International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2018; 4(4): 637-643

www.orthopaper.com
Received: 14-08-2018
Accepted: 18-09-2018

Dr. TC Premkumar
M.S. Ortho., Senior Assistant Professor, Department of Orthopaedics and Traumatology, Madurai Medical College, Madurai, Tamil Nadu, India

Dr. PV Thirumalaimurugan
M.S. Ortho., Senior Assistant Professor, Department of Orthopaedics and Traumatology, Madurai Medical College, Madurai, Tamil Nadu, India

Correspondence
Dr. PV Thirumalaimurugan
M.S. Ortho., Senior Assistant Professor, Department of Orthopaedics and Traumatology, Madurai Medical College, Madurai, Tamil Nadu, India

A study on functional outcome of transforaminal lumbar interbody fusion in spondylolisthesis

Dr. TC Premkumar and Dr. PV Thirumalaimurugan

DOI: https://doi.org/10.22271/ortho.2018.v4.i4h.76

Abstract
Background: The treatment of spondylolisthesis consists of conservative methods or surgical management. Radicular pain in spondylolisthesis, does not responds to conservative treatment needs surgical procedure. Various surgical procedure are there for spondylolisthesis.
Aim: In this study we evaluate the functional outcome of transformational lumbar interbody fusion in spondylolisthesis.
Material and Methods: 32 patients (4 males, 28 females) admitted in Department of Orthopaedics, Madurai Medical College and Government Rajaji Hospital with Spondylolisthesis from May 2011 to November 2013. All patients were treated with posterior decompression, stabilisation with pedicle screw system and Transforaminal Lumbar interbody fusion. Patients were followed up and assessed for functional outcome with oswestry Disability index (ODI Score) and visual analoq scale for back and radicular pain.
Results: 32 patients (4 Males, 28 Females) with Spondylolisthesis were treated with posterior decompression, stabilisation with pedicle screw system and Transforaminal Lumbar interbody fusion. The mean preoperative Visual analog score for Back pain was 10 which improved to 2(1-4),the mean preoperative Visual analog score for Leg pain was 8 which improved to 1(1-5), the mean preoperative Oswestry Disability Index (ODI) Score was 63.6% (range from 56%-74%)which improved to 20% at final follow up implying better score postoperatively. The neurological status improved in 81% of patients. The radicular pain is relieved in all patients (100%) final post operative follow up. The sensory improvement is seen in 10 out of 12 patients and in two patient no improvement is present. The four patients with pre-operative motor deficits, that patients had grade 1 increase in power.
Conclusion: The Transforaminal Lumbar Interbody Fusion is a safe, simpler and less morbid approach with low complication rate. It provides better functional outcome by providing pain relief and improving the quality of life in the patients. TLIF restores the normal saggital balance of spine and maintains the disc space height.

Keywords: spondylolisthesis, transforaminal lumbar interbody fusion

Introduction
Background
Spondylolisthesis is defined as forward slippage of cephalad vertebra on a cadual vertebra. The percentage of Isthmic spondylolisthesis in adult males and females is 5-6% and 2-3% respectively. Degenerative spondylolisthesis is common in age group of 50 years and above. 10% females in the age group of 60 years and above have degenerative spond ylolisthesis [1-3].
The main aim of treatment in spondyolisthesis is stabilization and fusion at involved cerebral level. Stabilization is done by Pedicle screws and rods. Various types of fusion are Anterior Lumbar interbody fusion, Posterior Lumbar interbody Fusion, transforaminal Lumbar interbody fusion and Posterolateral Fusion. Posterolateral fusion is considered the gold standard of treatment for adults with spondylolisthesis. Transforaminal lumbar interbody fusion (TLIF) is an alternative to posterior lumbar interbody fusion (PLIF) [4, 5].
In the year 1982, Harms and Rolinger used bone graft packed in a titanium cage which was inserted through the transforaminal route, termed transforaminal lumbar interbody fusion [6].
TLIF is done by distracting the vertebrae using pedicle screws which are placed before the cage insertion. The entire facet joint is removed on the one side and the cage is insertion. TLIF has the major advantage of restoring the disc space height, maintaining the lumbar lordosis and

sagittal balance. It also has the additional advantage of preserving the posterior elements on The contralateral side which increase the surface area for fusion lamina. When compared to other technique of fusion TLIF has better fusion rates, lesser dural damage and nerve damage [7].
In the study we evaluated the functional outcome of Transforaminal lumbar interbody fusion in spondyolisthesis.

Inclusion Criteria
1. Age 20-75 years
2. Isthmic spondylolithesis is grade I-III
   - Patients who doesn't respond to conservative treatment
3. Degenerative spondylolithesis grade I-II
   - patients who doesn't respond to conservative treatment
4. Traumatic spondylolithesis.

Exclusion Criteria
1. Unfit for anaesthesia
2. severe osteoporosis
3. Spondyloptosis
4. Age <20 and > 70 years.

During study age of patients, mode of presentation, level of the lesion and associated co morbid conditions are considered.

Materials & Methods
This study was conducted at Department of Orthopaedics, Madurai Medical College and Government Rajaji Hospital on 32 patients with Spondylolisthesis from May 2011 to November 2013. All patients were treated with posterior decompression, stabilisation with pedicle screw system and Transforaminal Lumbar interbody fusion.

Preoperative planning
1. Clinical neurological examination
2. Visual analog scale to assess pain [16]
3. Oswestry Low Back Pain Disability Questionnaire(16)
4. X-ray

Anterio posterior
Lateral view (standing)
Oblique views
Flexion and extension Lateral views

By using X rays vertebral level involved, pars interarticularis defect identified slip%, Myerding Grading done, Pelvic incidence, Sacral slope, Pelvic tilt,Disc space height measured.

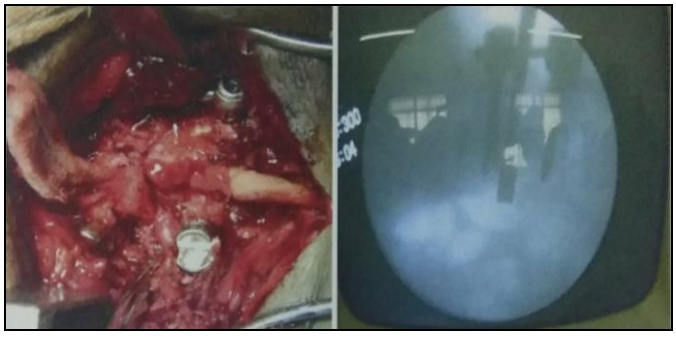
5. MRI- to find neural compression, canal stenosis, facetal hypertrophy, Disc prolapse.

The patients under the effect of general anesthesia were positioned on the fracture table and antero-posterior & lateral X rays were taken to determine the direction of the pedicles, end plates and disc spaces. All patient underwent posterior stabilization using Moss Miami rods and pedicle screws and Titaneum TLIF cages, Kidney shaped cages 8,9,10,11 sizes are used. During surgery operative blood loss, operative time are noted.

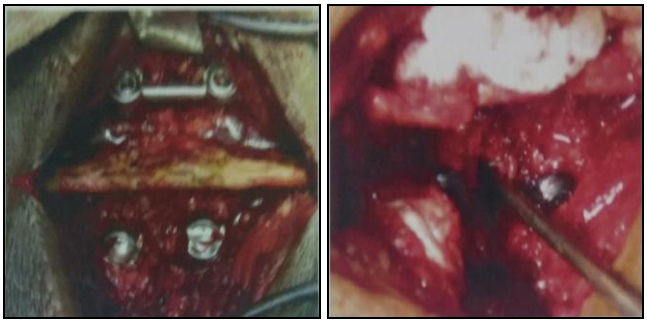
Surgical Technique
All patients were placed in prone position over radiolucent table. Bolsters are placed longitudinally under the patient's sides to allow the abdomen to be entirely free. Pressure points are carefully padded. After preparing and draping the surgical Site, Skin and subcutaneous tissue infiltrated with Tumuscent solution.
Midline longitudinal incision made over the spinous processes, extending from the spinous process above to the spinous process below the level of listhesis. The length of the incision depends on the number of levels to be explored.
The internervous plane lies between the two paraspinal muscles (erector spinae), each of which receives a segmental nerve supply from the posterior primary rami of the lumbar nerves.
Superficial Surgical Dissection, The incision is deepened through fat and fascia in line with the skin incision until the spinous process itself is reached. Paraspinal muscles detached subperiosteally as one unit from the bone. Self-retaining retractors are used to maintain tension on soft tissues during exposure.

- Among the three techniques for localization of the pedicle namely (1) the intersection technique, (2) the pars interarticularis technique, and (3) the mammillary process technique, we use the intersection technique which is a point between the line from transverse process and lateral aspect of facet joint. Pedicles screw are applied in proper angulation and trajectory. Lordotic curve of the lumbar spine produces rostal angulation for lumbar vertebra at the upper level. At L5 it is 5-10 degrees caudally placed and inserted. At L1 level pedicle screws are applied with 5-10 degrees medial angulation. From L1 level the medial angulation is increased by 5 degrees for each level upto S1.
- Under C-arm control, Pedicle screws were inserted. Next rod is connected to side opposite to nerve root involvement and distraction is done.
- On the involved side facetectomy is done. Osteotomy of inferior and superior articular process without violating the pedicle above and below is done.*Ligamentum flavum is removed and then existing and traversing nerve roots are identified and protected. Disc space is identified. Discectomy and end plate preparation is done.
- Trial cage inserted and disc space is serially dilated to appropriate size.
- Then anteriorly in disc space graft packed. Cage is inserted after filling the case with bone graft using the laminectomy chips or posterior iliac crest grafts.
- Rod is connected on the both side and after giving compression pedicle screws are tightened. Then wound closed in layers.

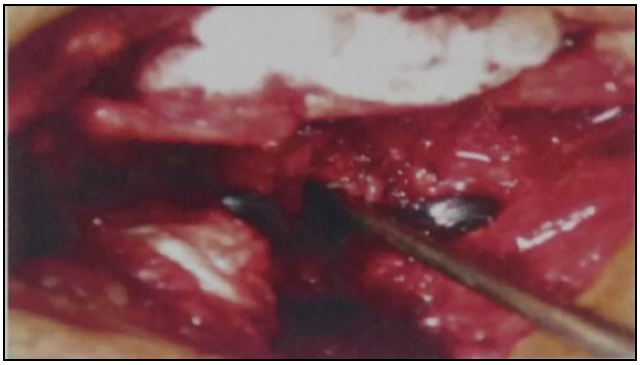
Intraoperative Technique



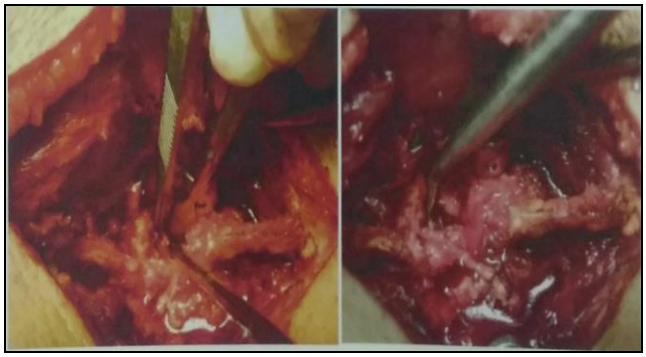
Exposure and pedicle screw application



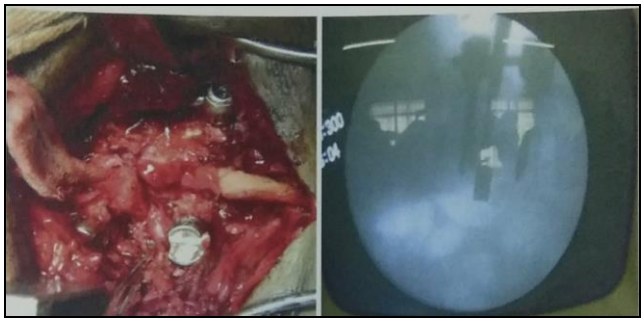
Rod connected on one side and distraction done –facetectomy



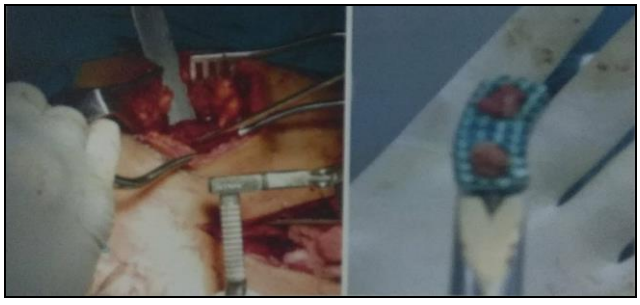
Decompression and nerve root identified and protected



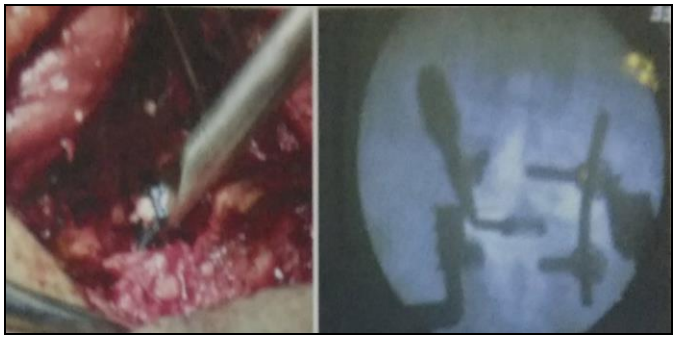
Discectomy and Endplate preparation



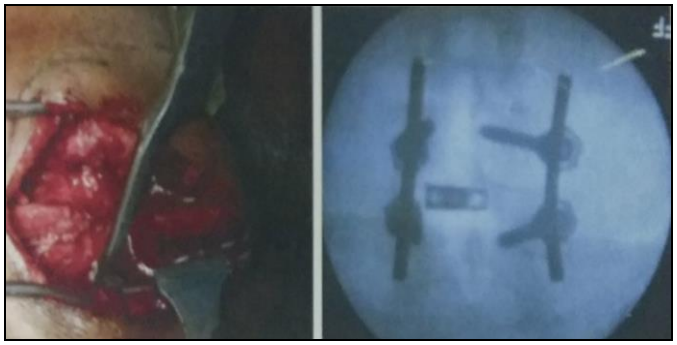
Trial cage insertion and serial dilatation done



Bone Graft Harvested and cage Packed with Graft



Cage inserted and position checked with C-arm



Rod inserted and final compression given. Screws tightened

Post-op protocol

- Early mobilisation from the bed with lumbosacral belt application.
- Muscle strengthening exercise as soon as pain subsides.
- Avoid bending and twisting movements for 3 months.
- Lumbosacral belt application for 3 months.

Post-op follow up

The patients are followed up at 3 months, 6 months, 1 year and every 6 months and evaluated for the pain using visual analogue pain scale and the functional outcome evaluated using Oswestry Disability Index.

Results

This study was conducted at Madurai Medical College and Government Rajaji Hospital on 32 patients with Spondylolisthesis from May 2011 to November 2013. All patients were treated with posterior decompression, stabilization with pedicle screw system and Transforaminal Lumbar interbody fusion.

The mean follow up period was 12 months (range 6-20 months).

The following observations are made in this study

- The majority of cases are females. female: male ratio was 7:1.
- The majority of patients are housewives (87.5%) followed by manual workers (12.5%).
- The co-morbid conditions associated are diabetes in four patients (12.59%), hypertention in two patient (6%), hypothyroid in two patient(6%).
- The most common age group affected is 6th decade (44%) and 4th decade (25%).Degenerative type is common in 5th and 6thdecade.Lytic type in younger age group below 5th decade.
- The mean duration of symptoms in these patients before surgery is 2.4 years (range from 1 year to 5 years).All

patients had undergone non-operative treatment for minimum period of 6 months.

- The 50% cases are of lytic type and other 50% is of degenerative type.
- The most common mode of presentation is Low Back ache (100%).Next to this is Radiculopathy(94%) and neurogenic claudication (50% among all cases and 100% in Degenerative type of listhesis).The sensory deficit is seen in 12 (37.5%) out of 32 patients. Motor deficit is present in 4(12%) cases. No bowel and bladder symptoms in any patient.
- The most common level involved is L4-L5 in 56% of cases and L5-S1 in 36% of cases. The L4-L5 Level is most commonly affected in Degenerative type (75%). L5-S1 level was most commonly affected in Lytic type (50%).
- The most common grade (Myerding grading) of listhesis was grade II (62%), Degenerative type (71%) and lytic type (56%).
- The most common type according to Spinal Deformity Study Group classification (SDSG classification) was Type 3- Pelvic incidence >60* (75%).
- In all our patients spondylolisthesis involved only single level, thus single level fusion is done in all cases.

The following are the results of the study

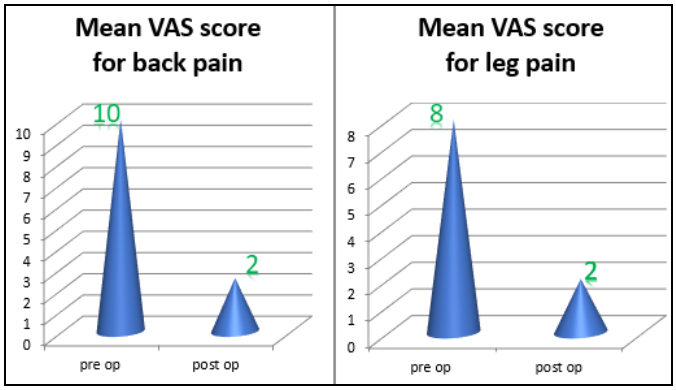
- The mean duration between surgery and onset of symptoms was 2.4 yrs (range 1 yr to 5 yrs).
- The mean surgical time was 3 hours 20 minutes (range 2h 20 min-4hr 10 min).
- The average blood loss was 450 ml (400 ml -1000 ml).
- The mean preoperative Visual analog score for Back pain was 10 which improved to 2(1-4) at final follow up implying better pain score postoperatively.
- The mean preoperative Visual analog score for Leg pain was 8 which improved to 1(1-5) at final follow up implying better pain score postoperatively.
- The mean preoperative Oswestry Disability Index (ODI) Score was 63.6% (range from 56%-74%) which improved to 20% at final follow up which indicates improvement in daily activities of the patient.
- The neurological status improved in 81% of patients. The radicular pain is relieved in all patients (100%) final post-operative follow up. The sensory improvement is seen in 10 out of 12 patients and in two patient no improvement is present. The four patients with pre-operative motor deficits, that patients had grade 1 increase in power.
- The mean slip percentage pre operatively was 32% (range from 64% to18%) which decreased to 14% (range from 45% to 10%) post operatively and this was maintained in final follow up.
- The preoperative Myerding grading of slip in two patient with grade III reduced to grade II postoperatively, all of the patients with grade II slip (18 patients) reduced to grade I. In other patients with grade 1 slip remained to have some amount of slip but slip percentage decreased in these patients.
- The Pre-operative mean disc space height at the involved segment is 5.6mm (range 2mm to 8mm). The mean post-operative disc space height at final follow up is 9mm (range 8mm -10mm).
- According to Modified Macnab's criteria, patients results

Are assessed and categorized into

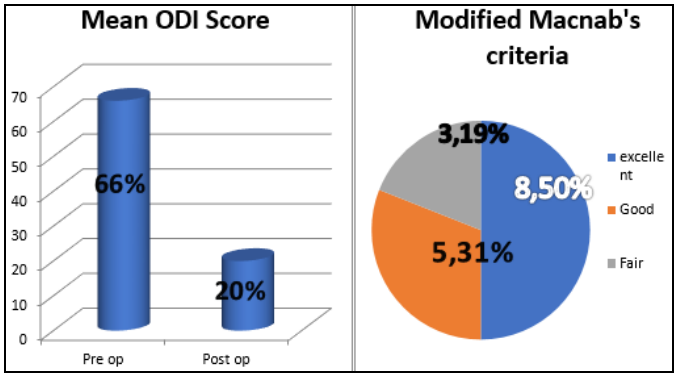
1. Excellent: when patient had No pain and patient return to There normal activity and work.
2. Good: When patient had occasional non radicular pain, and return to modified work.
3. Fair: Some improvement in functional capacity, but patient is still handicapped.
4. Poor: Patient had continued symptoms. Operative intervention is needed in these patients in post-operative follow up.

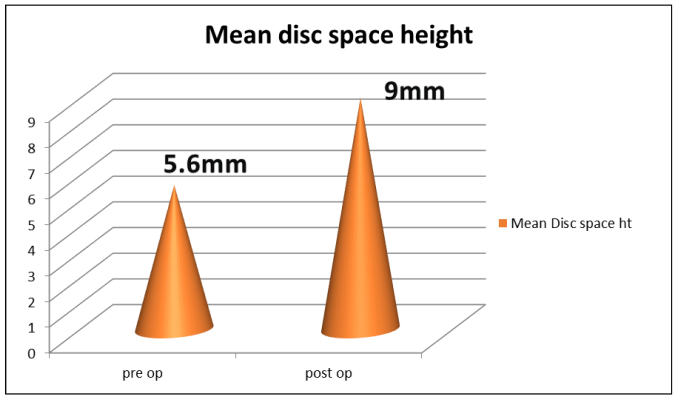
In our study results are,
Modified Macnab's criteria

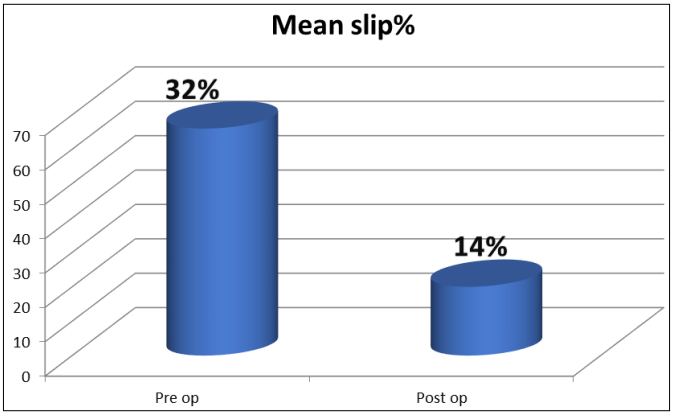
Excellent	**16 out of 32 patients (50%)**
Good	10 out of 32 patients (31%)
Fair	6 out of 32 patients (19%)



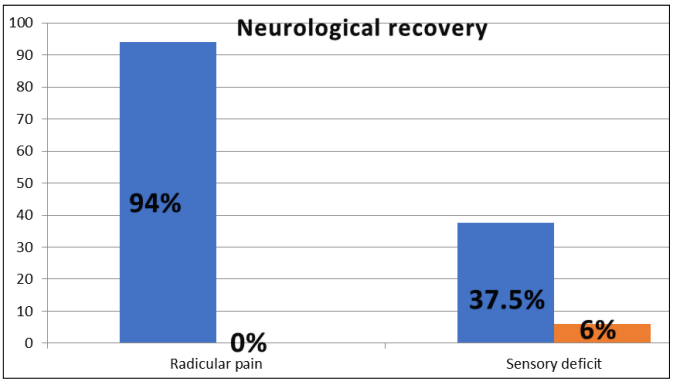
	Mean VAS Score	
	Back pain	**Leg pain**
Pre- operative	10	10
Post- operative	2	2







Mean Slip %	
Pre op	32%
Post op	14%



Pre op	94%	37.50%
Post op final follow up	0%	6%

Complications

- In our study Eight patients developed complications out of which two was major complication with Pedicle screw misplacement which lead on to Foot drop post operatively on Rt side, other six patients had minor complications which includes four with radiculitis and two with superficial wound infection.
- In two of our patient (6%) we had pedicle screw misplacement which lead on to foot drop on Rt side postoperatively. CT Scan was taken which showed pedicle screw misplacement on Rt side. So we removed all pedicle screws leaving the cage in situ and adviced patient for rest and Brace application for 3 months. Foot drop splint was applied. After 5 months of rest and Bracing, patient X ray at 5 months showed fusion at the involved level.
- Two patients developed superficial wound infection (6%) which healed by conservative methods and extended antibiotic therapy.
- Four patients (12%) developed radiculitis postoperatively which was treated conservatively and radiculitis settled within three weeks in all patients.

Discussion

The treatment of Spondylolisthesis consists of conservative methods or surgical management.

Conservative Treatment

Most of the spondylolisthesis patients are treated conservatively.

Favorable indications for conservative treatment are

- Patients without any neurologic deficit.
- High patient comorbidity.
- When the low back pain is tolerable and patients pain threshold is high.
- Improvement by exercise program.
- Symptoms are of short duration.
- Improvement with brace application.

In spondylolisthesis acute onset of pain are treated,

- By advicing the patients to take bed rest for 1 week and modifying his activities.
- By prescribing analgesics, anti-inflammatory drugs and muscle relaxants.
- After the pain gets subsided, patients are advised to participate in exercise program which improves strength of paraspinal and abdominal muscles.
- Patients are adviced to use braces which prevent twisting and bending movements and helps in pain relief.

Radicular pain in spondylolisthesis patients occur due to disc bulge or stenosis at the level of foramen. In such patients, conservative treatment is not very much successful and may need long period of non-operative management. If the patients doesn't have neurological symptoms then non-operative management may be carried out for a period of 3 months to 6 months. If they doesn't respond to treatment or symptoms worsen then surgical intervention should not be delayed.

Spinal injections in the form of Epidural steroids, spondylolysis block, Nerve root block are given which helps to inflammation and thus helpful in treating patients with radiculopathy. Pain relief in these patients are temporary or permanent.

Operative treatment

The main objectives of surgical treatment in spondylolisthesis are:

- To stabilise the listhetic segment.
- To stop the progression of slip.
- To maintain the saggital balance by correcting lumbosacral kyphosis and maintaining the lordosis.
- To give relief from back and leg pain.
- To prevent neurological deficits.

Main Surgical Indications in spondylolisthesis are

- When the patient doesn't respond to conservative treatment for a trial of 3-6 months.
- When there is progression of neurological deficits.
- When there is progression of slippage.
- When the patient present with severe radicular and neurogenic claudication pain.
- When the children present with high grade listhesis and severe lumbosacral kyphosis with gait disturbance.

The surgical treatment for spondylolisthesis are pedicle screw stabilization and decompression and fusion. The fusion is done in many ways,

1. Posterolateral fusion(PLF)
2. 2.Interbody fusion - posterior lumbar interbody fusion(PLIF)
    - Transforaminal lumbar interbody fusion (TLIF)
    - Anterior Lumbar interbody fusion (ALIF).

Posterolateral fusion

Watkins in 1953 described a technique which consists of decorticating spinous process, transverse process, pars and facets and application of bone grafts using iliac bone strips over decorticated areas(8). This remains gold standard method for spinal fusion. This fusion rate is around 60-70% in various studies. The main disadvantage of PLF was pseudoarthosis. Pseudarthrosis rates range from 14 to 70%.Reoperation and disability rates are 24% and 25%, respectively. Thus to increase the fusion rates and thereby to decrease the pseudoarthrosis rates and reoperation rates nowadays Interbody fusion is used in spondylolisthesis [9].

This fusion technique is developed to restore the load-bearing capacity and the sagittal plane alignment, and it uses the compressive forces on the bone to increase the fusion rates. The interbody fusion provides immediate stability to postoperatively and also there is wide surface area for contact at the intervertebral space to the graft thus increases rate of arthrodesis. When compared to the posterolateral space, intervertebral space has high vascularity thus increase the chances for solid fusion of graft to form. Interbody fusion maintains the normal height of disc space, lumbar lordosis and sagittal balance in the spine. Interbody fusions can be done anteriorly, posteriorly and Transforaminal route.

Anterior lumbar interbody fusion

Capener described this technique in 1932 mainly for management of spondylolisthesis and surgery was performed extensively and popularised by Lane and Moore. In this disc space is accessed anteriorly through abdominal approach and thorough discectomy and endplate preparation is done. The main advantage is it preserves the posterior elements and there is no damage to a paravertebral muscles. The disadvantages in this technique is due to the abdominal approach which lead on to complications such as retrograde ejaculation in male cases (range, 1-15%) and vessel injuries (range 1-4%). The various studies related to PLIF has shown mean fusion rate of 75% (range, 60-92%).

Posterior lumbar interbody fusion (PLIF)

Jaslow described PLIF in the year 1946 and this technique of fusion is established and made popular by Cloward. In this technique it is more medial and central dissection of all posterior elements in the vertebral level involved and then the dura and traversing and exiting nerve roots are identified and fully retracted carefully to one side and the cage filled with bone graft is inserted into the intervertebral space. In this technique two cages are used and retraction of cord and nerve roots while inserting on either side causes increased chances of root damage and Dural tears which lead on to CSF leakage. The disadvantage in this technique is it needs an extensive decompression centrally to allow cage insertion which destabilizes the spine. As already mentioned due to severe retraction of the cord and roots it lead on to high chances of nerve root damage [10, 11], dural tears, CSF leakage preoperatively and postoperative scarring, risk of cage displacement into the canal. PLIF achieves increased fusion rates and good functional outcome when compared to posterolateral fusion. The fusion rate was 70-80% (range75-85%).

Transforaminal lumbar interbody fusion (TLIF)

This fusion technique was described first by Harms and Rolinger in the 1982. They used cage packed with bone graft which was inserted into intervertebral disc space through transforaminal route and it was termed as "transforaminal lumbar interbody fusion" (TLIF) [14]. In this technique first the pedicle screws are inserted in the involved vertebras and then distraction is done either by lamina spreader or connection rod and then entire facet joint is removed on the side with radicular symptoms. Thus in this approach we remove facet joint on only one side thus we preserve the facts, lamina on opposite side and spinous process. In TLIF the disc space is approached more laterally by removing the entire facet joint when compared to the PLIF, it doesn't require the retraction of cord and thus decreases the chance of dural damage and CSF leak. The nerve root are protected and not retracted too much, thus chances of nerve root injuries are very less. After discectomy and end plate preparation cage filled with graft is placed within the anterior or middle of the disc space, this anterior placement helps to restore the normal lumbar lordosis and saggital balance of the spine.

In most of the cases unilateral facetectomy is enough, in few cases with severe symptoms of bilateral neural compression bilateral facetectomy is performed. After the placement of the cage in correct position, rods are connected and final compression is given which helps to restore the lumbar lordosis while maintaining the restored disc height and increases the chances of fusion. Thus this procedure allows full decompression of the foramen and nerve roots, restoration of intervertebral height, and near-total discectomy and restoration of segmental lordosis at the fused level. The TLIF is derived from PLIF mainly decrease incidence of dural or nerve root injuries. The interbody space has more vascularity than the posterolateral space, hence less potential for a solid fusion mass to form [3, 4]. The added advantage is preservation of the lamina, facet, and pars on the contralateral side which increase the surface area for fusion and increased fusion rates. The various studies has shown mean fusion rate of 89% (range 85-95) [15].

Various studies demonstrated efficacy of TLIF in relation to pain, Yan D *et al* comparing PLIF with TLIF for lytic listhesis the mean VAS score for pain improved from 7.2 to2.8. In another study by Yahya *et al*. of 30 patients the VAS score for low back pain decreased from 7.0 to 2.1 and that for leg pain decreased from 6.4 to 2.0, whereas the ODI decreased from 69.3% to 11.8% [12, 13].

In our study we found the better functional outcome using Transforaminal lumbar inter body fusion. VAS score for low back ache and leg pain was decreased from 10 to 2 (9)and mean ODI score from 63% to 20%.The Modified Macnab's criteria shows Excellent results in 50% of patients, Good results in 31% patients and 19% fair results. This shows dramatic functional outcome in our patients with spondylolisthesis.

Conclusion

- The Transforaminal Lumbar Interbody Fusion is a safe, simpler and less morbid approach with low complication rate.
- It provides better functional outcome by providing pain relief and improving the quality of life in the patients.
- TLIF restores the normal saggital balance of spine and maintains the disc space height.

References

1. Solomon L, Warwick DJ, Nayagam S. editors. The back. In: Apley`s system of orthopaedics and fractures. 8th ed. London: Arnold, 2001, 397.

2. Fredrickson BE, Baker D, McHolick WJ, Yuan HA, Lubicky JP. The natural history of spondylolysis and spondylolisthesis. J Bone Joint Surg Am. 1984; 66:699-707.
3. Kraft CN, Krauspe R. Spondylolisthesis. In: Boos N, Aebi M. editors. Spinal disorders: fundamentals of diagnosis and treatment. Berlin: Springer, 2008, 733-96.
4. Schnee CL, Freese A, Ansell LV. Outcome analysis for adults with spondylolisthesis treated with posterolateral fusion and transpedicular screw fixation. J Neurosurg. 1997; 86:56-63.
5. Zdeblick TA. A prospective, randomized study of lumbar fusion. Preliminary results. Spine (Phila Pa 1976), 1993; 18:983-91.
6. Harms J, Rolinger H. A one-stager procedure in operative treatment of spondylolistheses: dorsal traction-reposition and anterior fusion. Z OrthopIhre Grenzgeb. 1982; 120(3):343-7.
7. Dehoux E, Fourati E, Madi K, Reddy B, Segal P. Posterolateral versus interbody fusion in isthmic spondylolisthesis: functional results in 52 cases with a minimum follow-up of 6 years. Acta Orthop Belg. 2004; 70:578-82.
8. Watkins W. Collective Economy: The International Congress. Annals of Public and Cooperative Economics. 1953; 24(1):9-11.
9. Suh S, Jo Y, Jeong H, Choi W, Kang C. Outcomes of Revision Surgery Following Instrumented Posterolateral Fusion in Degenerative Lumbar Spinal Stenosis: A Comparative Analysis between Pseudarthrosis and Adjacent Segment Disease. Asian Spine Journal. 2017; 11(3):463.
10. Spruit M, Pavlov PW, Leitao J, De Kleuver M, Anderson PG, Den Boer F. Posterior reduction and anterior lumbar interbody fusion in symptomatic low-grade adult isthmic spondylolisthesis: short-term radiological and functional outcome. EurSpine J. 2002; 11:428-33.
11. Kwon BK, Berta S, Daffner SD, Vaccaro AR, Hilibrand AS, Grauer JN, *et al*. Radiographic analysis of transforaminal lumbar interbody fusion for the treatment of adult isthmic spondylolisthesis. J Spinal Disord Tech. 2003; 16:469-76.
12. Yan DL, Pei FX, Li J, Soo CL. Comparative study of PILF and TLIF treatment in adult degenerative spondylolisthesis. EurSpine J. 2008; 17:1311-6.
13. Yehya A. TLIF versus PLIF in management of low grade spondylolisthesis. Bull Alex Fac Med. 2010; 46:127-33.
14. Cole CD, McCall TD, Schmidt MH, Dailey AT. Comparison of low back fusion techniques: transforaminal lumbar interbody fusion (TLIF) or posterior lumbar interbody fusion (PLIF) approaches. Current reviews in musculoskeletal medicine. 2009; 2(2): 118-26. PubMed PMID: 19468868. Pubmed Central PMCID: PMC2697340. Epub 2009/05/27. eng.
15. Lars Hackenberg, Henry FH. Halm, Viola Bullmann, Volker VV. Transforaminal lumbar interbody fusion: a safe technique with satisfactory three to five year results, Published 2004 in European Spine Journal, DOI:10.1007/s00586-004-0830-1
16. Poh SY, Yue WM, Chen LT, Guo CM, Yeo W, Tan SB. Two-year outcomes of transforaminal lumbar interbody fusion. Journal of orthopaedic surgery (Hong Kong). 2011; 19(2):135-40. PubMed PMID: 21857032. Epub 2011/08/23. eng.
17. Steffee Ad, SitkowskiDj. Posterior lumbar interbody fusion and plates. Clin Orthop Relat Res. 1988; 227:99-102.
18. Audat Z, Moutasem O, Yousef K, Mohammad B. Comparison of clinical and radiological results of posterolateral fusion,posterior lumbar interbody fusion and transforaminal lumbar interbody fusion techniques in the treatment of degenerative lumbar spine. singapore medical journal. 2012; 53(3):183-7. pubmed pmid: 22434292. epub 2012/03/22. eng.
19. Fathy M, Fahmy M, Fakhri M, Aref K, Abdin K, Zidan I. outcome of instrumented lumbar fusion for low grade spondylolisthesis; evaluation of interbody fusion with & without cages. asian journal of neurosurgery. 2010; 5(1):41-7. pubmedpmid: 22028742. pubmed central pmcid: pmc 3198657. epub 2010/01/01. eng.
20. Dai LY, Jia LS, Yuan W, *et al*. direct repair of defect in lumbar spondylolysis and mild isthmic spondylolisthesis by bone grafting, with or without joint fusion. eur spine j. 2001; 10:78-83.
21. Cloward RB. The treatment of ruptured lumbar intervertebral discs by vertebral body fusion. indications, operative techniques, international journal of orthopaedics traumatology & surgical sciences. 2016; 2(2):324-329
22. Vijayanand, Balasubramanian, Balajidouraiswami. Sureshsubramani-outcome of transforaminal lumbar interbody fusion in spondylolisthesis—a clinico-radiological correlation, journal of orthopaedics. 2018; 15(2):359-362.
23. Latchoumibady K, Pragash M, Prashanth P. Functional outcome of spondylolisthesis treated by transforaminal lumbar interbody fusion with cage and pedicular screw fixation – a prospective study,international journal of orthopaedics traumatology & surgical sciences, june-november. 2016; 2(2):324-329.
24. Abdul Satar, Muhammad Inam, Waqar Hassan, Muhammad Arif. Functional outcome of transforaminal lumbar interbody fusion (Tlif) for degenerative disc disease and spondylolisthesis of lumbar spine, rmj. 2012; 37(3):288-292.