Degenerative spondylolisthesis functional outcome after transforaminal lumbar interbody fusion (TLIF) using single cage and without posterolateral fusion (PLF)

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ABSTRACT

Introduction

Results of surgical treatment of symptomatic degenerative spondylolisthesis (DS) with or without spinal canal stenosis is better than that of the non-operative treatment. Indications for surgical treatment includes: failed adequate trials of non-operative treatment at least for 3 to 6 months, progressive neurological deficits, bowel / bladder involvement. Different surgical options of neural decompression with or without instrumentation have been described in literatures. We present our result of Transforaminal Lumbar Interbody Fusion (TLIF) using single cage and without posterolateral fusion.

Material and methods

Over a period of 5 years between January 2013 and November 2018, files of 32 patients having Degenerative Spondylolisthesis treated surgically by TLIF procedure have been reviewed retrospectively.

All patients' neurological status, preoperative visual analogue score and modified Oswestry Disability scores were recorded. All patients were subjected to standing antero-posterior and flexion / extension lateral views of lumbo-sacral spine. Percentage of the slip was calculated. They were subjected to Magnetic Resonance Imaging (MRI) to evaluate for amount of neural tissue compromise and status of the adjacent disc. Post-operatively all patients were followed up at 6 weeks, 3 months, 6 months, 1 year and subsequently every year. Post-operative improvement in VAS and ODI were recorded. Post-operative changes in the follow up x-rays were noted.

Results

There were 18 females and 14 males having average age of 55.19 + 10.14 years. The mean follow up period was 27. 47 $\pm$ 17.62 months. Preoperative VAS score improved from 8.12 $\pm$ 1.91 to 1.59 $\pm$1.41 and modified ODI reduced to 20 from 68.06 $\pm$ 7.87 at last follow up. All patients demonstrated significant improvement in walking distance, which was only 40.78 $\pm$ 36.41 meters before surgery.

Conclusions

TLIF is one of the viable options for surgical treatment of symptomatic Degenerative Spondylolisthesis with or without spinal canal stenosis. Use of single cage and interbody bone graft obtained from resection of the facet joint and without posterolateral fusion can produce comparable good to excellent results. It avoids morbidity associated with harvesting bone graft from the iliac crest.

Keywords: **Degenerative spondylolisthesis, TLIF, single cage**

Introduction

Degenerative Spondylolisthesis (DS) is one of the common conditions that patients present with in regular clinical practice. This is one of the major causes of low back pain and leg pain due to spinal canal stenosis[1-3]. It differs from spondylolytic Spondylolisthesis from not having pars defect[4]. DS usually do not slip beyond Grade II. In one study which included 200 patients the average slip reported to be was 14%[5].

Study by Sclafani et al. on 95,647 Medicare beneficiaries with the diagnosis of DS, over 50% underwent at least one corticosteroid injection, 37% opted for physical therapy, 21% underwent surgical intervention and 36% did not utilize any of the procedures[6]. This data indicates that Initial step of management is activity restriction and analgesics along with physical therapy that helps to strengthen core muscles of the back. Patients with low grade slip (Grade I) or hypermobile slip, without neurological deficits fare better with non-operative measures[7].

Surgical treatment may be indicated in about 15 to 20% of the patients where all non operative measures have failed and patients usually presents with caudaequina symptoms, progressive muscle weakness or significant neurogenic claudication hampering activities of daily living[1].

Different techniques of surgical procedures have been described in the literatures which include Postero-Lateral fusion (PLF), Posterior Lumbar Interbody Fusion (PLIF), Anterior Lumbar Interbody Fusion (ALIF) or Transforaminal Lumbar Interbody Fusion (TLIF). Each procedure has its own merits and demerits. And the indication of the particular procedure also depends upon the surgeon's preference. This article is aimed at evaluating the outcome after TLIF procedure in our setup.

Methods and Materials

This is the retrospective study of TLIF done in 32 patients having degenerative Spondylolisthesis performed by single surgeon at Grande International Hospital over the period of 5 years between January 2013 and November 2018. Inclusion criteria included all patients with failed conservative treatmentof at least for 6 months duration and no history of previous lumbar fusion surgery

All patients were evaluated to rule out neurological deficits. Pre-operative and post-operative pain was evaluated using Visual Analogue Scale (VAS) and levels of functional activity were evaluated using Modified Oswestry Disability Index (MODI). All patients were asked for their claudication distance. And all patients were evaluated for associated medical co-morbidities. Table 1.

Radiographic analysis consisted of standing plain x-rays of lumbosacral spine anteroposterior (AP) and lateral flexion/extension views. Percentage of slip was calculated in each x-ray. Magnetic resonance imaging (MRI) was performed to define neural compromise and condition of the intervertebral discs at adjacent level (Figure 1)

All the patients were subjected to Transforaminal Lumbar Interbody Fusion (TLIF) through unilateral approach and using single banana shaped titanium or PEEK cage. In no patients bone graft was harvested from the iliac crest to fill the gap between the vertebral bodies.

All the patients were followed up at the interval of 6 weeks, 3 months, 6 months, 1 year and subsequently every year. At the time of follow up patients were evaluated for pain using VAS system and functional outcome using Modified ODI. Radiological and clinical findings of the last follow up are reported.

Operative technique

Patient was positioned prone on the ordinary spinal frame made up of foam. It was made sure that the abdomen was hung free. Both the hips were left in the same position as achieved during positioning the patient prone over the spinal frame (Generally it is about 15 degrees of the flexion). This position would help us during exposure of the spine. Hips placed in maximum extension would help for postural reduction of Spondylolisthesis but at the cost of leaving small area for the exposure. Longitudinal midline incision of about 7.5 cm to 10 cm was given depending upon size of the patient. Para-spinal muscles were reflected off the spinous processes and laminae up to the tips of the transverse processes.

Level where TLIF to be performed was confirmed on the fluoroscope. Side to be approached was dependent upon the side of the neurological symptoms. In cases of bilateral neurological symptoms left sided approach was chosen since the

surgeon being right handed. Pedicle screws pilot holes were made. Pedicle screws were introduced on the contra-lateral side. Pre-contoured connecting rod in normal lordosis was threaded on the contra-lateral side and inner screws were placed in loose manner.

Total facetectomy of inferior facet of upper vertebra was done using sharp 8 mm osteotome. The exposed superior facet of the inferior vertebra was then removed using the osteotome and Kerrison's rongeur. Soft tissues around the area of intervertebral foraminal area was gently removed to expose the exiting nerve root. Ligamentum flavum was removed to expose the lateral margin of the thecal sac and traversing nerve root. Usually bleeding is encountered at this point and cauterized using bipolar.

Exiting nerve root and lateral margin of the thecal sac was protected using nerve hook retractors. Disc was exposed and annular window was made using no. 15 scalpel. Disc material was removed using pituitary rongeur. Seven or eight mm reamer was introduced into the disc space horizontally and rotated inside to place it vertically so that the height of the disc space is restored. The rod put on the contralateral side is tightened to maintain the position of the disc space. Then the end plates were cleaned by serially introducing larger size reamer up to 10 to 12 mm. The wound and the disc space was thoroughly irrigated. Disc space template was used to measure the size of the interbody cage. The bone graft harvested from facet joints was used to fill the gap anteriorly. The cage between 22 to 26 mm in length is introduced. Pedicle screws were placed on the ipsilateral side and connected with the pre-contoured rod. Compression between the screws was achieved. Wound was closed in multiple layers over the suction drain.

Post-operatively, patients were provided with rigid lumbo-sacral orthosis and mobilized on day one. Physical therapy exercises were begun immediately. Sutures were removed on 14th postoperative day. Average hospital stay of the patient was 5 days.

Results

Out of total 32 patients, 18 (56.2%) of them were females and 14 (43.8%) were males. The age ranged from 45 to 66 year with the mean age being 55.19 years. In 26 patients (81.3%) the level of involvement was L4- L5 region whereas in 5 patients (15.6%) level was L5-S1 and in one patient (3.1%) it was L3-L4 level. In 22 patients (68.8%) spondylolishesis was found to have Meyerding Grade II whereas in 10 patients (31.2%) it was Grade I.

All patients presented with pain and neurogenic claudication. After a trial of adequate non-operative measures patients were posted for TLIF. The mean pre-operative VAS score was 8.12 $\pm$1.91. And the mean neurogenic claudication distance was 40.78$\pm$36.41 meters. The mean modified ODI was 68.06$\pm$ 7.87.

First dressing change of the surgical wound was done on the 3rd post-operative day. Sutures were removed on 14th post-operative day. The first post-operative check x-rays were done on day one. Then the patients were followed up at 6 weeks, 3 months, 6 months, 1 year and subsequently every year. The mean follow up period was 27.47 $\pm$ 17.62 months.

At the last follow up the VAS pain score reduced to 1.59 $\pm$ 1.41 whereas the modified ODI improved to average 20.

Post-operative x-rays showed gradual appearance of haziness in the intervertebral fusion area. No settling of the interbody cage or breakage of the pedicle screws or rods have been observed till the last follow up of the patient. Lumbar lordosis has been maintained and there was no mismatch between pelvic incidence and the lumbar lordosis.

Discussion

Degenerative Spondylolisthesis (DS) results from the chronic inter-segmental instability at the lumbar motion segment. The reasons for having inter-segmental instabilities are: facet joint degeneration , ligamentous hyperlaxity, poor muscle support to the back[4]. Patients usually are above the age of 50 and they have disc generation which may compound to the development of degenerative Spondylolisthesis due to segmental instability in sagittal plane[8]. Associated risk factors for degenerative Spondylolisthesis are: age above 50 years, high body mass index, female gender, pregnancies, ligamentous hyperlaxity, anatomical variations (Hyperlordosis, High pelvic incidence, Sagittal orientation of facet joint)[4]. The DS was more common in females than in males (18 vs 14) and average age at presentation was 55.19 years.

Table 1: Demographics and clinical information of patients

SN	Age	Sex	Level	Grade	Pre op pain	Neurogenic claudication distance (m)	Fixation level	Post op pain	Follow up time (months)
1	32	F	L 4 L5	I	10	10	L3 L4 L 5	0	36
2	50	M	L 4 L5	II	6	10	L4 L5	2	44
3	37	F	L 4 L 5	I	10	10	L4 L5	0	24
4	48	F	L 4 L 5	I	8	100	L4 L5	2	48
5	57	F	L 4 L 5	II	10	5	L4 L5	0	2
6	51	M	L 4 L 5	II	7	50	L4 L5	2	60
7	73	F	L 4 L 5	II	10	5	L4 L5	1	1.5
8	65	M	L 4 L 5	II	6	100	L3 L4 L 5	1	24
9	55	m	L 4 L 5	II	5	100	L3 L4 L 5	1	60
10	60	F	L 4 L 5	II	8	50	L3 L4 L 5	0	60
11	45	F	L 4 L 5	II	10	10	L4 L5	0	24
12	42	F	L 5 S 1	II	8	50	L5 S1	3	72
13	66	M	L 4 L 5	II	10	5	L3 L4 L5	0	18
14	66	M	L 4 L 5	II	10	10	L4 L5	1	12
15	57	M	L 4 L 5	II	5	100	L4 L5	2	24
16	68	M	L 4 L 5	II	10	10	L3 L4 L5	4	9
17	52	F	L 5 S 1	II	8	50	L5 S1	2	24
18	58	M	L 4 L 5	II	6	100	L4 L5	0	30
19	60	M	L 4 L 5	II	5	50	L4 L5	2	36
20	57	F	L 4 L5	I	9	50	L3 L4 L5	1	18
21	55	F	L 5 S 1	I	5	50	L5 S1	2	9
22	66	M	L 3 L 4	I	10	5	L2 L3 L4 L 5	5	9
23	68	M	L 4 L 5	II	9	10	L4 L5	2	30
24	65	F	L 4 L 5	II	5	10	L4 L5	3	30
25	52	M	L 4 L 5	II	7	100	L4 L5	0	24
26	43	F	L 4 L 5	I	10	10	L4 L5	2	40
27	44	F	L 4 L 5	II	7	10	L4 L5	1	36
28	47	M	L 4 L 5	I	10	25	L4 L5	3	48
29	65	F	L 5 S 1	I	8	50	L5 S1	2	36
30	45	F	L 4 L 5	I	10	100	L5 S1	0	48
31	66	F	L 5 S 1	II	10	10	L5 S1	2	12
32	51	F	L 4 L 5	II	8	50	L3 L4 L5	3	1

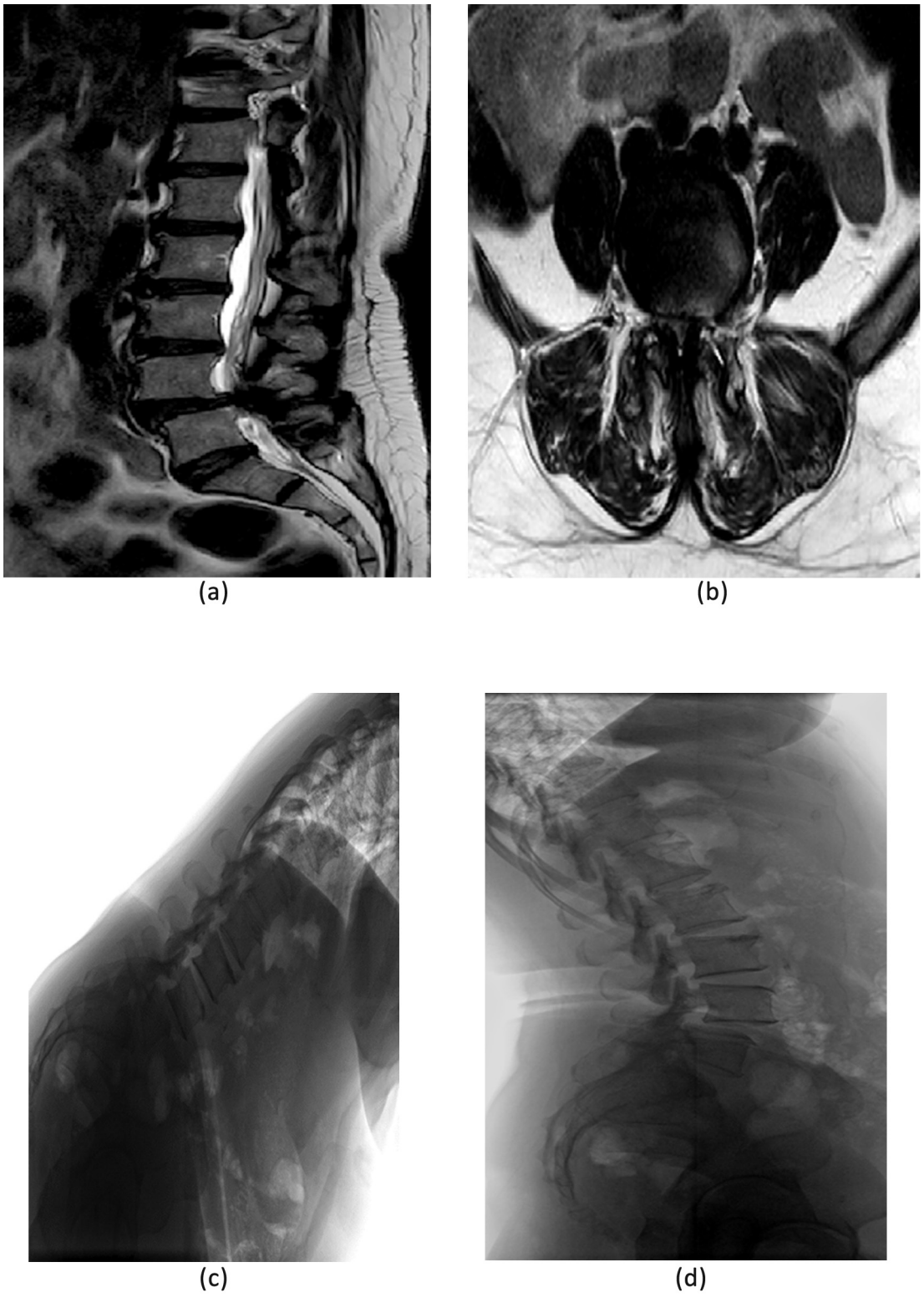

Figure 1: a: MRI Sagittal view, b: MRI axial view, c: Flexion view LS spine, d: Extension view LS spine

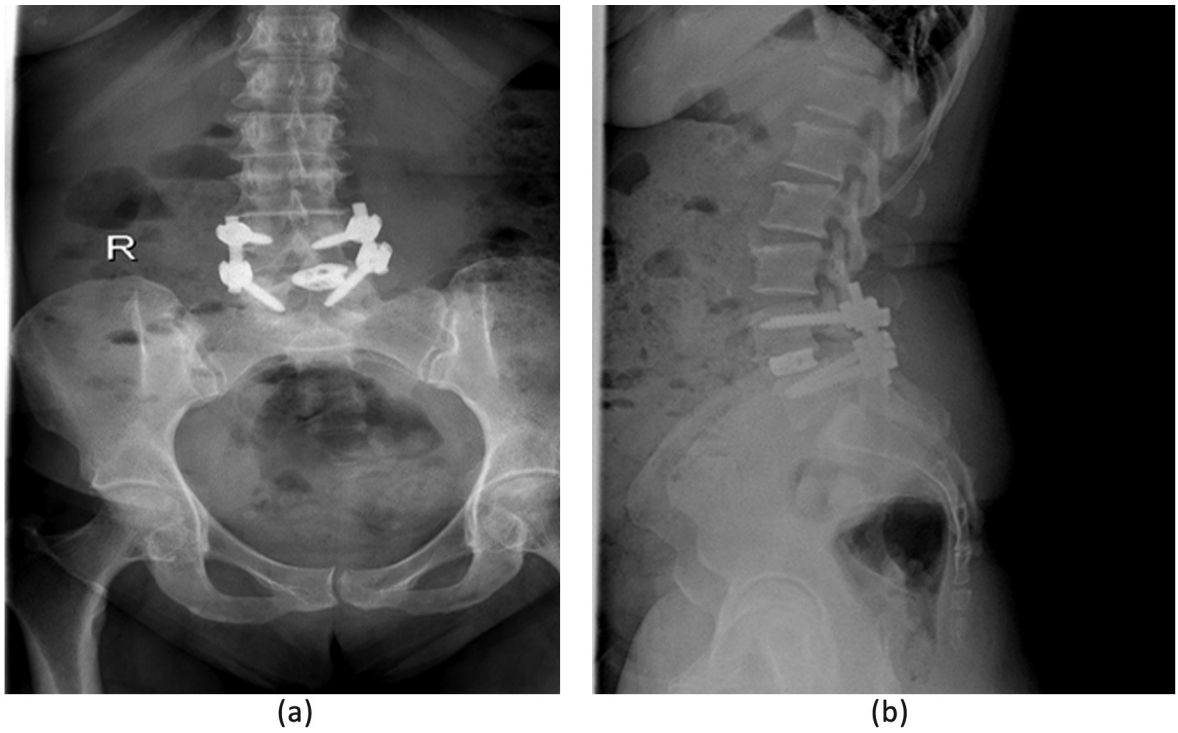

Figure 2: a, b – Immediate post-operative AP view, lateral view LS Spine

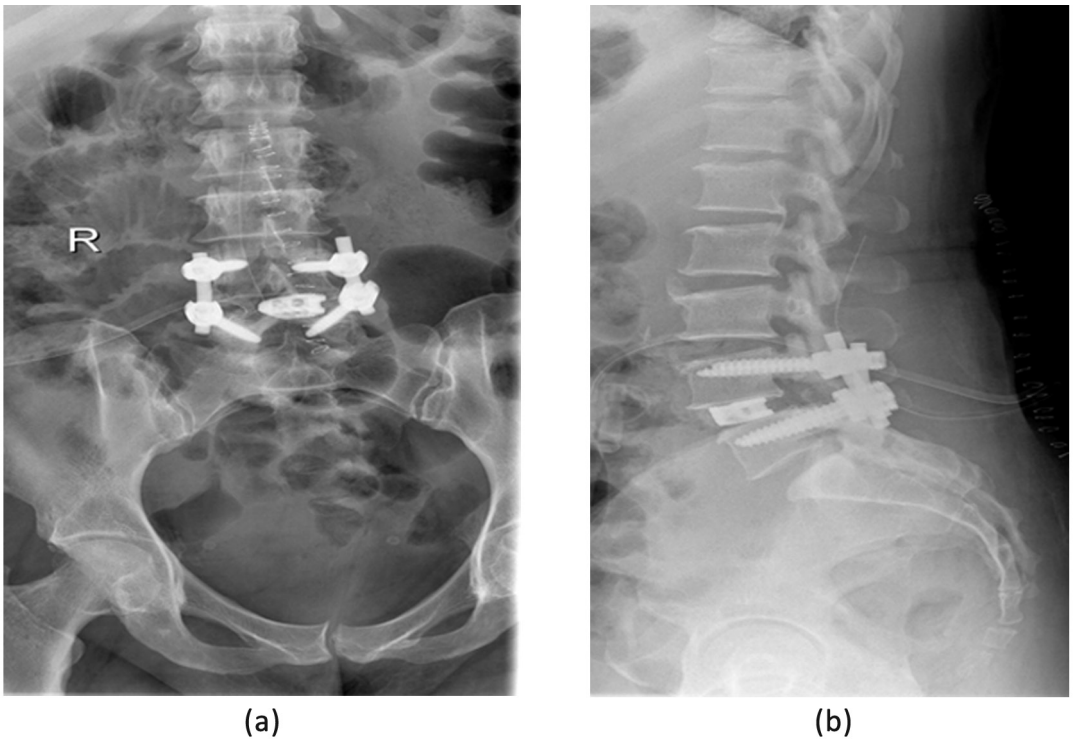

Figure 3: a, b – Post-operative 6 months AP view, lateral view LS spine

Primary complaints of the patients are back pain due to segmental instability or leg pain or neurogenic claudication due to compression of the nerve roots or cauda equina. The common reasons for signs and symptoms in DS are: degenerated or subluxated facet joints, tension in the joint capsule / ligaments / supporting muscles and central spinal canal stenosis and intervertebral foraminal stenosis[4]. The most characteristic feature of DS with spinal canal stenosis is that the pain shifts from one leg to another. Some patients complain of cold feet, altered gait or "drop episode" where the patient tends to fall frequently while walking. About 42 – 82% of the patients present with significant neurogenic claudication seeking for surgical advice[9]. Patients usually hesitate to undergo surgery until and unless they have significant deterioration in their quality of life. In our group of the patients, the major determining factor for undertaking surgery is the neurogenic claudication rather than the low back pain.

The plain radiograph demonstrates anterior slippage of L4 over L5 and rarely L5 over S1 or L3 over L4. The presence of intact neural arch differentiates DS from isthmic or congenital Spondylolisthesis[10]. Additional features of DS are disc space narrowing, vacuum signs, peridiscal osteophytes, facet joint hypertrophy and end plates sclerosis[1]. Additional imaging studies include CT scan, CT myelography and Magnetic resonance imaging (MRI). The gold standard is MRI that can depict vertebral slip along with neural compromise due to bulging disc, hypertrophied ligamentum flavum, and hypertrophied facet joint or synovial cyst[11-13]. In cases where metastatic disease also suspected then Technetium Bone scan is also recommended. Electrodiagnostic studies are recommended in cases with bowel and bladder dysfunction. The degenerative Spondylolisthesis is 6 to 9 times more common at L4-L5 level than at other spinal levels. One of the reasons being strong ilio-lumbar ligament that is holding the L5 vertebra strongly at its place especially by the posterior band[14]. In our series 81.3% of the patients have DS at L4-L5 level while only 15.6% and 3.1% of the patients have spondylolisthesis at L5-S1 and L3-L4 levels respectively.

In most of the cases symptoms gradually resolves in due course of time due to progressive disc degeneration leading to autofusion and formation of osteophyte which naturally stabilizes the spine. In about 10 to 15% of the patients require surgical intervention[15]. In about 34% of the patients with DS, progression of the vertebral slip was observed during long term follow up but there was no correlation between the slip progression and clinical findings[16]. In about 76% of the patients who had no neurological deficits at the time of presentation remained same at 10 years follow up where as 83% of the patients who had neurological problem in the form of intermittent claudication or bowel / bladder dysfunction, and they refused decompressive surgery, experienced deterioration[16]. In another study of spinal canal stenosis, where 9 patients had DS, in 70% of patients the symptoms remained unchanged, 15% showed improvement and 15% deteriorated[4].

Surgical treatment of DS with spinal stenosis is still debatable. Indications for surgery includes: persistent back or leg pain in spite of adequate trial of non-operative measures at least for 3 to 6 months, progressive neurological deficits, bowel / bladder involvement[15]. Involvement of bowel / bladder or progressive neurological deficits should be treated on urgent basis[17]. Weinsein et al. have reported greater pain relief and improvement in function after surgery as compared to non-operative treatment[18].

Non-operative treatment is the main stay of treatment for degenerative Spondylolisthesis. It includes rest, anti-inflammatory medications, brace and physical therapy. Spinal flexion strengthening and back isometric exercises have demonstrated pain relief in DS[17,19]. Cycling is one of the recommended exercises for the patients with DSwith spinal stenosis because it increases flexion of the spine which helps to increase antero-posterior diameter of the spine thus decompressing the nerve roots[1,20]. Another alternative for failed non-invasive measures is epidural steroid injection (ESI). It gives a short term benefit but lasting long term benefit of ESI has not yet been proved[21,22]. We invariably recommend for different non-operative measures for the treatment of DS with or without spinal canal stenosis. Unless the patient has demonstrable motor weakness or bowel / bladder dysfunction, we do not urge patients to undergo surgery.

The aim of the surgery is to decompress the nerve roots and stabilize the spine. Nerve roots are decompressed by decompressive laminectomy

which relieves the leg pain and neurogenic claudication whereas fusion was done with or without instrumentation to relieve the back pain. Interbody fusion with instrumentation has been demonstrated better outcome as compared to decompression alone or fusion without instrumentation[8].

Spinal canal decompression is the primary aim of surgical treatment of DS with spinal stenosis. Laminectomy serves to decompress central canal, lateral recess and neural foramina. In a metaanalysis published by Mardtejko SM et al. have reported 69% satisfactory outcome[23]. Likewise other similar literatures have reported good to excellent results in 82% of the patients treated surgically by decompression only[24]. In select patients with stable DS where there is disc space narrowing and profuse osteophyte formation, decompression alone without fusion fare better so far as morbidity, mortality and cost is concerned[25]. Laminectomy with fusion without instrumentation have demonstrated good to excellent results in some of the prospective randomized trials and results were shown to have superior as compared to decompressive laminectomy alone. However, fusion without instrumentation is associated with about 36% of pseudoarthrosis, though it has not demonstrated clinical relevance till the follow up period[26,27]. Instrumented fusion results solid fusion in 82% of the patients as compared to non-instrumented fusion where solid fusion were observed in 45% of the patients. There was no significant difference in clinical outcome in patients who have pseudoarthrosis. But during long term follow up of more than 7 years clinical outcome was observed better in patients having solid fusion[28,29]. Results of the Spinal patient outcome research trial (SPORT) on DS have also demonstrated better outcome in surgically treated group as compared to non-surgical group, in terms of significant decrease in modified ODI (23 vs 8.6) and improvement in medical outcome study 36 – item form (26.6 vs 7.7). In addition to that 67.1% of patients treated surgically demonstrated significant pain relief and improvement in function as compared to 21% of the patients treated non-operatively[30]. Furthermore, no consistent clinical outcome differences have been observed over a period of 4 years in postero-lateral in situ fusion without instrumentation or posterolateral fusion with instrumentation or 360 degrees fusion[31].

Addition of interbody fusion has generated debate in the surgical management of DS.Interbody fusion in unstable DS (> 4mm translation or > 10 degrees of disc angulation in dynamic x-rays) have demonstrated better outcome as compared to decompression and postero-lateral fusion (PLF) alone[32]. It increases the surface area available for the fusion and provides initial stability to the spine. It is indicated in the patients having risk of pseudoarthrosis, segmental kyphosis, high grade slip, segmental instability due to sagittaly oriented facet joints, effusion in the facet joints and tall intervertebral discs. In cases where anterior load sharing is preserved posterior-only construct with pedicle screw fixation should suffice[33]. Traditionally approached method has been anterior lumbar interbody fusion (ALIF). Other surgical techniques described are posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF) or lateral lumbar interbody fusion (LLIF). Each technique has its own merits and demerits.

Advantages of ALIF includes large foot print for graft placement, helps to restore sagittal alignment and reduction of the slip, indirect decompression of the nerve roots, restoration of the disc height. However, it is associated with significant morbidity. ALIF procedure has demonstrated significant improvements in Japanese Orthopedic association outcome score as well as good to excellent functional outcome as compared to posterior decompression only (77% versus 56%)[34,35]. Interbody fusion rate at 10 years follow up was 100% but 30% of the patients showed deterioration in functional outcome due to adjacent segment disease[36].

Posterior approaches to the interbody fusion are posterior lumbar interbody fusion (PLIF) and Transforaminal Lumbar Interbody Fusion (TLIF). Both the techniques avoid morbidities associated with ALIF. And both the techniques have similar good to excellent JOA functional scores (PLIF 83.5% and TLIF 84.6%). Visual analogue score for pain and modified Oswestry Disability Index have significantly reduced in both the groups. Intervertebral disc height and intervertebral foraminal heights were increased and percentage of slip were reduced. TLIF decompresses lateral recess as well as neural foramen and is safer and easier to perform than PLIF. Furthermore, TLIF may preserve posterior midline structures and associated with minimal neural tissue handling

and decompression can be achieved bilaterally from one side only approach[37,38]. Our approach to TLIF is unilateral through the symptomatic side. We use single banana shaped Titanuim or PEEK cage. We have used bone graft that has been obtained only from facet joint removal or partial removal of lamina. Posterior osteoligamentous structures were all preserved. In no patients posterolateral fusion was done. We were very particular about preparation of the end plates as the bed for the graft and the cage.Post-operatively VAS score was significantly reduced to from 8.12 ± 1.91 to 1.59±1.41, whereas modified ODI came down from 68.06±7.87 to 20. All patients demonstrated significant improvement in their walking distance which was only 40.78±36.41 pre-operative. Follow up x-rays demonstrated haziness and gradual increase in radiodensity in the interbody space. No setteling of the cage has been observed and no implant failure has been seen till the last average follow up period of 27.47 ± 17.62 months. However, all the patients need to be followed up for longer duration.

Lateral (Transpsoas) lumbar interbody fusion (LLIF) is performed through minimal invasive technique. It avoids the complications like neural injury, visceral and vascular injuries those are associated with ALIF and PLIF. However, LLIF is associated with lumbar plexus injury leading to post-operative anterior thigh / groin pain, quadriceps weakness or dysesthesia. But most of these complications are transient and usually resolve over the period of 6 weeks time. Short term success rate of LLIF is better than that of ALIF or PLIF but intermediate and long term results are yet to be compared[39,40]. However, this approach requires expertise and additional training.

Conclusions

Transforaminal Lumbar Interbody fusion (TLIF) is one of the viable surgical options for symptomatic Degenerative Spondylolisthesis with spinal canal stenosis. It is the easier approach as compared to ALIF and PLIF and associated with fewer complications, lesser neural tissue handling and lesser soft tissue dissection. It can be approached unilateral and posterior osteoligamentous structures are all preserved. Use of single cage supplemented with interbody bone graft without posterolateral fusion does produce comparable result.

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