Research Article

Direct lumber spondylolysis reconstruction by bone grafting and fixation by pedicle screw-rod-laminar hook system: Clinical, radiological and functional assessment.

Nady S. Al Said Al Shwikh, Mohamed A. Ahmed, Khaled O. Thabet and Waleed A. Mohamed
Department of Orthopedic, Faculty of Medicine , Minia University

Abstract
Direct repair of a defect in the pars interarticularis was performed with the use of bone grafting and internal fixation with pedicle screw –rod- laminar hook system in order to achieve a higher prevealance of osseus union than that achieved with commonly used procedures**.** This study was conducted in Minia University Hospital from October 2017 to January 2019, the study included 15 patients (5 males, 10 females) with mean age 26 years old and follow up ranging between 7 to 18 month with averge 9 month**.** Most of cases (60%) had spondylolysis at level L4, (33%) at L5 level and only one patient had multiple level spondylolysis at L3,4,5. The type of spondylolysis were of stress type (isthmic) in 7 patients (46%), traumatic in 5 patients (33%) and degenerative in 3 patients (20%). there were 2 patients (13%) with hamstring tightness that improved postoperatively. The disc status was evaluated preoperatively in all patients to follow the grades of Pffirman classification in our inclusion criteria and it was as follow; the commonest was grade 1 in 53% of patients , grade 2 in 26% and grade 3 in 20% patients that all included in the first 3 grades of pffirman classification . 80% of patients showing grade 0 spondylolithesis and 20% with grade 1 spondylolithesis according to meyerding classification that all are included in our inclusion criteria. Only 2 patients are associated with other injuries in polytrauma patients.

Keywords: Lumbar spine, Spondylolysis, Direct pars repair, Pars interarticularis

Introduction
Lumber spondylolysis (LS) is a bony defect in pars interarticularis of the spine characterized by a chronic disabling problem affecting approximately 6% of populations and manifested by chronic low back pain[1, 2], sometimes radiating to thighs without evident radicular lower limb pain . It occurs most common in L5 pars interarticularis and can be either on one side (unilateral) or on both sides (bilateral) of the spine. This spondylotic defect could accentuate disc degeneration mainly because of disc mobility both above and below the defect[3]. Although pars interarticularis defect is a common radiological finding in the spine [4]

Management of lumber spondylolysis is often by conservative methods and the operative interference which is preserved for symptomatic patients not responding to medical treatment and for those with multiple pars fractures [5]**.**

The concept of pars defect reconstruction was reported by kimura 1968[6] and became an alternative to in situ segment spinal fusion .The goal of this reconstruction is to obtain the consolidation of the isthmus , so different osteosynthesis techniques such as translaminer screw fixation, cercelage wiring loop, pedicle screw-rod hook system, rod – screw construct … were developed[4]**.**

Deguchi et al.,[7] compared the biomechanics performance of these various fixation techniques and found that the pedicle screw rod laminer hook system brings a biomechanical advantage for pseudoarthrosis fusion (great stability to the defect during motion)

Repair of pars interarticularis defect by bone grafting (reconstruction) and fixation is preferred and appear more logical and less aggressive than in situ spinal fusion for symptomatic patients with lumber spondylolysis[4].

Also reconstruction of pars defect is a motion preserving technique allowing maintainance of the spinal motion even over the spondylotic level and consequently permit early rehabilitation of the patient and return of daily activities[8] .

Patients and Method

This prospective study was conducted on 15 patients with symptomatic lumber spondylolysis treated by reconstruction of pars defect using bone graft and fixation by pedicular screw rod laminar hook system in Minia University Hospital from October 2017 to January 2019.

Informed consent was obtained from the patients following the rules of our local medical ethical committee.

Inclusion criteria

1- Patients aged 15-40 years
2- Pars interarticularis defects either non healed traumatic or non traumatic (degenerative or lytic type)
3- Symptomatic patients not responding to medical treatment more than 6 months
4- Patients with the ability to ambulate without assistance before injury.
5- Patients with spondylolithesis(≤Meyerding grade 1) and MRI T2 based disc status grade 1,2 and 3 according to Pfirrmann classification

Exclusion criteria .

1- Associated disc degeneration (> grade 3 of Pfirrmann).
2- Associated spondylolythesis (> Meyerding grade 1).
3- Medically unfit patients.
4- Non compliant patients.

The study included 15 patients (5 males, 10 female) with mean age 26 years old and follow up ranging between 7 to 18 month with averge 9 month. Most of cases (60%) had spondylolysis at level L4, (33%) at L5 level and only one patient had multiple level spondylolysis at L3,4,5. The type of spondylolysis were of stress type (isthmic) in 7 patients (46%), traumatic in 5 patients (33%) and degenerative in 3 patients (20%) . there were 2 patients (13%) with hamstring tightness that improved postoperatively.

The disc status was evaluated pre-operatively in all patients to follow the grades of Pffirman classification in our inclusion criteria and it was as follow; the commonest was grade 1 in 53% of patients, grade 2 in 26% and grade 3 in 20% patients that all included in the first 3 grades of pffirman classification.

80% of patients showing grade 0 spondylolithesis and 20% with grade 1 spondylolithesis according to meyerding classification that all are included in our inclusion criteria. Only 2 patients are associated with other injuries in polytrauma patients.

Operative interference

Complete surgical fitness was done to the patients to decide whether the patients were candidate for surgery or not. Preoperative 1 gm. 3rd generation cephalosporines was given to all patients 1 hour before surgery.

Under general and hypotensive anesthesia, all patients were underwent reconstruction of pars defect and internal fixation .

1- Patient positioning: The patients were placed in prone position on a radiolucent table over spinal frame supporting chest and pelvis so that the anterior abdominal wall clears the table reducing intraoperative bleeding

2- Surgical incision: Midline posterior incision was done over the affected vertebra .The incision was extended proximal and distal according to planned level to be operated . C-arm was used to locate the affected vertebra.

3- Superficial and deep surgical dissection:

- Palpation of the individual spinous processes, continuing subperiosteal dissection down to the middle of spinous processes and move the muscle origins to either side of the surface by using Cobb elevator.

- Para spinal muscles were subperiosteoly elevated from the spinous processes and partially from the laminae by sub periosteal dissection, and then keep the dissection open by using self –retaining retractors.
- Using Cobb elevator to elevate the short rotators from the base of spinous processes and laminae. Then stripping the muscles from the rest of the laminae till transverse processes specially cases with multi level lumber spondylolysis to detect the starting point for pedicular screw insertion.
- The muscles were cleared without disturbing facet capsule to reduce incidence of degeneration. Bleeding was secured by proper hemostasis using diathermy.

The implants used:

- titanium standered pedicle screw (mono axial or polyaxial) with size 6.2 mm.
- Laminer hook of different sizes (6.5, 8mm).
- Rod with bending at inclination angle 90 to 120 degree.

4- Insertion of pedicle screws

The projection of the lumbar pedicle was used to determine the entry points for pedicle fixation. Without opening the spinal canal, the following landmarks should be recognized for proper identification of the pedicle:

- The midline of the transverse process corresponding to the middle of the pedicle.
- The zygapophyseal joint line, which gave the most medial entry point of the pedicle screw insertion.
- The mamillary process of the lumbar vertebra or the lateral side of the superior articular facet.
- The accessory process at the base of the transverse process.
- The lateral side of the pars interarticularis marked by a bony ridge joining the lamina, the transverse process, and the superior facet.
- A rongeur was used to decorticate the bone over the mammillary process, Insertion of awl into the pedicle, and advance it through the pedicle; monitor the path of the probe with postero-anterior and lateral C-arm images.
- Removing the probe after the vertebral body was entered and confirmtion of the continuity of the pedicle wall with a small ball-tipped probe, probe the pedicle in all four quadrants to ensure that it in the pedicle, and there is no violation into the spinal canal or inferiorly into the neuroforamen has not occurred, tap the pedicle and vertebral body to at least one half of the depth of the vertebral body using a tap for a screw diameter chosen from preoperative pedicle measurements, insert a pedicle screw with a polyaxial head.

5- Identification of the lamina:

Ligamentum flavum was dissected from the undersurface of lamina to become free from yellow ligament and allow easy insertion of the hooks to under surface of corresponding lamina of the spondylotic level in proper size and trajectory.

6- Identification of the pars defect and removal of all pseudoarthrosis tissue using high speed bar, nippler and refreshment of the edges of the defect till obtaining fresh bloody edges then measurement of the size of the defect is mandatory to determine the size of graft used .

7- Harvesting of corticocancellous bone graft from iliac crest at the same side from the same incision through the lumber fascia with a size suitable for the defect in each case.

8- Rod is prebent at certain angle (90-120) to be adjusted for both pedicular screw and hook, in case of multiple level spondylolysis repair rod bending was better at heigher obtuse angles (120-130).

9- Impaction and incorporation of the bone graft into the pars defect to allow osteo integration .

10- The hook–rod complex was inserted and impacted and it was joined to the screw head then axial compression of the hook towards the screw through the rod and the construct was then loaded with by means of a secured hook compressor (to avoid subluxation of the posterior facet joint) and to allow impaction and

compression of bone block graft into the lamina and pediculolaminar junction.

The good positioning of the implants was checked by intraoperative radiography, stability of the construct was checked intraoperatively by holding the construct to test the mobility of construct and posterior lamina after fixation and tightness.

Wound closure:

Closure of the wound was done in layers and there was no need for suction drain insertion in our cases after good heamostasis .

Intraoperative complications and difficulties

1- In case of multiple level spondylo-lysis there were some difficulties that were faced in our operation and over comed as hemostasis due to wide area of dissection and adjustment of rod bending in the different levels in certain obtuse angles to avoid metal contact.

In cases with associated injuries such as fracture vertebra at a higher level or other sites as fracture tibial plateau, after stabilization of the general condition of the the patient and exclusion of the life threatening conditions of the patient at the emergency room, the fracture vertebra was operated at time of presentation and other injuries then pars repair by screw rod hook system.

All patients were followed closely; clinical examination and radiographies were performed one month, three months, 6 months, 9 months and one year after operation.

1- Pain assessment: by Visual Analogue Score (VAS) for back pain at preoperative time, 2 weeks postoperative time and during the follow up .

2- Radiological assessment:

- Plain x-ray (2 perpenicular views: AP, Lateral)
- MDCT (healing time in each case)

A Computed Tomography (reverse gantry angle and thin section) was done at the last visit to check the fusion of the pars interarticularis. It was considered to be present when trabeculae across the lytic and the bone-grafted area was observed in at least three consecutive CT scan cuts.

3- Functional assessment:

1- Modified Prolo Score
2- Macnab Criteria
3- Oswestry disability index (ODI)

Results

- **Age**

The results revealed that mean age of patients was 26.47+6.97 as shown in table (1) .

Table (1): showing distribution of age of patients

Age	
Range	15-40
Mean± SD	26.47 ±6.97

- **Sex**

Sex distribution was more increased in females than males as shown in table(2).

Table (2): showing sex distribution

Sex	**N**	**%**
Female	10	66.7
Male	5	33.3
Total	15	100.0

- **Follow up**

The mean follow up period was9.47±3.07 months (range 7-18 month) as shown in table (3)

Table (3): showing range and mean follow up of patients

Follow up	
Range	7-18
Mean± SD	9.47±3.07

- **Clinical evaluation:**

Evaluation of results of postoperative lower limb radicular pain and hamstring tightness

There were **2** patients with preoperative lower limb radicular pain (one on rt. side and the other on lt. side) that improved postoperatively.

There were no patients developed postoperative hamstring tightness while there were **2** patients with preoperative hamstring tightness that improved postoperative .

Table (4): showing changes of radicular lower limb pain pre and postoperatively

radicular LL pain	**Pre**		**Post**	
	N	%	N	%
No	13	86.7	14	93.3
Yes	2	13.3	1	6.7
Total	15	100.0	15	100.0

Table (5): showing changes of hamstring tightness pre and postoperatively

Hamstring tightness	**Pre**		**Post**	
	N	**%**	**N**	**%**
No	13	86.7	15	100.0
Yes	2	13.3	0	0.0
Total	15	100.0	15	100.0

Evaluation of results of low back pain according to VAS score:

The mean VAS value changed from 6.27 ± 0.80 preoperatively to 1.20 ± 0.41 at final follow up with significant difference between both (P<0.001)

Perioperative outcomes :

The blood loss in all patients ranged from 200-500 cc with mean 261.33±98.77. It was increased in cases of multiple level spondy-lolysis and associated fracture vertebra.

The operative time ranged from 80 to 180 min. with mean 97.67±25.63. It was increased in cases of multiple level spondy-lolysis and associated fracture vertebra.

The hospital stay ranged from 3 to 11 days with mean 4.40±2.06. It was increased in cases with associated injuries.

Copmplications:

The complications reported in this study were found in 2 patients, one of them

developed postoperative lower limb radicular pain on one side due to medial breaching of the pedicular screw on the canal and it was revised 10 days later and the position of the pedicular screw was corrected and she was relieved from radiculopathy, the other patient had superficial wound infection which resolved after debridment.

Radiological outcome:

Union time

The mean union time was 4.5 month with range (4-6 month), 6 patients in this study showed union at 4 months after pars reconsruction, 8 patients with union at 5 month and one patient at 6 months.

Functional outcomes:

1- Oswestry disability index

The mean ODI value changed from 47.00 ± 9.22 preoperatively to 5.67 ± 1.76 at final follow up with significant difference between both (P<0.001)

2- Modified Prolo score

The mean Modified prolo score value changed from 9.87 ± 3.62 preoperatively to 19.47±0.74 at final follow up with significant difference (P<0.001).

3- Macnab critreria

Results of Macnab criteria were excellent in 10 patients (66.7%) and good in 5 patients (33.3%) with patients satisfaction

4- Return to activity

Patients returned to activity within 4 to 6 months with mean 5.47 ± 0.9.

- **Correlation**

Correlation between final VAS score , ODI and modified prolo score during follow up there was significant strong positive correlation between final VAS and final ODI (r=0.784, P<0.001, while the correlation was significant moderate negative between final VAS and final Mpfes (r = -0.557, p=0.031) and significant strong negative between final Mpfes and final ODI (r = -0.801, P<0.001)

Discussion

Spondylolysis refers to a defect of the pars interarticularis of the vertebrae, it can be found at any level of the spine but the most common vertebrae involved are L4 and L5[4] .

Single level spondylolysis is a common presentation among young patients and its reconstruction after failure of conservative management using pedicular screw rod laminar hook system brings a satisfying results and totally relieved back pain [4].

This lesion is frequently asymptomatic and heals without treatment (spontaneous healing of the defect). Hypermobility of the loose posterior arch with stimulation of the defective tissue and relative instability of the vertebral body that induces excessive stress in the underlying disk can account for the symptoms. Likewise, fusion failure of this fracture (pseudarthrosis) can also cause comp-laints; neural elements (nociceptive nerve endings) are found in the pars defect tissue[10] . Conservative measures are successful in most patients(rest, bracing, physical therapy, temporary restriction of activity, analgesia, infiltration); the surgery must only be considered when these treatments fail (attempt of at least 6 months) [4] .

Fusion of the involved level has been widely accepted as the treatment of syptomatic spondylolysis with or without degenerative disc signals and spondylolisthesis. But, some investigators believe that lumbar fusion may lead to a significant acceleration of degenerative lesions at adjacent levels [5].

This study differs from Johnson and Thompson (1992) [8] who treated patients with lumber spondylolysis using scott wiring technique regarding more number of patients (22 patients) with longer follow up period (4 years) and macnab criteria as they reported 20 patients with good results and 2 patients had poor results[8] .

Rajasekaran et al., 2011[11] used bucks procedure and these results disagree with their study as they had less number of patients (9 patients), cases with unilateral level spondylolysis, longer follow up (45months), more union time (10 months) and no recorded complicayions in their

study, while this study coincides with Rajasekaran et al., regarding clinical and functional outcome with good and excellent results according to macnab criteri [11] .

The study of Zhou et al.. (2013)[12] who used the same technique with grafting disagree with these results in having more cases (22) , more males , more L5 level spondylolysis , longer follow up (12-45 m) and no reported complications while these results coincide with Zhou et al.,. in the satisfactory outcome with good results according to (VAS, ODI scores) [12].

Karatas et al.,.(2016)[13] compared direct pars repair pars compression screw (9 patients) versus pedicle screw rod hook (7 patients), these results disagree with karatas et al., study as they have lower mean age (15.8 years), less number of cases operated (7 patients), more cases with L5 spondylolysis, less cases of spon-dylolithesis (one case grade 1), longer follow up period in their study and regarding complications they recorded more cases of superficial wound infection and one patient with mild sensory deficit while this study coincides with karatas et al.,. in mean union time (5-6 months)and clinical evaluation as they reported excellent results of macnab criteria in both groups [13].

Snowdan and sasso (2019)[14] reported a new technique with using pedicular screw and laminar screw construct. In com-paring these results with Snowdan and sasso, they differ in less cases (6), limited age less than 25y, excluded any degree of disc degeneration with no reported complications. They used iliac crest bone graft in 3 cases and (master graft + bone morphogenic protein) in the other 3 cases with evidence return to activity earlier in the last 3 cases with (master graft + bone morphogenic protein) at 4 months while the cases used iliac crest bone graft showed return to activity at 4,7,8 months [14].

Our results don't go in line with snowdan and sasso results due to different surgical technique used.

It was found that this technique is highly dependent on the thickness of lamina for better stability of the laminar screw without failure or backout and in need of high surgen experience for optimal entery of laminar screw with less trials to avoid laminar damage.

References

1- Noggle, J.C., D.M. Sciubba, A.F. Samdani, et al., 2008 Minimally invasive direct repair of lumbar spondylolysis with a pedicle screw and hook construct. Neurosurgical focus. 25(2): p. E15.

2- Nourbakhsh, A., F. Preuss, M. Hadeed, et al., 2017 Percutaneous direct repair of a pars defect using intraoperative computed tomography scan: a modification of the Buck technique. Spine. 42(11): p. E691-E694.

3- Mihara, H., K. Onari, B.C. Cheng, et al., 2003 The biomechanical effects of spondylolysis and its treatment. Spine. 28(3): p. 235-238.

4- Debusscher, F. and S. Troussel, 2007 Direct repair of defects in lumbar spondylolysis with a new pedicle screw hook fixation: clinical, functional and Ct-assessed study. European Spine Journal. 16(10): p. 1650-1658.

5- Hensinger, R.N.,1989 Spondylolysis and spondylolisthesis in children and adolescents. JBJS. 71(7): p. 1098-1107.

6- Kimura, M.,1968 My method of filing the lesion with spongy bone in spondylolysis and spondylolisthesis. Seikei Geka. 19: p. 285-296.

7- Deguchi, M., A.J. Rapoff, and T.A. Zdeblick,1999 Biomechanical comparison of spondylolysis fixation techniques. Spine. 24(4): p. 328-333.

8- Johnson, G. and A. Thompson,1992 The Scott wiring technique for direct repair of lumbar spondylolysis. The Journal of bone and joint surgery. British volume. 74(3): p. 426-430.

9- Ghobrial, G.M., K.M. Crandall, A. Lau, et al., 2017 Minimally invasive direct pars repair with cannulated screws and recombinant human bone morphogenetic protein: case series and review of the literature. Neurosurgical focus.43(2):p. E6.

10- Rajasekaran, S., M. Subbiah, and A.P. Shetty, 2011 Direct repair of lumbar spondylolysis by Buck's technique.

Indian journal of orthopaedics. 45(2): p. 136.

11- Zhou, Z., Y. Song, J. Zeng, et al., 2013 Effectiveness of posterior intrasegmental fixation with pedicle screw-lamina hook system in treatment of lumbar spondylolysis. Zhongguo xiu fu chong jian wai ke za zhi= Zhongguo xiufu chongjian waike zazhi= Chinese journal of reparative and reconstructive surgery. 27(3): p. 274-277.

12- Karatas, A.F., O. Dede, A.A. Atanda, et al., 2016 Comparison of direct pars repair techniques of spondylolysis in pediatric and adolescent patients: pars compression screw versus pedicle screw-rod-hook. Clinical spine surgery. 29(7): p. 272-280.

13- Snowden, R. and R. Sasso, 2019 Repair of Pars Interarticularis Defect Utilizing a Pedicle and Laminar Screw Construct: A Technique Discussion and Case Series. Techniques in Orthopaedics: p. 1.