Postoperative Lumbosacral Instability: Proposal of a New Classification Based on Etiology

Sait Naderi, MD; Özgür Akşan, MD; Süleyman Men, MD; Levent Fırat, MD; Tansu Mertol, MD; M. Nuri Arda, MD

Abstract
Objective: Postoperative lumbosacral instability is one of the causes of failed back surgery syndrome. This process results from a variety of preoperative, intraoperative and postoperative reasons. A careful preoperative workup and planning can decrease the rate of this type of instability. The aim of this study is to review the results of surgery for postoperative instability, and to determine the factors contributing to its formation.

Methods: Between 1998 and 2005, 22 cases of postoperative lumbosacral instability were operated. The charts and radiographs could be reviewed in 18 cases. The study was designed in two parts. The first part consisted of the general retrospective review of cases, and the second part consisted of analysis of factors contributing to formation of instability.

Results: There were 13 female and five male cases aged from 30 to 74. Instability occurred after six months to 19 years after primary surgery. The diagnosis during the primary surgery was lumbar disc herniation in 14 cases, lumbar spinal stenosis in two cases and instrumentation of degenerative spondylolisthesis in two cases. The causes of instability include preoperative overt instability in 11.1%, aggressive bony resection in 61.2% and adjacent level degeneration in 11.1% of cases. A transpedicle screw fixation and intertransvers fusion procedure were performed. The Odom Clinical Situation was evaluated as excellent in 77.9%, good in 16.6% and poor in 5.5% of cases. The second part of the study revealed that postoperative instability was associated with an increased L4-5 facet angle and decreased lumbar lordosis angle.

Conclusion: It is concluded that aggressive facet resection during the primary surgery was the most important cause of postoperative lumbosacral instability. Increased facet angle and decreased lumbar lordosis angle were the main contributing factors. All these factors need to be taken into consideration before and during the primary lumbosacral surgery.

Key Words: instability, laminectomy, postoperative, spondylololisthesis

Introduction
Lumbosacral instability is one of the causes of failed back surgery syndrome complicating the postoperative course. This process results in low back and/or leg pain. A variety of preoperative, intraoperative and postoperative factors may lead to postoperative lumbosacral instability. The main preoperative cause of postoperative lumbosacral instability include failure to notice the preoperative instability or avoiding fixation procedure. The major intraoperative cause of postoperative lumbosacral instability is aggressive bony and ligamentous decompression, whereas the major postoperative reasons include adjacent level degeneration in already fixated cases and natural degeneration of the lumbosacral spine.

Many authors sought to predict the formation of postoperative lumbosacral instability. They studied many factors, including age, disc height, the presence of abnormal motion in dynamic radiographs, the amount of bony resection, and the facet angle. However, controversies remain.

The aim of this study is to review the clinical and radiological data in cases operated for postoperative lumbosacral instability and to determine the factors affecting formation of instability after surgery.
Materials and Methods

Ninety-seven cases with lumbosacral instability underwent surgery between 1998 and 2005. Twenty-two (22.8%) out of 97 cases were classified as postoperative lumbosacral instability. Three patients were missed during follow-up, and could not be included in the study. The clinical and radiological data of 18 cases with postoperative lumbosacral instability were retrospectively reviewed.

The radiological studies included plain AP and lateral lumbosacral radiography, lateral dynamic (flexion-extension) lumbosacral radiography, lumbosacral magnetic resonance imaging (MRI) and computed tomography (CT). The indications for surgery included presence of axial pain with or without leg pain concomitant with radiological signs of lumbosacral instability, i.e., presence of abnormal motion (> 4mm) and angulation (> 20° for L3-4 and L4-5 and 25° for L5-S1 level) in flexion and extension radiographs.

The study was designed in two parts. Part I consisted of the general review of the cases, and part II consisted of the analysis of the factors affecting instability.

Part I: The retrospective analysis include the age, gender, the number and location of unstable segments, the diagnosis of primary surgery, the duration between the primary surgery and admission for instability, the causes of instability, the type of surgical treatment and surgical outcome using VAS score and Odom Scale.

Part II: To detect the factors affecting occurrence of postoperative instability, following radiological parameters were analysed: Facet angle, lordosis angle, disc height and facet resection amount. The results obtained from the patient group were compared with the results of asymptomatic individuals of a control group.

The facet angle was measured as described elsewhere. The mean facet angles of the L3-4, L4-5, and L5-S1 levels were compared with the facet angles of analoge levels of control group.

The lumbar lordosis angle was described as angle between the lines intersecting the lines parallel to the L1 and S1 superior endplates. The angle obtained from the patient’s group was compared with the control group’s mean angle.

The disc height of each level was measured as the mean of height of anterior and posterior aspect of intervertebral disc, and the obtained results were compared with results of the control group.

The amount of facet resection was measured in axial lumbar spine CT with respect to the contralateral side.

Results

Part I. General Results

There were 13 female and five male cases, aged from 30 to 74 (mean 49.7). There was a one-segment instability in 16 (88.9%), and two-segment instability in two cases (11.1%). Instable segment was located at L3-4 in two cases (%1.1), at L4-5 in nine cases (50%), and at L5-S1 level in seven cases (38.9%).

The instability occurred after hemipartial laminectomy for lumbar disc herniation in 14 (77.8%), after laminectomy for lumbar spinal stenosis in two (11.1%), and long time after lumbar instrumentation for degenerative spondylolisthesis in two cases (11.1%) (Table 1).

The duration between the first primary surgery and admission for instability ranged from 6 months to 19 years.

The radiological investigations revealed that there was a preoperative instability in two cases (11.1%), whereas instability was secondary to intraoperative reasons (>50% facetectomy) in 11 cases (61.2%). In two cases (11.1%) who underwent spine instrumentation 10 years ago, instability was secondary to adjacent level degeneration after spine instrumentation. In three cases (16.6%) no reason could be detected (Table 2).

A one-segment (two vertebrae) pedicle screw fixation was performed in 14 cases, two-segment fixation in three cases, and a three-segment fixation was performed in only one case.

Follow-up ranged between 18 months and 80 months (mean 50.2). Preoperative VAS was 7.9±1.1, whereas postoperative VAS was 3.±1.4.

The Odom clinical situation was found to be excellent in 14 (77.9%) cases, good in three (16.6%) cases, and poor in one case (5.5%).

Part II. Factors Affecting to Formation of Iatrogenic Instability

There was no statistically significant difference between the facet angles of L3-4 and L5-S1 levels of the control group and patient group. The mean facet angles in L4-5 level of the patient group was 52°±15.5° in the right, and 41.8°±18.13° in the left side. When compared with the control group, the patient group facet angle was statistically larger (p<0.001 in the right, p<0.05 in the left) (Table 3).

The mean lordosis angles were measured as 20.82°±11.08 and 43.53°±18.35 in patient and control groups, respectively (p<0.001).

Table 1. The diagnosis of primary surgery

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Cases (Percentage)</th>
</tr>
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<tbody>
<tr>
<td>Lumbar disc herniation</td>
<td>14 (77.8%)</td>
</tr>
<tr>
<td>Lumbar spinal stenosis</td>
<td>2 (11.1%)</td>
</tr>
<tr>
<td>Degenerative spondylolisthesis</td>
<td>2 (11.1%)</td>
</tr>
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</table>

Table 2. The causes of iatrogenic instability

<table>
<thead>
<tr>
<th>Cause</th>
<th>Cases (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overt preoperative instability</td>
<td>2 (11.1%)</td>
</tr>
<tr>
<td>Aggressive bony resection</td>
<td>11 (61.2%)</td>
</tr>
<tr>
<td>Adjacent level degeneration after spine instrumentation</td>
<td>2 (11.1%)</td>
</tr>
<tr>
<td>No detectable reason</td>
<td>3 (16.6%)</td>
</tr>
</tbody>
</table>
The disc height was measured as 8.3 ± 2.4 mm, and 7.9 ± 3.3 mm, in control and patient groups, respectively (p>0.05).

Discussion

This study revealed that the postoperative instability was most commonly secondary to aggressive facet resection during lumbar disc herniation surgery. Increased facet angle and decreased lumbar lordosis angle were the main contributing factors. All these factors need to be taken into consideration both before and during the primary lumbosacral surgery.

There are many reports on the occurrence of instability after macro and microdiscectomy procedures, as well as after laminectomy for lumbar spinal stenosis. There is lack of consensus regarding the factors contributing to formation of instability. Principally, these factors can be categorised as preoperative, intraoperative and postoperative factors. Such a categorization facilitates the understanding of causes of postoperative lumbosacral instability.

Preoperative Reasons

Preoperative reasons may cause postoperative lumbosacral instability in two manners; (1) presence of an overt spinal instability and (2) presence of factors predisposing postoperative instability. Both are of importance and require a careful preoperative clinical and radiological assessments. This dictates the use of dynamic radiographs to find out the abnormal motion and instable segments before lumbosacral spine surgery.

It is of note that the preoperative study should be focused not only to abnormal motion, but also to other case-specific anatomic variations such as facet joint angle, lumbar lordosis and disc degeneration as evidenced by traction spurs or diminished disc height, Modic’s signs as well as facet size. The aforementioned factors are important variables and contribute to the sagittal spinal geometry and preserve intrinsic spine load bearing abilities.

The contribution of facet joint orientation to instability was studied by many authors. In a second study, Naderi et al reported that intraoperative reduction was achieved easier in cases with increased facet angle. On the other word, increased facet joint angle both predispose instability and facilitate reduction of slipped vertebra.

The present study supported the effect of increased L4-5 facet angle in the occurrence of postoperative lumbosacral instability. Based on the aforementioned studies, we recommend an additional fixation procedure in cases with increased facet angle who are candidates for aggressive lumbosacral decompression, even if there is no overt instability.

There are controversies regarding the effect of narrowed intervertebral disc on postoperative instability. A narrowing of the intervertebral disc more than 30% was reported to be a clear sign of segmental instability by Schaller et al, whereas Robertson et al addressed the stabilizing effects of reduced disc height. The current study failed to demonstrate a clear association between the intervertebral disc height and likelihood of postoperative instability.

Another controversial factor is the angle of the lumbar lordosis. This study demonstrated a decrease in the lumbar lordosis in cases with postoperative lumbosacral instability.

Intraoperative Reasons

Facet joint, pars interarticularis, lamina, interspinous and supraspinous ligaments are the main posterior osseoligamentous structures preserving spinal stability. Resections of posterior bony or ligamentous structures normally lead to a decrease in stability. The degree of instability depends on the extent of resection, the loading pattern and the condition of the intervertebral discs. There are many clinical and biomechanical studies focusing on the consequences of facet joint resection.

The biomechanical and kinetics of graded facetectomy was studied by many authors in both fresh cadavers and finite element models studies. Such a resection may change both the load-bearing and motion characteristics of the spine and accelerates segmental degeneration. Biomechanically, the excision of the supraspinous/interspinous ligaments and facetectomy greater than 50% affects the motion of the intervertebral joint and induces additional stress to the remaining components of the spine. Haer et al reported that destruction of the facet joints establishes an alternate path of loading and the load is transferred to the anulus and anterior longitudinal ligament to support the spine. An increase in annular stress after aggressive posterior bony and ligamentous resection results in an accelerated degeneration of intervertebral discs.

Table 3. Facet angles of the different levels in control and patient group

<table>
<thead>
<tr>
<th>Level</th>
<th>Normal Group</th>
<th></th>
<th>Patient Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>L3-4</td>
<td>51°±1.6°</td>
<td>50°±1.3°</td>
<td>53.4°±19.5</td>
</tr>
<tr>
<td></td>
<td>41°±8.9°</td>
<td>41°±1.4°</td>
<td>52.0°±15.5</td>
</tr>
<tr>
<td>L5-S1</td>
<td>38°±1.8°</td>
<td>37°±1.6°</td>
<td>55.0°±12.74</td>
</tr>
</tbody>
</table>

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Similar results can be drawn from clinical studies, too.(3,33,35,36) Shenkin and Hash reported six cases of postlaminectomy instability (9.8%) after three years of follow-up in 59 patients who underwent laminectomy and facetectomy. They reported 6% and 15% of instability after two level and more level laminectomy, respectively (33). Similarly, Guigui et al, analysed the causes of postoperative instability after surgery for lumbar spinal stenosis in 38 patients. They reported that in 25% of their cases, postoperative destabilization (ie, total bilateral facetectomy without fusion, wide laminectomy extended into the pars interarticularis with resultant in isthmic fracture) was the cause of failure.(35) Postoperative instability is not reported only after total facetectomy, it can also occur after a limited facet resection. Mullin et al reported a high rate of spinal instability after laminectomy for lumbar spinal stenosis.(36) They reported that 54% of cases showed radiographic signs of instability after decompressive lumbar laminectomy with medial facetectomy. The evidence of instability after limited facetectomy may be attributed to the predisposing factors.

The results of the current study support the importance of the facet joint integrity even in cases of lumbar disc herniation. Based on the aforementioned clinical and biomechanical studies, a bilateral resection of more than 50% of a facet joint, or total unilateral facetectomy is not recommended. Such a procedure requires addition of a spinal fusion and fixation procedure.

It is of note that aggressive resection may result in instability even in instrumented cases, if the extent of instrumentation is shorter than extent of decompression. Etebar and Cahill (37) addressed the instability secondary to decompression beyond the level of instrumentation. This type of instability is caused by decompression-instrumentation mismatch, and requires a careful surgical planning.

### Postoperative Reasons

The results of the current study revealed that degeneration related-instability forms only a small percent of postoperative instability. This type of instability may occur long time after a fixation procedure (23,37-39), and is secondary to accelerated degeneration of the adjacent levels. This type led some surgeons to use new treatment modalities such as dynamic spine fixation or lumbar arthroplasty. The long-term results of these modalities, however, are not known.

### Classification

Although there are comprehensive classifications of spondylolisthesis (40), there are only a few studies addressing postoperative instability classification. Setfer and McAfee (41), classified postlaminectomy spondylolisthesis as preoperative listhesis, new spondylolisthesis, and iatrogenic listhesis. Based on the results presented here, we propose a classification for postoperative lumbosacral instability according to causes of instability (Table 4).

1A. Instability caused by overt preoperative instability. It is clear that an overt preoperative instability is associated with postoperative lumbosacral instability. This dictates the surgeon to perform a spinal instrumentation in addition to the primary procedure. However, missing the instability or avoiding an instrumentation procedure will cause postoperative instability.

1B. Instability caused by predisposing factors (potential instability). Predisposing factors may increase the risk of postoperative instability even after limited bony resection. This type of instability can be called as potential instability. In other words, there is no instability unless these cases undergo decompressive procedure. Therefore, before any decompressive procedure in cases with predisposing factor, a careful preoperative planning is mandatory. Unfortunately, still most surgeons do not routinely use instrumentation in such cases.

2A. Instability caused by aggressive bony and ligamentous resection. This type of instability is caused by aggressive facet, pars interarticularis and interspinous ligamentous resections. Depending on the amount of osseoligamentous resection and the presence or abscence of risk factors, this type of instability may occur after a short time or a long time after surgery. The limited decompression may decrease the rate of this type of instability.

2B. Instability caused by adjacent level degeneration. It is well known that there is an increased stress in the level adjacent to the instrumented level. Such a stress may result in instability in long term. The preventive and treatment modalities are not standard. The use of dynamic systems may decrease the percentage of this group.

2C. Instability caused by instrumentation-decompression mismatch. It is reported that aggressive bony and ligamentous resection beyond (extended over) the instrumented level may result in instability shortly after instrumentation.(23,37) If this occurs, there is an instrumentation-decompression mismatch. Therefore, one should avoid further cranial or caudal bony and ligamentous resections.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>The proposed classification for iatrogenic lumbosacral instability based on the cause of instability.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Instability due to preoperative reasons</td>
</tr>
<tr>
<td>A</td>
<td>Overt instability</td>
</tr>
<tr>
<td>B</td>
<td>Potential instability (No overt instability: Presence of predisposing factors facilitating instability)</td>
</tr>
<tr>
<td>2</td>
<td>Iatrogenic instability</td>
</tr>
<tr>
<td>a</td>
<td>Instability due to aggressive decompression</td>
</tr>
<tr>
<td>b</td>
<td>Instability due to adjacent level degeneration</td>
</tr>
<tr>
<td>c</td>
<td>Instability due to instrumentation-decompression mismatch</td>
</tr>
<tr>
<td>3</td>
<td>Instability unrelated to primary surgery</td>
</tr>
</tbody>
</table>

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Redecompression beyond the instrumented level. In other words, all decompressed levels should be fixedated.

In summary, iatrogenic lumbosacral instability is a multifactorial situation. Preoperative factors such as overt instability and the presence of factors predisposing instability, or the need for aggressive decompression may facilitate postoperative lumbosacral instability. The addition of a lumbosacral fusion and instrumentation will decrease the likelihood of postoperative instability and failed back surgery syndrome.

References