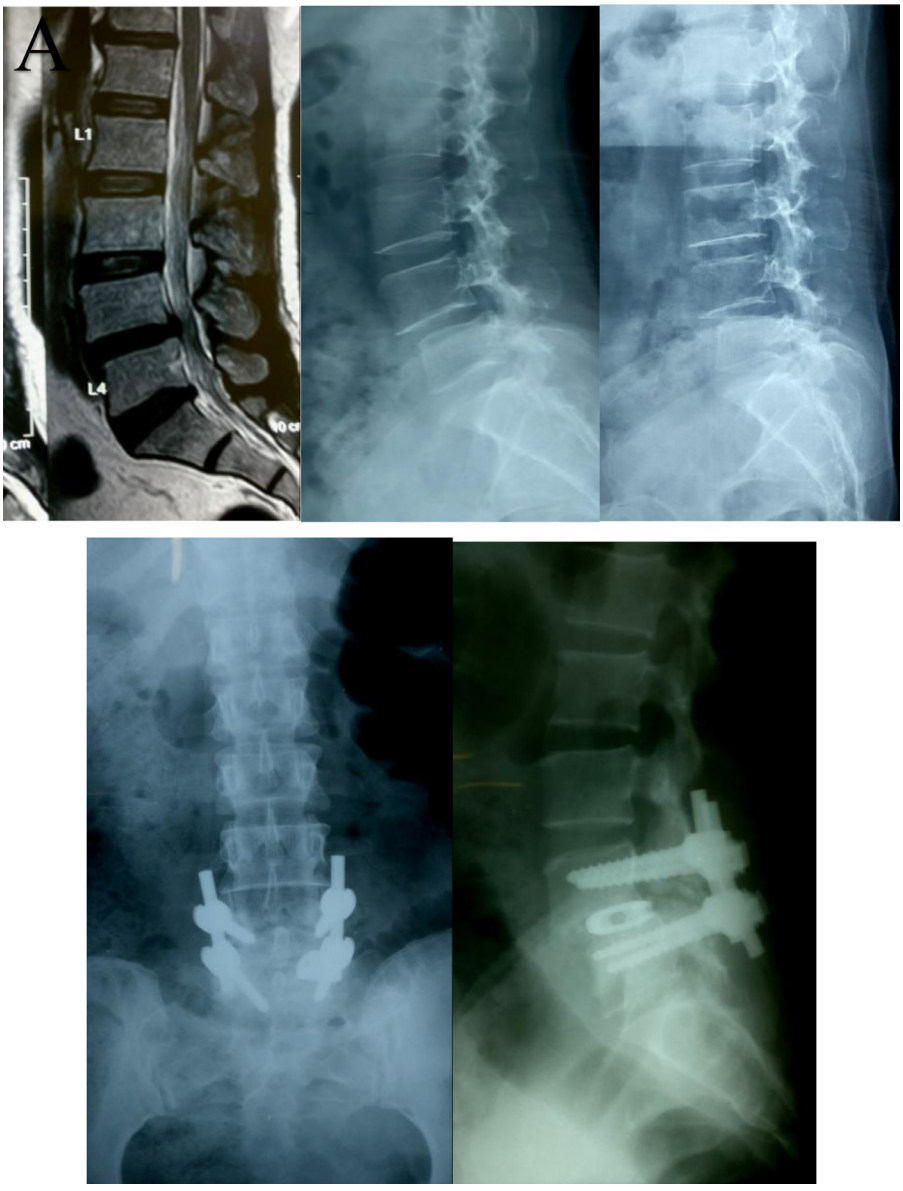

Fig. 3. 58 Year Female with L4-L5 level Spondylolisthesis operated with open single level TLIF (A) T2 weighted sagittal image of LS spine MRI shows no instability. (B,C) Standing Flexion-Extension LS spine radiographs shows dynamic instability at L4-L5 level. (D,E) Three months postoperative AP and lateral radiographs showing fusion at L4-L5 level.

kyphosis of >10° on lateral flexion and extension radiographs. Preoperative lateral lumbar spine X-rays was used to measure sagittal alignment for the specific level involved. This was then compared with postoperative lateral films at 12 months follow-up. Fusion mass was assessed on anterior-posterior (AP) and lateral postoperative films at 12 months. For patients who did not demonstrate union at 12 months were followed-up on every three month interval until fusion was achieved. Failure of the appearance of bony fusion radiologically was considered as failure.

The criteria for a radiologic bony fusion of which at least three would have to be present were

1. Trabecular structure appearing in the bone graft,
2. Bony bridging anterior to the cage,
3. The lack of radiolucent lines around the graft, and
4. Bony continuity between the upper and lower endplates.

The criteria for radiologic nonunion was the absence of these signs and the occurrence of a lucent zone around 1 of the pedicle screws or the cage.

Anterior fusion was assessed using a four point grading system [21]

Grade I: Fused with remodelling and trabeculae;

Grade II: Graft intact, not fully remodelled and incorporated, but no lucency present;

Grade III: Graft intact, but potential lucency present at top and bottom of graft;

Grade IV: Fusion absent with collapse/resorption of graft.

On lateral radiographs, the posterior and anterior intervertebral disc heights were measured. The slip was measured in relation to the vertebral endplate of the lower vertebral body and was be described in percent of a slip in relation to the endplate.

Results

A total of 480 pedicle screws were inserted. One level instrumentation was performed in all 120 patients. The operating segments included L5-S1 in 54 and L4-L5 in 64 patients. The mean age was 50.97 years (42–62 years). The study included 24 men and 96 women. The mean duration of symptoms was 11.8 months (6–24 months). The mean follow-up was 14.5 months (12 to 18 months). The main symptom was low-back pain, neurological claudication and/or radiating pain to the lower extremities in all patients. There was no difference in the clin-

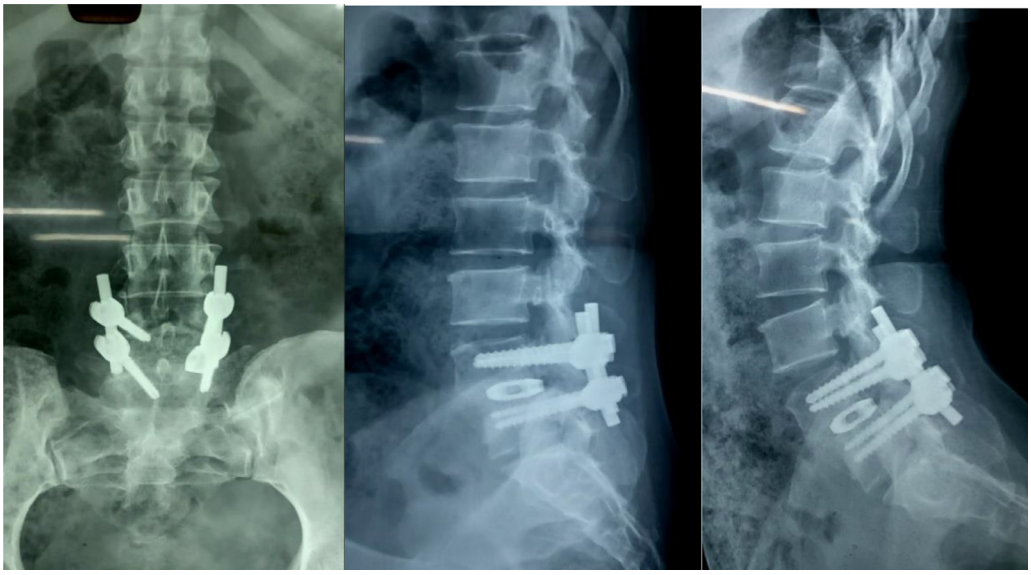

Fig. 4. Twelve months postoperative radiographs showing solid fusion at L4-L5 level on dynamic radiography.

Table 1
The radiographic findings of patients.

X-ray finding	Frequency	Percent
Decreased disc space	92	76.7
Loss of lumber lordosis	16	13.3
Decreased disc space, Loss of lumbar lordosis	12	10.0
Total	120	100.0

Table 2
Postoperative Complications.

Complication	Numbers	%
Screw Loosening	4	3.3
Screw breakage	4	3.3
Screw Bending	4	3.3
L5 Paraesthesia	4	3.3
Deep Wound Infection	4	3.3
Superficial wound Infection	12	10

Table 3
Functional Outcomes.

	Paired t-test	Mean	Std. Deviation	p value
VAS	Pre-op VAS	6.90	1.322	0.0001
	3 Months VAS	4.43	1.357	
	12 Month VAS	2.47	1.613	
ODI	Pre-op ODI	38.73	4.034	0.0001
	3 Months ODI	28.20	5.006	
	12 Month ODI	21.30	6.727	

ODI – Oswestry Disability Index; VAS – Visual analogue scale.

Table 4
Comparing the radiologic spinopelvic parameters.

Parameters	Preoperative	Postoperative	P
PI	60.1 ± 14.9	60.5 ± 14.5	0.432
PT	21.6 ± 8.7	21.8 ± 7.2	0.782
SS	37.1 ± 10.5	37.8 ± 9.5	0.466
LL	−43.1 ± 19.8	−48.1 ± 20.5	<0.001
SLL	−7.7 ± 1.9	−12.7 ± 8.5	<0.001

LL – Lumbar lordosis; SLL – Segmental lumbar lordosis; PI – Pelvic incidence; PT – Pelvic tilt; SS – Sacral slope.

ical symptoms and physical findings between males and females. The degree of anterior displacement measured by Meyerding's method was grade I in 40 (33.3%) patients and grade II in 80 (66.7%) patients. The radiographic findings of patients were recorded as follows [Table 1].

The MRI findings of patients with grade I or II spondylolisthesis showed canal/foraminal stenosis with or without disc bulges without significant spinal cord or neural compression. The mean blood loss was 264 ml (180–400; SD 63.98) and mean operative time 3.14 h (2.30–4.25; SD 0.45). Hospital stay on average was 7.8 days (5 to 21 days). All the patients spent at least the first day in the recovery ICU. There were no intraoperative complications. Four patients had deep wound infections that were treated with intravenous antibiotics for two weeks followed by oral antibiotics for 4 weeks. Four patients developed a wound infection subsequent to a wound haematoma. The infection was treated with surgical debridement and prolonged intravenous antibiotics. This patient was admitted for 21 days and was given intravenous antibiotics for 3 weeks followed by oral antibiotics of 3 weeks. Four patient developed paraesthesia in the L5 region postoperatively which resolved over 6 months. Four patients developed extensor hallucis longus weakness postoperatively which improved from grade 3 to grade 5 power over 3 months with conservative treatment. 12 patients had developed superficial wound infection which was successfully treated with oral antibiotics as per antibiotic susceptibility report. During follow up eight patients had screw breakage (Fig. 1, 2 and 3) and four patient had screw bending. four patient had screw loosening present. A postoperative complication has given in the table. [Table 2]

The mean duration of follow-up was 14.5 months (12 to 18 months; SD 1.59). Neurological and functional recovery of patients according to the VAS score and ODI was statistically significant at any time during the follow-up period. [Table 3]

Preoperative PI was 60.1 ± 14.9 and Postoperative 60.5 ± 14.5 (P = 0.432), Postoperative PT changed from 21.6 ± 8.7 to 21.8 ± 7.2 (P = 0.782), SS from 37.1 ± 10.5 to 37.8 ± 9.5 (P = 0.466), LL −43.1 ± 19.8 to −48.1 ± 20.5 (P < 0.001) and SLL −7.7 ± 1.9 to −12.7 ± 8.5 ($P < 0.001$). [Table 4], [Table 5].

Preoperative minimum ODI scoring was 32 while the maximum was 49, with a mean of 38.73 (SD 4.034). The mean ODI scoring at 12 months follow up was 21.30 (SD = 6.727) with a minimum of 12 while a maximum of 41. Majority of our patients, 92 (76.67%) out of 120, had a moderate disability (ODI 21–40) and 28 (23.33%) patients had a severe disability (ODI 41–60). All patients except eight were subjectively satis-

Table 5
Result of Radiological Fusion.

Fusion grade	Frequency	Percent
Fusion grade could not assessed	14	3.3
I	84	70.0
II	12	10.0
III	8	6.7
IV	12	10.0
Total	120	100.0

Table 6
Results of fusion Grade and functional result.

Radiological Result			Functional Result	
Fusion grade	Frequency	Percent	Mean VAS	Mean ODI
I	84	70.0	2	19.09
II	12	10.0	1.66	17.66
III	8	6.7	3.5	28
IV	12	10.0	6	35.66

Table 7
Correction between fusion rate and clinical improvement.

	Fusion	VAS improved ≥ 50%	ODI improved ≥ 30%
Successful Fusion (Fusion grade I & II)	80%	70%	66%
Fusion Failure (Fusion grade III & IV)	16.7%	–	–

Table 8
Slip Percentage.

Paired t-test	Mean	N	Std. Deviation	p value
Preop	31.37	120	9.290	0.0001
Postop	19.67	120	7.415	

Table 9
Result of Disc Height.

Paired t-test	Mean	N	Std. Deviation	p value
Preop Disc height	7.13	120	1.05	0.0001
Postop Disc height	9.48	120	1.08	

fied and were willing to undergo the same surgery if they had a chance to reselect. Four of them were young patients with a severe disability had developed deep wound infection which was debrided, followed up for 12 months with the poor union on radiographs. Another four patient who followed up for 12 months had implant failure with poor union with poor ODI and VAS scores. Out of the 120 levels fused, 84 (70%) achieved grade-I fusion (Fig. 4) and 12 (10%) achieved grade-II fusion. 20 patients had pseudoarthroses (grade III or IV). Analysing the radiological fusion with clinical scores, poorer radiological fusion grades correlated with higher VAS scores for pain ($P < 0.01$). Respectively in grade-I and grade-II fusions, the mean VAS scores were 2 and 1.66 and the mean ODI were 19.09 and 17.66. [Table 6]

80% of patients achieved >50% reduction in pain after successful fusion and 66% achieved > 30% reduction in ODI. [Table 7]

One patient followed up for 6 months and did not follow-up further, so fusion mass could not be assessed and was included under loss to follow-up. This patient, however, showed significant improvement in functional scores at 6-month follow-up. The mean preoperative slip was 31.37% (SD 9.290%) and the mean postoperative slip at 6 months was 19.67% (SD 7.415%). [Table 8]

The mean preoperative disc heights improved from 7.13 to 9.48 postoperatively at 6 months. [Table 9]

Discussion

In our study, transpedicular instrumentation with interbody cage was performed at a single lumbosacral level Meyerding grade I and II spondylolisthesis. Our experience with the TLIF procedure confirms the findings of prior studies in that it produces good clinical outcomes, 83.33% fusion rate without intra-operative and catastrophic complication. It provides circumferential fusion via a posterior approach and, thus, avoids the need for a separate anterior surgery that would entail additional risk of retrograde ejaculation or injury to abdominal viscera or vascular structures. In addition, TLIF avoids the need for dural retraction present when performing a PLIF, which may increase the potential for complications such as neurapraxic injury and dural laceration.

Our results are similar to recent studies in terms of surgical data and hospital stay [2,4]. The complication rate in this study was low. There were no intra-operative complications and specifically no unintentional durotomies which is common in PLIF. This is reflected in similar studies [4,5] In a recent MRC study [11] a peri-operative complication rate of up to 36% is reported. Transient neuritis due to excessive nerve root retraction has been reported to be as high as 7%; however, this has not been our experience. There have been anecdotal reports of catastrophic vascular injuries to the great vessels during decompression [12] or cage placement. Complications reported in ALIF include great vessel injury (1.7%) with venous injury as high as 15.6% [12], retroperitoneal damage resulting in dyspareunia in female patients and retrograde ejaculation in male patients. These complications place TLIF as a favourable alternative option to a circumferential fusion. The debate whether clinical outcome and fusion rate correlate has been raging in the literature for years [22–25].

Our patients were operated for degenerative spondylolisthesis and our clinical outcomes can be regarded as good to excellent with significant improvement in all of the scoring systems that were applied. If one considers that our union rate was 80% it is clear that clinical results correlate with the fusion rate. In our study majority of the patients were female 96 (80%) out of 30 patients while only 24 (20%) were male patients. In degenerative spondylolisthesis, the female gender is shown to be predominant [26]. Hackenberg in their study reported the results of TLIF with a minimum follow up of 3 years [27]. In their study, along with low grade Spondylolisthesis, they included patients with disc degeneration disease in whom TLIF was performed. But like our study, their main focus was on the functional outcome and the tool was ODI scoring like in our study. Their mean ODI scoring preoperative was 41.6% and 31.6% at latest follow up. Butterman G et al. in their study reported improvement in mean ODI from 63% to 33% 3 years after fusion surgery for Spondylolisthesis [28]. Like these studies, our mean preoperative ODI was 38.73, while postoperatively it was 21.30. Our study included patients with degenerative spondylolisthesis only. They had mainly patients with low-grade isthmic spondylolisthesis. Our follow-up was short compared to them. We found statistically significant improvement in pain scores (VAS and ODI) and significant improvement in SLR test postoperatively at 3 months and 6 months follow-up as compared with pre-operative scores. The improvement was significant when a comparison was made between 3 months and 12 months results. We believe that the initial relief in the symptoms may be due to the stabilization effect of the internal fixation device, and permanent relief can be related to attainment of satisfactory fusion, and resorption of the osteocartilaginous mass may also contribute to the clinical improvement.

A fusion rate of 68–100% has been reported with posterolateral fusion in low grade spondylolisthesis. We used radiographic criteria for fusion assessment and our fusion rate was 80%. Adding pedicle screw fixation to fusion has been reported to increase the rate of arthrodesis for low grade spondylolisthesis [29], and also to improve clinical outcome [30]. But McGuire and Amundson [31] found no advantage in using instrumentation. Kim et al. [32] also noted no additional benefits from instrumentation. The fusion rate in their instrumented patient was lower than those in the uninstrumented group. There is disagreement in the lit-

erature as to whether fusion correlates with clinical outcome in the treatment of lumbar spinal disorders [33]. A direct relationship between failure to achieve arthrodesis and unsatisfactory pain outcome was reported in a prospective study [31]. Some other studies have also reported a direct relationship between failure to achieve a satisfactory arthrodesis and an unsatisfactory outcome [34]. On the other hand, Schnee et al. [33] reported good clinical results in only 60% of cases, though a 90% fusion rate had been achieved. They concluded that factors other than preoperative symptoms and radiographic fusion significantly influenced results. In this study, we found that poor radiological fusion correlated with poor clinical and functional outcome. analysing the radiological fusion with clinical scores, poorer radiological fusion grades correlated with higher VAS scores for pain ($p < 0.01$). Respectively in grade-I and grade-II fusions, the mean VAS scores were 2 and 1.66 and the mean ODI were 19.09 and 17.66 at 12 months postoperatively. This is as opposed to the mean VAS score of 6 and mean ODI of 36 in fusion grade- IV (non-union). Objective assessment of clinical status in non-traumatic lumbar disorders remains elusive [35]. We used VAS score and ODI for a final assessment of results because we found it to be simple and it had been used in a study comparing results of posterolateral fusion and transforaminal lumbar interbody fusion; our results showed a 90% satisfactory outcome and it is comparable to the 60–98% reported in the literature [36]. A strict comparison of results is, however, difficult because of differences in surgical procedures, types of bone grafts, choice of instrumentation, postoperative immobilization, rehabilitation and smoking. The results of our study showed a close relation between satisfactory clinical outcome (90%) and solid fusion (80%). Reduction of spondylolisthesis is not required in most cases of low-grade isthmic spondylolisthesis to affect a better outcome [37]; in fact, short-segment posterior stabilization (in situ fusion and fixation) is associated with a measurable reduction when used as the sole treatment [38]. Kim et al. [32] reported an overall correction of 35% in anterior displacement without any attempt at reduction. In our study, an average correction of anterior displacement of 11.7% was seen in the early postoperative period, though no separate attempt to reduce the slip was made. Slip reduction is the most controversial part of the Spondylolisthesis treatment and many advocates against it. They claim that in situ fixation has good comparable results with a low rate of complications [39]. Still, there are proponents of reduction who think that it is against the basic principles, leaving the basic pathology unaddressed [40]. Like Pan J achieved an average reduction from 24% (grade-II) to 10% (grade-I). According to them it was spontaneous and was due to circumferential release [41]. In our study, the mean preoperative slip was 31.37% (grade-II) and postoperatively was 19.67% (grade-I), with an average correction of 11.7%. We think that even with one-sided release and disc removal easy reduction can be obtained without increasing the complication rate. The distraction of a lumbar disc space serves to increase the cross-sectional area of the neural foramen and has been assumed to be of clinical value in relieving neural compression [42]. Although the importance of restoration of disc space height (DSH) and segmental lordosis has been emphasized in numerous works, there are limited experimental data to validate these concepts in clinical practice [43]. In our study, we demonstrated excellent clinical outcomes with a significant increase in DSH. A possible explanation for this might be that the elimination of segmental motion could stop irritation of a nerve root and result in symptomatic improvement with an increase in the dimensions of the neural foramen.

Cheng et al. demonstrated that whole LL was improved after TLIF as a result of the spontaneous restoration of lordosis at the unfused lumbar levels in lumbar spondylolisthesis [44]. Jagannathan et al. found postoperative increased segmental and Global LL in their study. We found the same finding in our study with single level TLIF [45].

Drawbacks of this study are the lack of a comparative study group, short follow-up and smaller data size. Theoretically, with such short duration of follow up, we cannot effectively compare the results but our analysis is fairly comparable with the results of previous studies. Future prospective comparative studies (with other similar surgeries or to conservative management alone) with the larger patient number and longer follow-up are required for confirmation of our results.

Conclusion

The Transforaminal Lumbar Interbody Fusion is an effective option to achieve circumferential fusion without severe complications. An increased pelvic incidence may be an important factor predisposing to progression in developmental spondylolisthesis. TLIF increases global and segmental LL and provides a satisfactory outcome in symptomatic low-grade degenerative spondylolisthesis.

Declaration of Competing Interests

The authors declare that they have no conflicts of interest.

Compliance with ethical standards

All patients gave written informed consent prior to participation in the study, which was approved by the Institutional Ethics Committee.

Acknowlegement

None

Ethics approval

The study was conducted from June 2015 to March 2018 after approval from the institutional ethics committee.

Consent to participate

Informed patient consent was taken from all the patients.

Consent for publication

taken from all the patients

Availability of data and material

Available

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.xnsj.2020.100011.

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