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Outcomes of Direct Lumbar Spondylolysis Reconstruction by Bone Graft and Fixation Using Pedicular Screw Rod Laminar Hook Construct

Khaled Omran, MD., Mohamed A Ahmed, MD.

Orthopedic Surgery and Traumatology Department, Faculty of Medicine, Minia University, Egypt.

ABSTRACT

Background Data: Lumbar spondylolysis is often managed by conservative methods in most patients. Operative interference is indicated in symptomatic patients not responding to medical treatment or patients with multilevel pars defect.

Purpose: To evaluate the clinical, functional, and radiological results of bone graft and pedicular screw fixation and rod laminar hook construct in treatment of lumbar spondylolysis.

Study Design: A prospective clinical case cohort study.

Patients and Methods: Between October 2017 and January 2019, fifteen patients with symptomatic lumbar spondylolysis not responding to conservative treatment for more than 6 months were treated by reconstruction of pars defect by bone block autografting and fixation using pedicular screw laminar hook construct. The mean follow-up was 9.47±3.07 months. All patients were examined pre- and postoperatively and they were followed up clinically; for measuring their pain scale, Visual Analogue Scale (VAS); functionally, Oswestry Disability Index (ODI); radiologically (pars defect healing). Perioperative outcomes and complications were documented.

Results: Clinical, radiological, and functional outcomes were significantly improved. Bony union was evident in all patients (100%). Blood loss, operative time, and hospital stay were reported. Two cases reported complications in this study: misplaced pedicular screw and superficial wound infection.

Conclusion: Direct reconstruction of pars defect by bone graft and fixation using pedicular screw rod laminar hook construct is an effective feasible procedure in treating lumbar spondylosis. It preserves lumbar motion and hence may decrease adjacent segment problems. (2019ESJ194)

Keywords: Lumbar spondylolysis; Pedicular screw laminar hook rod construct; Pars defect.

Address correspondence and reprint requests: Khaled Omran, MD.
Orthopedic Surgery and Traumatology, Faculty of Medicine, Minia University, Egypt.
Email: khaled.omran@mu.edu.eg

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INTRODUCTION

Lumbar spondylolysis (LS) is a bony pars defect characterized by a chronic low back pain that could be disabling and sometimes refers to pain in posterior thighs. It affects approximately 6% of the population with incidence of 11.5%.[7,14,15] Although pars interarticularis defect is a common radiological finding in the spine, its discovery is often fortuitous.[3] L5 pars defect is the commonest affected segment. This spondylolytic defect could accentuate disc degeneration mainly because of disc mobility both above and below the defect.[3] Pars infiltration block is useful to detect if the defect is the main source of pain or not.[25,28] On the contrary, Wald et al.[26] found that CT guided chronic pars defect injection was beneficial in 38% of patients with pain relief up to 2 months.

The concept of pars defect reconstruction involves the consolidation of the isthmus by different osteosynthesis techniques and became an alternative to in situ segmental spinal fusion.[3,24,27] On the other hand, Westacott et al.[26] revealed little clinical difference between pars repair and fusion techniques. The advantage of this procedure is preservation of motion over the spondylolytic level in young patients taking into consideration the disc status in Magnetic Resonance Imaging (MRI) finding. It also permits early rehabilitation and return of daily activities. Moreover, it avoids adjacent segment degeneration after in situ fusion.[7,9,10,12]

This study research aims to assess clinical, radiological, and functional outcomes of pars interarticularis defect reconstruction-fixation using pedicle screw rod laminar hook system and identification of drawbacks and difficulty of this procedure.

PATIENTS & METHODS

This prospective study was conducted on 15 patients, 5 males and 10 females with mean age 26.47±6.97 (range, 15–40) years. Patients had symptomatic lumbar spondylolysis treated by pars defect reconstruction using bone graft and fixation by pedicular screw rod laminar hook system from October 2017 to January 2019. All patients underwent operation at our institution, Orthopedic Surgery and Traumatology Department, Faculty of Medicine, Minia University. Informed consent was obtained from the patients following the rules of our local medical ethical committee. Patients were followed up for 9.47±3.07 (range, 7–18) months.

Inclusion criteria included patients between the ages of 15 and 30, pars interarticularis defects either traumatic or lytic type, symptomatic patients not responding to medical treatment for more than 6 months, patients able to ambulate without assistance before injury, patients with spondylolisthesis (≤ Meyerding grade 1), and MRI T2 based disc status grades 1, 2, and 3 according to Pfirrmann classification.[18] Patients with associated disc degeneration (> grade 3 of Pfirrmann), the ones with associated spondylolisthesis (> Meyerding grade 1), medically unfit patients, and asymptomatic patients were excluded from the study.

Clinical Assessment. All patients were preoperatively examined for low back pain which was mechanically disabling and evident in all of them. Intensity of low back pain was assessed using VAS: 0 being the least and 10 the severest. Posterior thigh pain was evident in 2 (13.3%) patients (one on the right side and the other on the left side). Tightness of hamstring was present in two patients (13.3%). Two patients (13.33%) were associated with other skeletal injuries (polytrauma patients), such as concomitant vertebral fracture and lower extremity injuries

Functional Assessment. Oswestry Disability Index (ODI) was evaluated in preoperative, postoperative, and final follow-up state in all patients.

Radiological Assessment. Plain X-ray (anteroposterior, oblique, and lateral views in flexion and extension) and Multislice Computed Tomography (MSCT) (cuts 2 mm, 4 mm, and 6 mm) were performed

for all cases. The state of the adjacent disc was assessed by T2-weighted MRI and was classified according to the Pfirrmann criteria.[18]

The radiological examination revealed that nine (60.0%) patients presented with L4 spondylolysis and six (40%) patients with L5 spondylolysis (Table 1). Based on the type of pars defect and MRI grading of disc status according to Pfirrmann classification[18], ten patients (66.7%) presented with isthmic type spondylolysis (disc status grade 1 was present in 6 cases, grade 2 in one case, and grade 3 in 3 cases); five patients (33.3%) were traumatic in origin due to indirect trauma like fall from height (disc status grade 1 in 2 cases and grade 2 in 3 cases). Grade 1 spondylolisthesis was evident in three patients (20.0%) according to the Meyerding classification.

Surgical Technique

Patients were laid in prone position on the radiolucent table under general anesthesia. Posterior midline incision was performed over the affected level after their confirmation using C-arm. Paraspinal muscles were subperiosteally dissected from the midline laterally towards the facet joint without disruption of facet capsules to detect the starting point of bilateral pedicular screw insertion at the affected vertebrae. Sublaminar dissection of ligamentum flavum was performed to make the undersurface of involved lamina free from yellow ligament to facilitate easy application of hooks to lamina and ensure the proper sized laminar hooks (6.5, 8 mm).

The next step was detection of pars defect (pseudoarthrosis) which is important for excision of fibrous tissue between distal remnant of lamina and proximal pediculolaminar junctions to reach the sclerotic edge of pars defect and to become devoid of any fibrous or cystic tissue from dorsal to ventral aspect of pars towards the disc; then decortication of sclerotic defect edges was done mandatorily using high-speed burr, small Kerrison, and rongeur to make fresh bleeding bony edges. Measurement of pars defect after its cleaning and decortication was done to determine the required size of bone graft block for reconstruction of isthmus of pars. Harvesting of the measured corticocancellous bone graft block from posterior iliac crest was performed from the same incision to be impacted and incorporated in the pars defect.

The bending rod (120–130°) was applied in direction of laminar inclination, connected to sublaminar hooks and pedicular screws; axial compression between hook and pedicular screw among bending rods is essential to give more compression between lamina, bone graft, and pediculolaminar junction (isthmus) to enhance impaction and healing. Finally, tightening was applied to hooks and pedicular screws. Intraoperative mechanical stability was checked. Closure of the wound was performed in layers (Figures 1 and 2).

*Postoperative Course and Outcomes***.** Parenteral IV antibiotics (3rd-generation cephalosporin) were given for 3 days; then, oral antibiotics were continued until removal of stitches. Postoperative and follow-up plain radiographs were done to assess alignment, implant or graft placement, and pars healing. Patients started walking on the third postoperative day. Bracing was maintained for 2 weeks postoperatively until removal of stitches. Two weeks after surgery, patients were permitted to flex the spinal column to help early active mobilization of spinal segments (active exercise of spinal musculature) and enhance pars defect graft compression osteointegration. Operative time, blood loss, hospital stay, and intraoperative difficulty were recorded. Plain radiograph, pain, and functional indices (VAS and ODI) were assessed at one, 3, 6, and 9 months and one year after surgery.

Statistical Analysis

Data were collected, revised, verified, coded, and then entered on PC for statistical analysis done by using SPSS statistical package version 20. Descriptive statistics for qualitative data are expressed by number (N) and percentage (%), while those for quantitative data are expressed by mean (X~) and Standard Deviation (SD). Normally distributed variables (parametric) were

analyzed using paired-sample *t*-test for comparison of quantitative data. Not-Normally distributed variables (nonparametric) were analyzed using McNemar test. For all tests, probability (p) was considered: (nonsignificant, if P≥0.05; significant, if P<0.05; highly significant, if P<0.01; very highly significant, if P<0.001). Linear correlation coefficient test for detection of correlation between 2 quantitative variables (r<0.24, weak; r=0.25–0.49, fair; r=0.5–0.74, moderate; r=0.75–1, strong).

RESULTS

The results revealed that mean age of patients was 26.47±6.97 (range, 15–40) years and sex distribution was more increased in females than males (10 females and 5 males). The mean follow-up period was 9.47±3.07 months (range, 7–18 months) (Table 1).

Perioperative Outcomes. The blood loss, hospital stay, and operative time were estimated in all cases (Table 2).

Radiological Outcomes. The mean union time was 4.5 months with range of 4–6 months: 6 patients showed union at 4 months, 8 patients with union at 5 months, and one patient at 6 months.

Clinical Outcomes. Regarding back pain, the mean VAS value significantly declined from 6.27±0.80 preoperatively to 1.20±0.41 at final follow-up (P<0.001) (Graph 1). Both patients with preoperative referred posterior thigh pain and hamstring tightness improved postoperatively and no postoperative hamstring tightness was noticed in any of our patients (Table 1).

Functional Outcomes. The mean ODI value significantly decreased from 47.00±9.22 preoperatively to 5.67±1.76 at final follow-up (P<0.001). Patients returned to activity within 4 to 6 months with mean 5.47±0.92 (Table 1) (Graph 1).

A significant strong positive correlation was found between final VAS and final ODI (r=0.784, P<0.001 as shown in Graph 2).

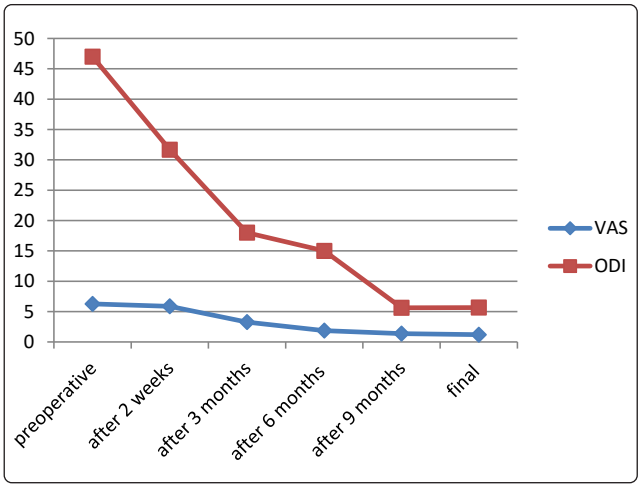
Complications. Two patients had a complication in this study: one of them developed postoperative lower limb radicular pain on one side due to medial breaching of the pedicular screw on the canal and was revised 10 days later to correct the position of the pedicular screw and she was relieved from radiculopathy; the other patient had superficial wound infection which resolved after debridement.

Table 1. Summary of demographic and clinical data.

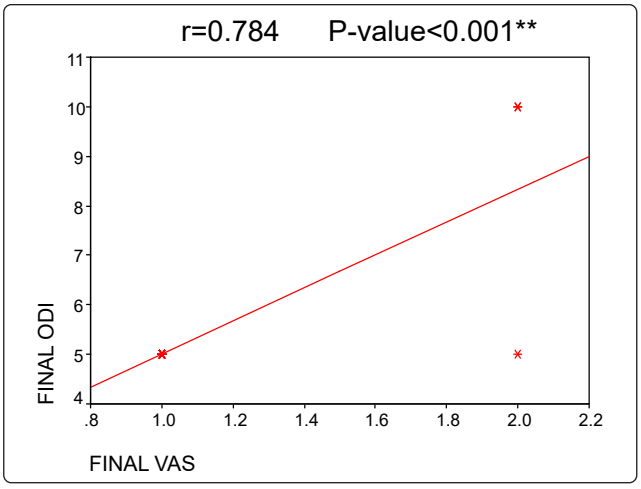
Parameters		Results
Age (years)		26.47±6.97 (15–30)
Sex	Female Male	10 (66.7%) 5 (33.3%)
Referred posterior thigh pain	Pre Post	2 (13.3%) 1 (6.7%)
Hamstring tightness	Pre Post	2 (13.3%) 0 (0%)
Operated levels	L4 L5	9 (60%) 6 (40%)
Follow-up (months)		9.47±3.07 (7-18)

Table 2. Summary of perioperative data.

Parameters	Results
Blood loss (cc)	261.33±98.77 (200–500)
Operative time (minute)	97.67±25.63 (80–180)
Hospital stay (day)	4.40±2.06 (3–11)
Complications	2 (13.3%)



Graph 1. Changes in VAS and ODI scores.



Graph 2. Correlation between final ODI and VAS score.

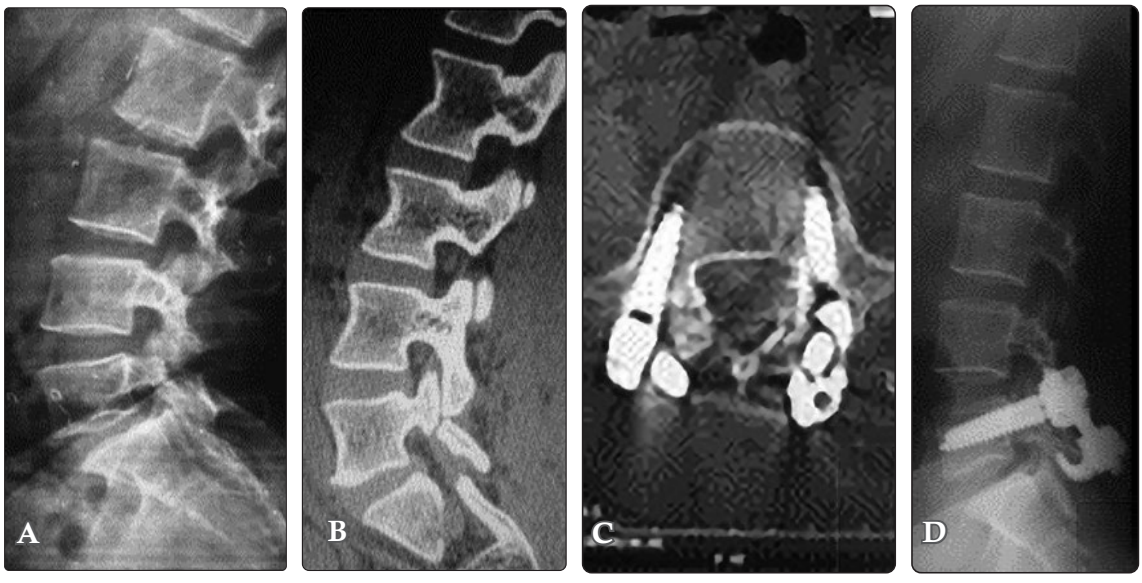


Figure 1. A 24-year-old female patient presenting with low back pain persistent for one year and not responding to medical treatment. (A) Plain radiograph and (B) MSCT-scan showing L5 spondylolysis. Pars reconstruction was done using screw rod laminar hook system. (C) Postoperative axial CT scan showing screw purchase. (D) Plain lateral view radiograph 6 months postoperatively showing healing pars.

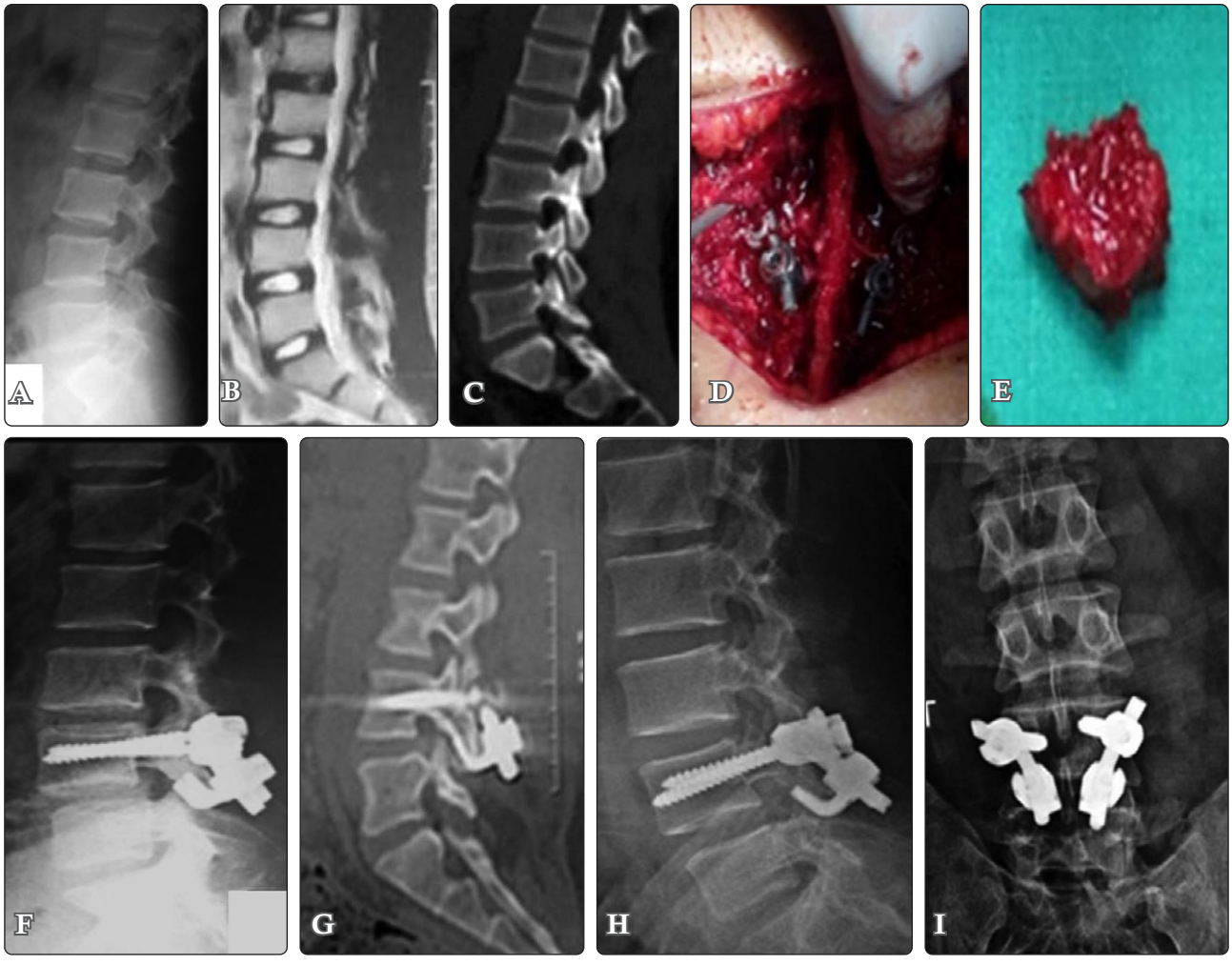


Figure 2. **A** 15-year-old male patient with persistent low back pain. Preoperative (A) plain lateral view radiograph showing L4 pars defect. (B) Sagittal T2 WI MRI showing intact disc space. (C) MSCT-scan sagittal reformate showing L4 pars defect. (D) Intraoperative photo demonstration of the procedure. (E) Iliac crest graft used. (F) Postoperative lateral radiograph. One year postoperatively, (G) MS SC-Scan sagittal reformats. (H) Lateral radiograph. (I) Anteroposterior radiograph showing pars healing.

DISCUSSION

Pars defect reconstruction is concentrated on the hypermobility painful area of spondylolysis in the posterior vertebral arch.[16] Pedicular screw laminar hook rod construct has more stiffness and rigidity than the other methods of fixation such as Buck's procedure[2] and the sublaminar Scott wiring cerclage[13] without hazards and complications.

This construct permits early mobilization to promote healing process as flexion at tension surface (lamina) of operated segment allows more compression of the sublaminar hooks holding the lamina towards corticocancellous graft and isthmus like tension band principle of internal fixation. This coincides with Deguchi et al.[4] and Fan et al.[5] who found that this construct allowed the least motion across the defect during flexion and provided more rigidity during rotation than either Scott's or Buck's technique. Bending rod in coronal laminar inclination in this study provided more rigidity and rotational stability than straight rod as described in the previous literature.

Roca et al.[20] disagree with this study regarding absence of bone grafting and longer follow-up

period (24–48 m) with difficult evaluation of union. They found better results in patients who are less than 20 years old than those older than 20 years. Unlike our results, it was revealed that 13 patients who were over 20 years had satisfactory results (good and excellent) and this is giving attention to the role of bone block grafting in union and satisfactory results at different age groups.

Our results reported better pain and functional scores than Debusscher and Troussel[3]. Additionally, they reported pseudoarthrosis in 2 cases which is due to the patient's age, disc status, and the broad defect. Five cases who were over 30 years and 7 cases with disc status of more than grade 1 had favorable outcomes regarding union and functional data in this study. Regarding the broad defect, it was overcome by its reconstruction utilizing measured iliac bone graft block according to the size of pars defect; however, union time was about 6 months in both studies.

Rajasekaran et al.[19], and Karatas et al.[11] agree with the present data regarding acceptable outcomes of pain and functional indices. Moreover, our complications are in line with Karatas et al.'s[11] study that recorded one patient with mild sensory deficit.

Data of Ryan and Rick[23] did not coincide with this study as they included limited age groups (less than 25 years) and excluded any degree of disc degeneration with no reported complications. This disagreement may be attributed to different surgical techniques 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, the need of surgeon skills, and experience for optimal entry of laminar screw with fewer trials to avoid laminar damage or screw loosening.

Noggle et al.[14] and Ghobrial et al.[8] studies had similar clinical outcome to ours with no restriction of activities after a period of physical therapy. They also recommended that open technique is more feasible and preferred over minimal invasive surgery regarding better visualization, pseudoarthrosis debridement, and optimal insertion-adjustment of the bending rod connecting pedicular screw with hook or compression lag screw.

Radiological union was better in this series than Fayed et al.[6] despite different fracture morphology. This may be due to bone graft block augmented by compression and rigidity of pedicular screw rod hook system. The superiority of this construct versus lag compression screw was clear even in the irregular comminuted fracture.

Multilevel LS is an unusual presentation; incidence varied between 1.2% and 5.6% of LS cases; the majority of the cases involved two levels (L4 and L5). To the best of our knowledge, just 11 cases with multilevel LS were documented in the literatures.[21,22] Sharfi et al.[22], Peng et al.[17], and Arai et al.[1] described similar cases who had three levels lumbar pars defect and were treated using a similar procedure with excellent results concerning union, pain disappearance, and functional recovery. This reconstruction acted as multiple separate anchors points maintaining normal motion which is better than spinal fusion.

Fracture pars interarticularis may be missed in polytrauma patients with concomitant higher-level spinal fractures and it is better to be reconstructed especially if spine fixation is going to be done on another or adjacent level to avoid stress loading on the affected segment, slippage progression, and acceleration of degeneration in future.

This study included small number of patients with short-term follow-up period; postoperative follow-up MRI should be done in future studies to evaluate disc status after pars healing especially in cases with Pfirrmann[18] grade III involved in the current study. These points are considered to be limitations of the study needing future considerations.

CONCLUSION

Direct reconstruction of pars defect by bone graft and fixation using pedicular screw rod laminar hook construct is an effective feasible procedure in treating lumbar spondylosis. It preserves lumbar

motion, hence decreasing adjacent segment problems.

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الملخص العربي

نتائج إعادة البناء المباشر للانحلال الفقاري القطني المباشر بواسطة الترقيع العظمي وتثبيته باستخدام نظام المسمار العنقي والقضيب الفقاري وخطاف الصفائح الفقارية

البيانات الخلفية: غالبًا ما تتم معالجة تحلل الفقار الفقري بالطرق المحافظة أو التداخل الجراحي الذي يتم استخدامه للمرضى الذين يعانون من أعراض ولا يستجيبون للعلاج الطبي والحالات التي بها عيب متعدد المستويات.

الغرض: الهدف من هذه الدراسة هو تقييم النتائج السريرية والوظيفية والإشعاعية لاستخدام الترقيع العظمي والتثبيت بواسطة نظام المسمار العنقي والقضيب الفقاري وخطاف الصفائح الفقارية في علاج الانحلال الفقاري القطني.

تصميم الدراسة: دراسة سريرية مستقبلية.

المرضى والطرق: بين أكتوبر 2017 ويناير 2019 ، تم علاج خمسة عشر مريضا يعانون من انحلال الفقاري القطني العرضي لا يستجيبون للعلاج التقليدي لأكثر من 6 أشهر عن طريق إعادة بناء عيب (pars) بواسطة التطعيم الذاتي للكتل العظمية والتثبيت باستخدام نظام المسمار العنقي والقضيب الفقاري وخطاف الصفائح الفقارية. كان متوسط وقت المتابعة 9.47 ± 3.07 أشهر. تم فحص جميع المرضى قبل وبعد العمل الجراحي ومتابعتهم سريريًا {الألم بواسطة مقياس التناظرية المرئية) ، وظيفيًا (بواسطة مؤشر العجز أوسويستري) وإشعاعيًا (التئام خلل pars). تم توثيق النتائج المحيطة بالجراحة والمضاعفات.

النتائج: تم تحسين النتائج السريرية والإشعاعية والوظيفية بشكل ملحوظ. الالتئام العظمي كان واضحًا في جميع المرضى (100٪). زاد فقدان الدم الجراحي والإقامة في المستشفى والوقت الجراحي في حالة وجود خلل في المستويات المتعددة والإصابات المرتبطة به. تم الإبلاغ عن حالتين كمضاعفات في هذه الدراسة (المسمار في وضع غير صحيح والالتهاب السطحي).

الاستنتاج: الاستيعاض المباشر لخلل (pars) عن طريق الترقيع العظمي وتثبيتها باستخدام نظام المسمار العنقي والقضيب الفقاري وخطاف الصفائح الفقارية هو إجراء عملي فعال في علاج الانحلال الفقاري القطني فيما يتعلق بالحفاظ على حركة الفقرات القطنية وتجنب مشاكل الجزء المجاور بعد الانصهار الفقري.