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Minimally Invasive Spinal Fusion Technique in Patients with Lumbar Segmental Instability

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ABSTRACT

Background: Lumbar spinal fusion is a common surgical procedure for treatment of lower back pain caused by degeneration of lumbar disc. The aim of fusion is to prevent motion in the destabilized segments to decrease the low back pain. A modified interspinous device can provide stabilization similar to pedicular screw fixation avoiding its complication when used for interbody fusion as a minimally invasive procedur.

Aim of work is to investigate using a new fusion technique, consist of trans-foraminal inter-body placement of peek cage and interspinous stabilization by rigid interspinous device which could provide stabilization of the posterior spinal elements similar to pedicle screw fixation as a minimally invasive procedure.

Patient and Methods: The study involved 20 patients with signs of moderate segmental instability in lumbar spine .Transforaminalinterbody fusion using the polyethere- therketone(PEEK)cage and rigid interspinous device fixation was performed. Patients were followed up and treatment outcomes were assessed within approximately 24 months after surgery.

Results: According to pain intensity level on the visual analogue scale, the need for painkillers and the quality of life according to the Oswestry Disability Index scale during the early postoperative period demonstrated significantly better outcomes due to a less severe operative trauma to the paravertebral soft tissues. The formation of interbody bone formation was observed after 20—36 months in 94% of patients . Postoperative complications occurred in 2.2% of patient.

Conclusion: The use of transforaminalinterbody fusion and rigid interspinous stabilization provides better clinical outcomes and fewer postoperative complications in patients with moderate lumbar segmental instability.

Keywords: segmental instability; lumbar spine ; degenerative disc disease ;TLIF ; rigid interspinous fixation.

INTRODUCTION

The study of the causes of the low back pain revealed that 80—90% of lumbosacral pain cases are associated with intervertebral disc pathology, including segmental instability to be present in more than a half of the patients.^{1,2,3,4,5}

The modern approach for treatment lumbar segmental instability includes inter-body cage placement and trans- pedicular fixation of the affected spine segment.^{6,7}This type of fusion is

associated with significant damage to paravertebral soft tissue, the muscles and ligaments, which results in significant paravertebral adhesive changes.

This changes lead to long period of healing and recovery and can worsen patients quality of life and affect their working capacity.^{8,9}

The search for new techniques to have a good results of patients with symptomatic lumbar segmental instability is planning to develop effective stabilization of the operated segment with minimal trauma to the surrounding tissues.

The aim of this study to investigate using a new fusion technique, consist of trans-foraminal inter-body placement of peek cage and interspinous stabilization by rigid interspinous device which can provide stabilization of the posterior spinal elements similar to pedicle screw fixation as a minimally invasive procedure.

PATIENT AND MATERIALS

This study was conducted between 2014and 2019 in Al-Azhar university hospitals , Cairo, Egypt. The

study included 20 patients who meet the inclusion criteria, but not the exclusion criteria, using TLIF with a modified interspinous device fixation. The protocol was discussed and approved for clinical study by the Ethical Research Committee of Al-Azhar University and a written informed consent was obtained. All patients were informed about the pathology and the suggested treatment according to their diagnosis and also informed about the possible complications. Inclusion criteria were as follows: signs of moderate segmental instability: grade I spondylolisthesis according to grade H. Meyerding (without spondylolysis) (figure1) and herniation or protrusion of the intervertebral disc followed by disc space or spinal canal narrowing that causes corresponding clinical symptoms (Figure2). Exclusions criteria include degenerative Spondylolisthesis greater than grade I according to Meyerding classification, any forms of isthmic spondylolisthesis, Prior decompressive laminectomy, hemilaminectomy or significant lamina fenestration which weakens the spinous process, Use in more than one level, Cases of L5/S1 as sacral 1 vertebra has no spinous process and Segmental stabilization without interbody fusion.



Fig 1: Preoperative lumbar spine x-ray : antero posterior and lateral views showing : grade I spondylolisthesis at level L4-L5.

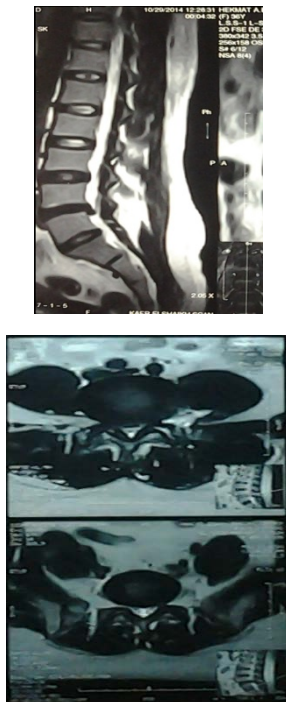


Fig 2: Preoperative magnetic resonance imaging (MRI) lumbo-sacral showing herniation of the

intervertebral disc L4-L5 with spinal canal narrowing.

The patients were undergo transforaminal interbody fusion using PEEK cage. The inner cavity of the cage was filled with the bone autograft obtained from surgical approach. The patients underwent decompression via unilateral access using an original technique¹⁰ in the extent of unilateral partial facetectomy followed by stabilization with the modified rigid interspinous implant. After surgery, follow-up was after 6 weeks, 6 months, 12 months, 18 months and 24 months postoperative. radiographic parameters for assessing the bone block formation capability were also assessed. A Clinical parameters were also assessed: the severity of pain according to the visual analog scale (VAS), the need for painkillers according to the number of nonsteroidal anti-inflammatory drug injections per day, and the quality of life in patients with low back pain according to the Oswestry index (ODI).^{2,11}

The statistical difference was calculated using two methods: 1) the Student's unpaired t-test for variables which were continuous and followed a normal distribution. 2) Mann-Whitney U test for those not following a normal distribution. If P-value was less than 0.05, this was considered significant.

RESULTS

All 20 patients included in this study had intermediate term follow up till 24 months post-procedure. Preoperative symptoms were back pain in all cases (100%). Back pain was associated with leg pain (radiculopathy) in 15 (75%) patients, hypoesthesia or sensory loss in 10 (50%) patients, lower extremity muscle weakness in 5 (25%). Two weeks after the procedure 50.0% of patients reported improvement of their back pain, radiculopathy improved in 60.0% of patients and sensory loss improved in 30.0% of patients. Assessment was mainly subjective using the VAS for pain assessment at 6 weeks, 6 months, 12 months and 18 months, 24 months (Table 1) (Figure3).

Also using the ODI for disability and quality of life assessment at 6 weeks, 6 months, 12 months and 18 months, 24 months postoperatively (Table 2) (Figure4). During follow-up (mean time of 24 months), control X-ray pictures of the spine in the patients revealed no dislocation and migration of an implant, as well as no signs of segmental instability. The interbody bone block formation was detected in 86% of the patients 10–15 months after surgery and in 94% of patients the bone block formation was detected 20–36 months after surgery. (Figure 5)

After interbody fusion and rigid interspinous stabilization, one (2.2%) complication was verified as a postoperative wound infection on the background of subcompensated type 2 diabetes. Local application of antiseptics and prolonged antibiotic course enabled to stop the inflammatory process.

	VAS		Paired t-test	
	Range	Mean ± SD	T	P-Value
Preoperative	4.0 - 9.0	6.4 ± 1.792	3.656	0.000
After 6 weeks	3.0 - 7.0	4.5 ± 1.357		
Preoperative	4.0 - 9.0	6.4 ± 1.792	8.732	0.000
After 6 months	1.0 - 4.0	2.45 ± 1.099		
Preoperative	4.0 - 9.0	6.4 ± 1.792	11.037	0.000
After 12 months	1.0 - 3.0	1.8 ± 0.767		
Preoperative	4.0 - 9.0	6.4 ± 1.792	12.943	0.000
After 18 months	1.0 - 2.0	1.3 ± 0.470		
Preoperative	4.0 - 9.0	6.4 ± 1.792	15.075	0.000
After 24 months	0.0 - 1.0	0.25 ± 0.444		

Table 1: Comparison between VAS preoperative and after 6 weeks, 6 months, 12 months, 18 months and 24 months postoperative.

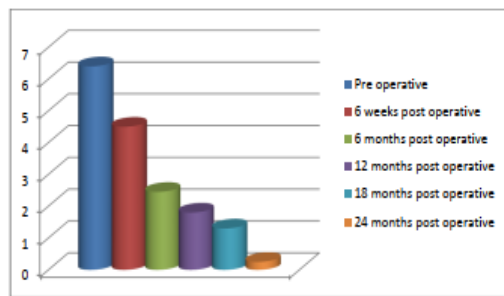


Fig 3: Comparison between VAS preoperative and after 6 weeks, 6 months, 12 months, 18 months and 24 months postoperative.

	ODI		Paired t-test	
	Range	Mean ± SD	T	P-Value
Preoperative	22 - 38	30 ± 5.331	16.436	0.000
After 6 weeks	13 - 19	16.8 ± 2.330		
Preoperative	22 - 38	30 ± 5.331	12.847	0.000
After 6 months	8 - 17	12.5 ± 2.946		
Preoperative	22 - 38	30 ± 5.331	14.316	0.000
After 12 months	6 - 15	10.5 ± 2.946		
Preoperative	22 - 38	30 ± 5.331	17.766	0.000
After 18 months	2 - 10	6.3 ± 2.677		
Preoperative	22 - 38	30 ± 5.331	6.862	0.000
After 24 months	1 - 5	3.1 ± 1.165		

Table 2: Comparison between ODI preoperative and after 6 weeks, 6 months, 12 months, 18 months and 24 months postoperative.

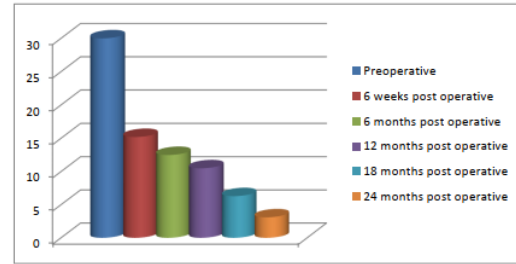


Fig 4: Comparison between ODI preoperative and after 6 weeks, 6 months, 12 months, 18 months and 24 months postoperative.



A



B



C

Fig 5: A-before surgery (anterior translation of the L4 above L5 level, 5 mm) B- 20 months after the L4—L5 interbody fusion using the peek cage and rigid interspinous fixation : no translation at the L4—L5 level and X-ray signs of bone block formation. C- anteroposterior view after surgery at the L4—L5 level and signs of bone block formation.

DISCUSSION

The study of new techniques of treatment for degenerative segmental spinal instability is linked to the lack of standard treatment approaches in the updated spine medicine, as well as to the efforts to improve the effectiveness of surgical methods followed by negative outcomes in 3-20% of cases according to different authors.^{8,9} These complications are associated with the insufficient interbody bone formation and with recurrence of the same neurological symptoms, and infection after surgery. The indications for decompression and fixation surgery, which is based on studying the severity of degeneration of the elements in lumbar spine, outcomes of surgical treatment, and mechanisms of fusion, cause decrease in complications mentioned before.^{7,8,9} It was found that the success of surgery for symptomatic instability in the SMS depends not only on decompression of neural structures in the intervertebral disc spaces and spinal canal, but also on the well performed surgical procedure, i.e. reconstruction and stabilization of the disc space between lumbar spine.^{7,20} Significant intraoperative trauma, as well as a relatively high risk of early and late complications in the form of recurrent spinal stenosis, insufficient bone block formation, and pseudoarthrosis formation limits the use of open transpedicular fixation at the first signs of segmental lumbar instability.^{2,10,15} There is a direct correlation between the degree of resection of structural elements of the lumbar spinal motion segment and the development of instability postoperative in the case of reconstruction of the spinal canal via posterior surgical approach.^{15,20,21, 22} In such cases, there are indication for stabilization procedure followed by rigid dynamic transpedicular fixation via either open or percutaneous access in most cases.^{12,13,14,15} The well functional recovery of patients after open transpedicular fixation is played by the following factors as Severity of intraoperative trauma to the muscles and ligaments, Adequate correcting the segmental instability and adequate bone block formation and its stability within prolonged time.^{7,23} Biomechanical studies have shown that a single transpedicular fixation in the case of unstable SMSs causes more stresses on the pedicle screws, resulting in its breakage (up to 10% of cases) and failure of the stabilization system.^{11,12,13,24} In order to avoid such complications, the new concept of rigid fixation combines interbody fusion and transpedicular fixation techniques regarded as "gold standard" of treatment for segmental spinal instability.^{14,15} The progression of the degenerative disc disease causes decrease the size of the interbody space gradually and also the neural foraminae.^{5,18} Treatment options for correcting the height of disc space include placement of osteoinductive or osteoconductive materials.^{14,16} A bone autograft was initially inserted into a disc space in order to form the fusion, but the tendency of resorption of the autograft and the high rate of development

pseudarthrosis caused the use of threaded cages.²³
^{25,26} Interbody cage placement causes indirect decompression to the disc space and spinal nerve roots by increasing the height of the intervertebral disc.^{5,13} This approach allow quick and proper fixation of the segment, increased the effectiveness of treatment, and reduced postoperative bed rest.^{24,26,27} The more invasive procedur of bilateral placement of threaded cages and the risks of implant displacement after a wide decompression of the spinal canal required further search for interbody fusion options.^{28,29,30} The routine method of transforaminal fusion uses a threadless bean-shaped cage, which is placed by unilateral transforaminal access. PEEK cages became more popular due to physical and chemical features, such as full biocompatibility, absence of cytotoxic and mutagenic effects and parameters in biomechanics similar to those of a bone.^{31,32}

The Treatment results of patients with posterior interbody stabilization are various. In 1985, Blume develop the unilateral transforaminal access with placement of a bean-shaped cage into the intervertebral disc space that was followed by transpedicular fixation as a search for a less traumatic posterior interbody fusion technique.^{33,34}

T. Lowe et al. found that the TLIF procedure have fusion rate reaches 90% with good and excellent clinical outcomes being observed in 85% of patients.^{15,20,35}

In recent years, became popular using different interspinous implants for stabilization procedure after microsurgical discectomy.^{36,37,38} In the same time, titanium U-shaped constructs accepted due to the capability of intralaminar placement.^{2,39,40,41} Using of these implants allows some actions as widening the size of the spinal canal and disc spaces by widening the posterior and middle parts of disc spaces without kyphosis development and restricting the SMS movement in sagittal plane.^{2,39}

There is indications for using interspinous implants: preventive measures for the adjacent segment syndrome after rigid stabilization, grade I degenerative spondylolisthesis, spinal stenosis, initial instability in the SMS or preventive measures after discectomy and degenerative facet disease.³⁸
^{40,41,43} Contraindications to the interspinous stabilization are regarded as follows: signs of osteoporosis, vertebral body fractures and grade II—IV spondylolisthesis.^{37,39}

Compared to the conventional TLIF technique, the advantages of rigid interbody fusion with interspinous stabilization are as follows: Minimally invasive as Less traumatic surgical approach, Simple rigid interspinous implant placement with less supplementary surgical instruments, Effective unstable segment fixation and high incidence of bone block formation and fewer postoperative complications.

CONCLUSION

Using both transforaminal interbody fusion and rigid interspinous stabilization for treatment of symptomatic lumbosacral degenerative disc disease combined with moderate segmental instability enables to achieve better clinical outcomes and causes fewer postoperative complications.

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