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Special aspects of surgical tactics in treatment of patients with lumbar degenerative spondylolisthesis

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Purpose Carry out a comparative study of the effectiveness of surgical treatment of patients with grade I degenerative spondylolisthesis treated with rigid transpedicular and dynamic interlaminar fixation. **Material and methods** Surgical treatment of patients with grade I degenerative spondylolisthesis at L4 vertebra was reviewed. The inclusion criteria were as follows, L4 spondylolisthesis measuring up to 5 mm; translation of ≤ 3 mm; L4-L5 segmental kyphosis of ≤ 17 degrees, local scoliosis of ≤ 10 degrees, absence of severe osteoporosis (T-score of > – 2.5). Decompression and dynamic stabilization of the spine was produced in group I (n = 24) with Coflex and Interfix implants. Group II included 20 patients who underwent transpedicular fixation and posterolateral spondylodesis. Standard and functional spondylography, MRI were performed for all the cases. Modified Pfirrmann grading system was used to assess intervertebral disk degeneration. L4 vertebral slippage and lumbar lordosis, intervertebral disc height, L4-L5 angle, translation at lumbar flexion/extension were measured. **Results** Oswestry Disability Index (ODI) score was insignificantly lower in the group of dynamic fixation. Pain intensity in the leg and the spine was comparable at follow-up. Adjacent segment syndrome was not common in group I and graded not more than Pfirrmann V. Both groups showed slight changes in lumbar lordosis. Advantages of dynamic interlaminar fixation included decrease in surgical trauma, blood loss and surgical time, and lower risk of complications avoiding overstress to adjacent level. **Conclusion** The use of interlaminar fixation for selective patients with grade I degenerative spondylolisthesis showed advantages over rigid transpedicular fixation. However, further research is needed for extended indications to the fixators to be used for this cohort of patients.

Keywords: spondylolisthesis, spondylodesis, dynamic fixation, transpedicular fixation

INTRODUCTION

Degenerative spondylolisthesis is defined as slipping of a vertebra with intact pars interarticularis due to degenerative changes in intervertebral disc below. Degenerative spondylolisthesis occurs most often after age 50 and 60. Females are more likely to be diagnosed with the condition than males. The disorder is more common at the level of L4 vertebra [1, 2].

The main objective of surgery in degenerative spondylolisthesis is decompression of the neural and vascular elements of the spinal canal followed by posterolateral (intertransverse) spondylodesis. Retrospective review of a great number of clinical observations showed that short-term results of patients with degenerative spondylolisthesis treated with stand-alone posterior decompression and combined with transpedicular fixation are comparable. However, 3-to-5-year follow-ups of surgical treatment showed more benefits of stabilising procedures [1, 2, 3, 4]. Poor quality of bone tissue and considerable realignment of the slipped vertebra predispose additional anterior lumbar interbody fusion [5].

Despite the evident advantages of rigid spinal fixation in degenerative spondylolisthesis there are some disadvantages typical for the technique on the whole including greater surgical trauma of the conventional surgical intervention associated with considerable muscle separation prior to transpedicular instrumentation and greater loading on adjacent spinal motion segments (SMS), superior one, in particular. In recent years, dynamic stabilisation has been designed and used for surgical treatment of degenerative spondylolisthesis as a major fixator of SMS following decompression [6, 7]. Dynamic interlaminar fixators are shown to have no disadvantages of rigid systems. Placement of the fixators is simple and requires no considerable spinal muscle separation that results in the reduction of surgical trauma. Dynamic stabilisation helps preserve motion and minimizes redistribution of loads at instrumented and adjacent segments and the risk of adjacent segment disease [8].

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The main aim of the study was to compare the effectiveness of surgical treatment of patients with grade I degenerative spondylolisthesis treated with rigid transpedicular and dynamic interlaminar fixation DIF).

MATERIAL AND METHODS

Twenty-four patients (group I) were enrolled in this prospective study. The patients presented with Meyerding grade I degenerative spondylolisthesis of L4 vertebra accompanied by degenerative stenosis of the spinal canal, neurogenic intermittent claudication and/or radiculopathy and underwent port-hole decompression posterior interlaminar dynamic stabilisation of the lumbar spine between 2009 and 2013. There were five inclusion criteria: 1) spondylolisthesis of L4 up to 5 mm; 2) translation of less than or equal to 3 mm on functional radiographs; 3) segmental kyphosis of less than or equal to 17° at L4–L5 level; 4) local scoliosis of less than or equal to 10°; 5) absence of severe osteoporosis (a T-score of -2.5). The control group (group II) was composed of 20 patients who underwent surgical treatment earlier between 2005 and 2009 for degenerative spondylolisthesis using pedicle screw fixation and posterolateral spondylodesis and had the above inclusion criteria.

Radiographic evaluation consisted of standard, functional (flexion, extension) radiographs, MRI performed for all patients pre-, postoperatively and at 3 years after the surgery. The slip of vertebral body, lumbar lordosis, intervertebral L4–L5 disc height, flexion/extension slip of L4 were measured.

All patients of both groups had signs of degenerative stenosis of the spinal canal, neurological disorders and spine pain of different intensity.

MRI was used to grade intervertebral disc degeneration with the modified Pfirrmann classification [9]. Primary intervertebral disc degeneration signs were observed preoperatively in 2 cases (8.3 %) of group I and 3 cases (15 %) of group II (Pfirrmann grades 2–5).

The mean age of patients of groups I and II was 61.4 ± 9.4 and 63.0 ± 8.0 years, correspondingly; L4 vertebra slipped by 7.3 % and 8.6 %, correspondingly. Preoperative lumbar lordosis in patients of groups I and II was 40.7° (range, 30.2 to 48.2°) and 38.7° (range, 28.2 to 50.1°); ODI measured 62.3 ± 15.8 and 61.7 ± 17.8; the VAS spine score was 7.2 ± 3.0 и 6,9 ± 2,9; the Vas leg score was 6.7 ± 1.2 and 7.1 ± 1.7, correspondingly.

RESULTS

Outcomes of surgical treatment were evaluated immediately after the surgery and at 3 years after the surgery. Oswestry Disability Index (ODI) was used to assess functional results of the treatment and VAS score showed intensity of pain in spine and the leg [10, 11].

ODI score was inconsiderably less in the group of dynamic fixation measuring 26.5 ± 14 immediately after the surgery and 19.3 ± 14.4 at 3-year follow-up, and 35.8 ± 16.6 and 27.3 ± 18.7 correspondingly, in group II. Intensity of back and leg pain was comparable in both groups measuring 1.7 ± 1.4 and 1.9 ± 3.4 postsurgery; 1.8 ± 1.4 and 2.0±1.2 at 3-years follow-up in group I, and 2.0 ± 1.1 and 2.8 ± 1.8, and 1.9 ± 1.2 and 2.1 ± 1.6, correspondingly, in group II.

Distribution of patients by the main clinical and radiological presentations and the type of surgery performed is presented in Table 1.

Spontaneous bone fusion at the slip level was observed in 2 (8.3 %) patients of Group I and 7 (35 %) cases of Group II at a long-term follow-up. It should be noted that neither evident neural foraminal narrowing nor compression of nerve roots were observed in these patients.

Degeneration of superjacent intervertebral disc was noted in 4 patients (20 %) of Group II at 1 year after the surgery and 10 patients (50%) at 3 years after the surgery including three cases with grades 7–9. Two patients underwent repeat procedure at the adjacent level. Adjacent segment disease developed in 2 (8.3 %) cases of Group I at 1-year follow-up and 4 (16.6 %) patients at 3-year follow-up with the condition graded not more than 5.

Lumbar lordosis showed inconsiderable changes in both groups throughout the observation period measuring 37.2° (range, 28.7 to 46.3°) and 39.4° (range, 30.4 to 48.5°) in Group I and 42.5° (range, 32.3 to 48.2°) and 40.7° (range, 31.2 to 49.5°) in Group II. Monosegmental transpedicular fixation could not provide considerable changes in lordosis profile whereas inconsiderable decrease in lumbar lordosis was noted to compensate with dynamic fixation in the course of time due to adjacent segments.

Table 1

Distribution of patients by the main clinical and radiological presentations and the type of surgery performed

Description	Group I (n=24), DIF (Non fusion)	Group II (n=20), TPF (Fusion)
Male	10	7
Female	14	13
Age	61.4 ± 9.4	63.0 ± 8.0
Extent of slip, %		
Preoperative	7.3 % (5–14)	8.6 % (6.1–15)
Postoperative	7.3 % (5–14)	1.2 % (0–12)
3 years after the surgery	8.5 % (7–21)	2.3 % (0–15)
Translation, mm		
Preoperative	1.9 ± 1.0	2.2 ± 0.4
Postoperative	2.0	0
3 years after the surgery	2.1 ± 1.4	0
Dynamic segmental angle L4-L5, °		
Preoperative	7.4 ± 2.7	6.5 ± 3.8
Postoperative	1.6 ± 1.1	0
3 years after the surgery	1.8 ± 0.9	0
Lumbar lordosis, °		
Preoperative	40.7° (30.2–48.2)	38.7° (28.2–50.1)
Postoperative	37.2° (28.7–46.3)	42.5° (32.3–48.2)
3 years after the surgery	39.4° (30.4–48.5)	40.7° (31.2–49.5)
Back pain (0–10 graphic rating scale)		
Preoperative	7.2 ± 3.0 (65 %)	6.9 ± 2.9 (72 %)
Postoperative	1.7 ± 1.4	2.0 ± 1.1
3 years after the surgery	1.9 ± 3.4	2.8 ± 1.8
Leg pain (0–10 graphic rating scale)		
Preoperative	6.7 ± 1.2	7.1 ± 1.7
Postoperative	1.8 ± 1.4	1.9 ± 1.2
3 years after the surgery	2.0 ± 1.2	2.1 ± 1.6
Oswestry Disability Index		
Preoperative	62.3 ± 15.8	61.7 ± 17.8
Postoperative	26.5 ± 14.3	35.8 ± 16.6
3 years after the surgery	19.3 ± 14.4	27.3 ± 18.7

The surgery resulted in realignment of the slipped L4 vertebra in majority of the cases. Group I showed no changes in the magnitude of spondylolisthesis after the surgery and exhibited slight increase (up to 8.5 %) at 3 years after the surgery.

Mean surgical time was 120 minutes in Group I and 150 ml in Group II, intraoperative blood loss was 150 ml and 200 ml, correspondingly.

No complications, episodes of fractured spinous processes were observed.

DISCUSSION

Despite the persistent interest to interspinous dynamic stabilisation as a stand-alone fixation technique used to treat degenerative spondylolisthesis there are controversies regarding clinical efficacy of this technique in current literature [12]. The complication rate of interspinous dynamic stabilisation has been reported to be 58 %. The outcome analysis of the procedures showed no consensus with respect to preoperative segmental stability, open decompression in patients with an average percentage of slip less than 25 % [13]. Some authors indicate to interlaminar stabilisation combined with open decompression as an acceptable alternative to transpedicular fixation in treatment of spinal stenosis including patients with degenerative spondylolisthesis graded not more than I [14, 15]. Five-year outcomes showed that interlaminar stabilisation device aids greater mobility of spinal motion segment, maintaining intervertebral foramen height and considerably improving back and leg pain [14, 16, 17].

Minimally invasive approaches have been developed with the usage of implantable interspinous process devices (DIAM, X-STOP) or intralaminar devices made from medical-grade metal providing greater fixation. According to Postacchini F. et al. (2016), stand-alone ILIF (Interlaminar Lumbar Instrumented Fusion) with interspinous bone grafting promotes vertebral fusion in degenerative spondylolisthesis in 84 % of the cases [16].

Outcome analysis of surgical treatment using rigid transpedicular fixation and dynamic SMS fixation in degenerative spondylolisthesis showed the possibility with dynamic interlaminar fixation used for this cohort of patients. However, diverse clinical and radiographic presentations of degenerative spondylolisthesis described below should be carefully considered with patient selection and surgical indication.

Intervertebral disc height. Analysis of literature shows that the maintained intervertebral disc height of greater than 50 % is an indication to transpedicular fixation aimed at prophylaxis of spondylolisthesis progression [2]. At the same time potential slip of the vertebral body is defined by SMS stability including condition of posterior columns and ligaments. Hypertrophied facet joints being fibrously ankylosed often provide sufficient segmental stability with relatively high intervertebral disc. The condition is commonly seen by surgeons since spinal stenosis primarily caused by hypertrophied facet joints is the main indication to operative treatment. Many authors support evaluation of pathological mobility in impaired SMS using functional radiography or MRI considering stability and the risk of spondylolisthesis progression [18]. The choice of spinal stabilisation technique relies on current local methods of decompression (e.g., port-hole technique) maintaining stability of the operated segment close to preoperative level in majority of the cases with horizontally oriented facet joints [19]. Hence, preoperative planning included evaluation of intervertebral disc height to use it for dynamic stabilisation.

The maintained intervertebral disc height of 50 % and over and absent signs of segmental instability in functional radiographs were an indication to the usage of interlaminar devices [6]. A clinical observation of the above technique applied in a 62-year-old male patient N. with spinal stenosis at L4-L5 level, grade I degenerative spondylolisthesis of L4 vertebra shows a good clinical outcome at 4 years after surgery (**Fig. 1**).

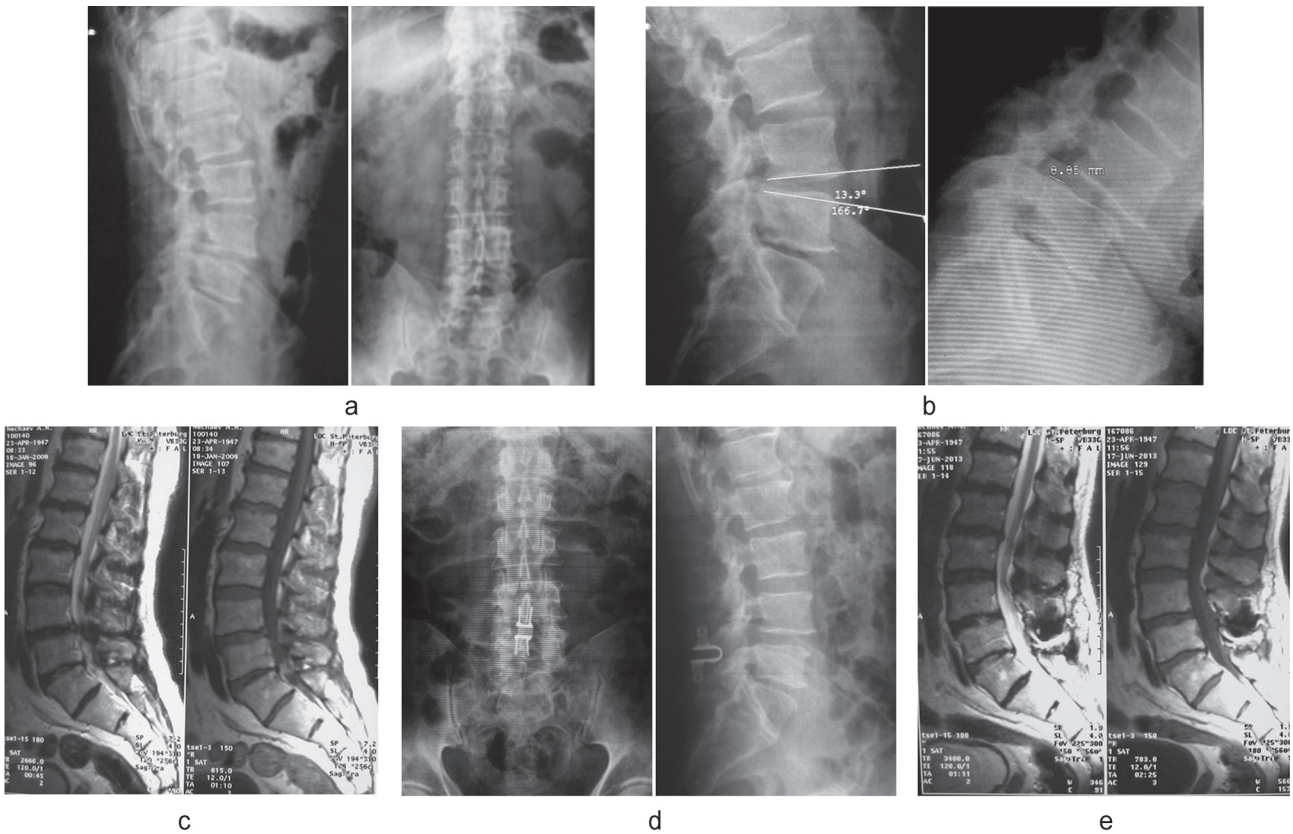

Fig. 1 Radiographs and MRI images of the spine of a 62-year-old male patient N. with spinal stenosis at L4-L5 level, grade I degenerative spondylolisthesis of L4 vertebra showing (a) preoperative AP and lateral views, (b) functional radiography, (c) preoperative MRI image of lumbar spine, (d) postoperative AP and lateral views of lumbar spine, (e) MRI image of lumbar spine at 4 years after the surgery

Kyphosis. Presence of true kyphosis at the level of degenerative anterolisthesis leads to disturbed sagittal alignment, biomechanics and indicates to unstable slip. Interspinous dynamic stabilisation is not practical for the case due to inevitable aggravation of local kyphosis with the placement of the devices [2]. Transpedicular fixation is the only solution for this scenario.

Degenerative scoliosis. The choice of spinal fixation technique in combined degenerative anterolisthesis and scoliosis relies on anatomical and functional presentation of spondylolisthesis, the magnitude of scoliosis and presence of coronal malalignment. If local scoliosis measures not more than 8 degrees, no laterolisthesis of the superjacent vertebral body and impaired coronal balance observed in stable grade I spondylolisthesis dynamic devices can be practical for stabilisation of the involved vertebral segment. Transpedicular fixation is useful for grades I and II local degenerative scoliosis accompanied by slightly impaired coronal balance and laterolisthesis of not more than 2 mm. Grade III degenerative scoliosis is considered the main pathology in defining surgical tactics.

Segmental instability. Excessive pathological segmental mobility in degenerative spondylolisthesis is an obvious indication to vertebral stabilisation. Most of spinal surgeons support the statement [2]. True (translational) instability with anterior displacement of superjacent vertebra of 4 to 5 mm in functional tests causes regular back pain, impaired sagittal balance and considerable postoperative risk of spondylolisthesis progression. Transpedicular fixation is to be applied to restore stability of the involved SMS. Less evident disorders of SMS termed as hypermobility can be treated with dynamic stabilisation systems. A considerable increase/decrease in angle between adjacent endplates at extension/flexion of the study segment is a sign of hypermobility on functional radiographs. Totaled difference in angles at extension/flexion compared with that at the neutral position is more than 10 degrees in hypermobility. Vertebrogenic pain syndrome is characterised by mild intensity in the case.

Dynamic fixators are important for hypermobility at both spondylolisthesis and adjacent levels. Short segmental rigid fixation in the case results in fast progression of degenerative process in the adjacent SMS coupled with instability and spinal stenosis.

Magnitude of vertebral displacement. Vertebral displacement is rarely graded more than grade I in degenerative spondylolisthesis on standard radiography. Interspinous fixation of stable degenerative spondylolisthesis with displacement up to 5 mm does not result in aggravated magnitude of slippage and impaired sagittal alignment as confirmed by our findings. Sagittal rotation of the displaced vertebra is observed in a more severe spondylolisthesis due to segmental instability. Interspinous distraction would inevitably lead to aggravation of local kyphosis and transpedicular fixation would be optimal for spinal stabilisation in vertebral displacement of more than 5 mm.

Condition of adjacent SMS. Evaluation of adjacent SMS is important for surgical planning to ensure long-term result of treatment. In the last 10 years, adjacent segment disease has been reported to develop in 15 to 20% of the patients who underwent transpedicular fixation for degenerative spinal conditions at several years after surgical intervention. The pathological condition is characterised by rapid onset or progression of degeneration in adjacent to transpedicular fixation segments. Patients present with decrease in intervertebral disc height, segmental instability (hypermobility) and spinal stenosis. Clinical manifestations are limited to back pain of different intensity and neurological deficiency with unfavourable course of degeneration [20].

Recurrent lower back pain after successful stabilising procedures for degenerative spinal disorders is normally caused by rapidly progressive degeneration at the adjacent level depreciating the long-term follow-up. Dynamic stabilisation devices aid decreased loading on adjacent segments reducing intensity of degeneration on adjacent levels.

Dynamic stabilisation is indicated for the cases when adjacent SMS has moderate MRI signs of degeneration and is hypermobile apart from fixation technique of 'primary' level. Transpedicular fixation is practical in presence of translational instability at the adjacent level. Radiographs of a patients treated with this technique are presented in Figure 2. The patient showed a good consistent 3-year follow-up.

Condition of bone tissue. Evident osteoporosis is a contraindication to dynamic stabilisation implants due a high risk of a fracture of spinous processes. Options with transpedicular fixation and bone segment augment and posterolateral spondylodesis or transpedicular fixation and circular spondylodesis are practical for this scenario to achieve reliable and long-term fixation of the involved segment.

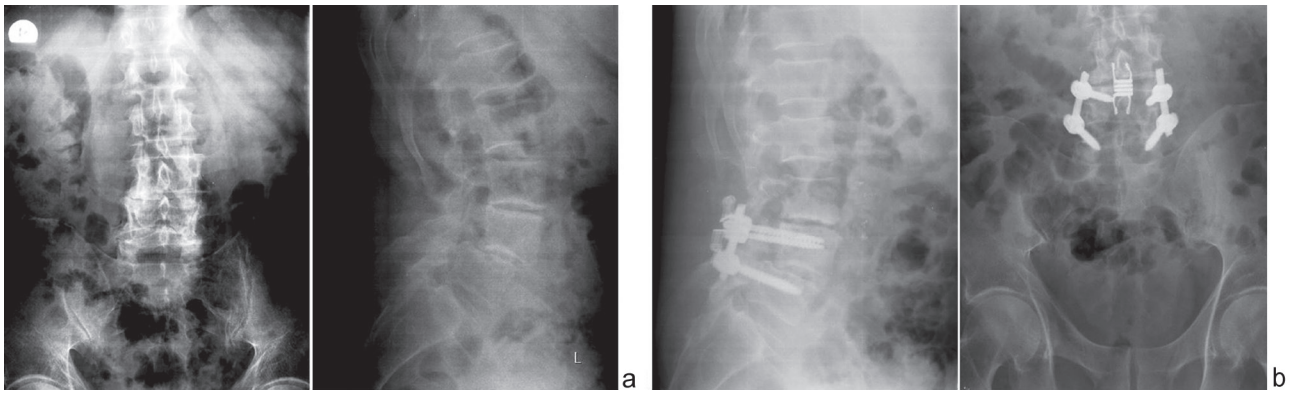

Fig. 2 Radiographs of the spine of a 62-year-old patient K. showing (a) unstable grade I spondylolisthesis of L4, degenerative subcompensated spinal stenonsis at L4-L5 level on preoperative AP and lateral views (b) bilateral decompression interlamin(facet)ectomy at L3–L4, L4–L5 level, transpedicular fixation of the spine, posterolateral spondylodesis at L4-L5 level using bone autograft, dynamic stabilisation of L3-L4 segment with interlaminar implant at 3-year follow-up

Open decompression. Application of interlaminar dynamic stabilisation device can be considered being dependent on the level of disturbed segmental stability after decompression. Excessive bone tissue of the inner portion of hypertrophied superior articular process of the vertebra below is normally excised during medial facetectomy produced for degenerative spinal stenosis. With normally aligned articular processes the excision is rarely more than 50 % of the facet breadth with hypertrophied internal and external articular parts. No severely impaired segmental stability is noted to occur. With sagittal alignment of facet joints even economic facet excision can lead to iatrogenic fracture of the articular process and evident instability of the operated segment and transpedicular fixation would be the most reasonable technique to be applied in the case. When planning interlaminar dynamic stabilisation in a borderline situation the surgeon is to be supplied with transpedicular instrumentation to use it if needed.

Anterior lumbar interbody fusion. The literature illustrates that anterior lumbar interbody fusion with transpedicular screw fixation has been employed in degenerative spondylolisthesis. The approach to the treatment is considered to be pathogenetic as in true spondylolisthesis. However, two grades of anterolisthesis can be identified by pathomorphological causes that differ by segmental instability, magnitude and prognosis of slippage progression and likelihood of sagittal malalignment. It should be noted that stable degenerative spondylolisthesis compared to the true condition is characterised by a benign course typical for isolated degenerative spinal stenosis. Positive outcomes of our series give evidence [5, 21, 22] that anterior lumbar interbody fusion is indicated for grade II displacement, expressed translational instability of 5 mm and over, segmental kyphosis of more than 17 degrees, sagittal malalignment and expressed osteoporosis.

CONCLUSION

Therefore, the use of dynamic interlaminar fixation and conventional transpedicular screw fixation with posterior lumbar interbody fusion for selective patients with degenerative spondylolisthesis allowed us to achieve comparable functional results.

Indications to dynamic interlaminar fixation in treatment of degenerative spondylolisthesis included displacement of less than 5 mm (not more than 15 %), absence of evident translational instability, presence of normal lumbar lordosis and decompression performed with port-hole technique.

Dynamic interlaminar fixation has advantages of reduced surgical trauma and surgical time, lower complication rate and lower risk for overloading adjacent level. In our opinion, reduction of a displaced vertebra is not indicated with adequately produced decompression of nerve roots.

The authors declare no conflict of interests.

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