Residual low back pain (LBP) is one of the major issues following laminectomy for lumbar canal stenosis (LCS). Clinical results and radiographic findings in 69 patients who underwent single level laminectomy for LCS were retrospectively reviewed in this study to identify radiographic predictors of residual LBP. The neural function and LBP status were evaluated by Japanese Orthopaedic Association (JOA) scoring system before operation and during follow-up periods. Patients’ clinical data and radiographic parameters like lordosis angle, range of motion and intervertebral rotational angle were analyzed using binary logistic regression analysis to detect factors significantly related with the occurrence of residual LBP. In our study the average preoperative JOA score of 14.8±5.05 improved to 21.59±5.51 at the final follow-up. Binary logistic regression analysis revealed that significant predictors of residual LBP were preoperative lumbar lordosis angle and range of motion. Although there have been a number of studies on the relationships between residual LBP after laminectomy and radiographic abnormalities, the correlations between residual LBP and preoperative radiographic parameters of the whole lumbar spine have rarely been studied. Our results suggest that patients with flat back and limited lumbar mobility before surgery tend to have poor results in terms of LBP. Therefore, these sagittal radiographic parameters should be taken into account when choosing laminectomy as the surgical option for LCS.

Decompressive laminectomy for the lumbar canal stenosis (LCS) is one of the most common surgical procedures. It substantially improves symptoms of neurogenic claudication and radiculopathy but seems to be less effective in relieving LBP.\(^1,2\) Post-laminectomy syndrome or LBP following spinal surgery is becoming a common entity in modern medicine.\(^3\) It is

### Objective
To identify radiographic predictors of residual low back pain (LBP) after laminectomy for lumbar canal stenosis (LCS).

### Methods
Clinical results and radiographic findings in 69 patients who underwent single level laminectomy for LCS were retrospectively reviewed. Patients who had an improvement in LBP scores evaluated by Japanese Orthopaedic Association (JOA) scoring system during the follow-up periods were classified as the recovery group, and others were classified as the non-recovery group. Patients’ clinical data and radiographic parameters like lordosis angle, range of motion and intervertebral rotational angle were analyzed using binary logistic regression analysis to detect factors significantly related with the occurrence of residual LBP.

### Results
The average preoperative JOA score of 14.8±5.05 improved to 21.59±5.51 at the final follow-up. Binary logistic regression analysis revealed that significant predictors of residual LBP were preoperative lumbar lordosis angle and range of motion.

### Conclusions
Our results suggest that patients with flat back and limited lumbar mobility before surgery tend to have poor results in terms of LBP. Therefore, these sagittal radiographic parameters should be taken into account when choosing laminectomy as the surgical option for LCS.

### Key words: Spinal canal; Radiography; Low back pain; Laminectomy
estimated that the incidence of the recurrence of LBP might be somewhere from 20% to 30%\textsuperscript{4}. In Datta et al’s series,\textsuperscript{5} 30% to 40% patients continue to complain of severe back pain for long period of time after laminectomy. Even though the exact incidence of residual LBP is still in controversial, many physicians have reported its severe impact on the clinical outcomes.\textsuperscript{6,7} It is therefore necessary to identify specific prognostic factors so that the selection of the optimal surgical patients could be permitted. Guyer et al\textsuperscript{8} attributed residual LBP to radiographic evidence of degenerative or age-related factors, such as disc herniation, spondylolysis, or spondylolisthesis, which could be asymptomatic before operation. Manchichanti\textsuperscript{4} noted that facet joint plays an important role in mediating residual LBP after lumbar laminectomy. Moreover, some authors\textsuperscript{9,10} have also reported that residual LBP should be derived from flatback and poorly aligned lumbar spine. Although a number of factors have been presumed in the development of residual LBP, the valuable predictor has not been determined previously. In the present study, we retrospectively analyzed the correlations between pre-and postoperative clinical and radiographic findings in patients with LCS to determine the radiographic signs for predicting prognosis of the residual LBP.

METHODS

Patient series

From 1996 to 2000, 128 consecutive patients admitted with LCS underwent decompressive laminectomy at Tianjin Union Medicine Centre. Of this population, 69 cases (31 males and 38 females, mean age 67.09 ± 8.30 years) who underwent one-level laminectomy were involved in the present study. Detailed radiographic documents and clinical records including gender, duration of symptoms, age at the time of surgery were available in all cases. All patients complained of LBP and unilateral or bilateral leg pain before operation. Diagnosis of LCS was confirmed by clinical manifestations and the results of magnetic resonance images (MRI) and computed tomography myelography (CTM). Radiographic images showed the canal stenosis located at either L\textsubscript{3-4} or L\textsubscript{4-5} level without true olisthys in all cases. Laminectomy through posterior medial approach was performed for all patients. If the patient complained of the leg pain caused by lateral recess stenosis, foraminotomy was additionally performed to enlarge the passageway where a spinal nerve root exits in the spinal canal. The neurological status was evaluated pre-operatively and during follow-up periods using Japanese Orthopedic Association (JOA) scoring system (total mark 29 points).\textsuperscript{11,12} The magnitude of LBP was also assessed by the JOA scoring system (Max 3 pts, Table 1). The recovery rate was also introduced and calculated as: (postoperative JOA score - preoperative JOA score) / (29 - preoperative JOA score) × 100 (%).\textsuperscript{11} Patients who had an improvement in LBP scores during the follow-up periods and whose scores were higher than the preoperative scores were classified as the recovery group. Those without improvement in the LBP scores were classified as the non-recovery group.

<table>
<thead>
<tr>
<th>Score</th>
<th>Magnitude of low back pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>none</td>
</tr>
<tr>
<td>2</td>
<td>Occasionally mild</td>
</tr>
<tr>
<td>1</td>
<td>Always present or sometime severe</td>
</tr>
<tr>
<td>0</td>
<td>Always severe</td>
</tr>
</tbody>
</table>

JOA: Japanese Orthopaedic Association

X-ray image study

Anterior-posterior and lateral X-ray images were taken preoperatively and during follow-up periods. The lumbar lordosis angle measured by Cobb method from the superior endplate of L\textsubscript{1} to the inferior endplate of L\textsubscript{5},\textsuperscript{13} lumbar range of motion (ROM) which is defined as the difference in lumbar lordosis angles between the flexion and extension lateral view films in the sagittal plane (Fig. 1), percentage of slip (% slip)\textsuperscript{14} and lateral intervertebral rotation angle\textsuperscript{12} (IRA, defined as the difference in intervertebral angle between flexion and extension lateral view films) at the decompressed level were measured on pre- and post-operative lateral X-ray images (Fig. 1).

Data analysis

All data were presented as the mean ± standard deviation and were analyzed using the statistical software package SPSS 13.0 (SPSS, Inc., Chicago, IL, USA). P<0.05 was defined as the significant level. Binary logistic regression analysis was used to detect the factors significantly related with the occurrence of residual LBP. Preoperative clinical factors (age at the time of operation, gender, duration of symptoms) and radiographic parameters (the lumbar lordosis angle, lumbar ROM, % slip, IRA, whether combined with
scoliosis) in both groups were collected and analyzed retrospectively. Thereafter, statistical differences were compared between the two groups using paired t test and independent sample t test.

RESULTS

Clinical outcomes after decompressive laminectomy

A total of 69 cases underwent single level laminectomy (including 48 additional foraminotomy) for surgical treatment and were successfully followed up for 6.33 ± 1.08 years (range from 6.0 to 9.75 years). The average preoperative JOA score of (14.8 ± 5.05) pts significantly improved to (21.59 ± 5.51) pts at the final follow-up (one sample t test, P<0.001) providing an average recovery rate of 49.36% ± 34.55 %. The mean LBP score improved from (1.59 ± 0.96) pts to (2.21 ± 0.33) pts even though the increase did not reach statistical significance (P=0.754). All patients complained of both sciatica and LBP preoperatively and obtained a complete relief in their leg pain immediately after surgery. Thereafter, the recurrence of radiculopathy was observed in 4 cases (One in recovery group and 3 in non-recovery group. The symptom was moderate and could be relieved by physical therapy) and refractory residual LBP developed in 15 cases that could be easily induced by long-term weight loading and movement of lumbar spine. Fig. 2 shows a typical case in non-recovery group. Both clinical and radiographic outcomes are showed in Table 2.

![Fig. 1 Delineation of the measurement of lumbar range of motion (ROM) and intervertebral rotation angle (IRA) that were defined as the difference in the lordotic and intervertebral angular measurements between the extension and flexion lateral radiographs respectively. ROM=Angle B - Angle A. IRA= Angle β - Angle α (provided L4-5 as the operated level).](image-url)

![Fig. 2 A patient in non-recovery group who had undergone second operation for severe residual low back pain and moderate leg pain 3 years after first operation. X-ray images revealed no significant difference between pre- (31° in Fig. 2A) and post-operative (32° in Fig. 2B) lordosis angle, but notable slippage (arrows in Fig. 2B) developed 3 years after primary treatment of L5 laminectomy (arrowhead in Fig. 2B), compared with the same level before operation (arrows in Fig. 2A). Additional posterior lumbar intervertebral fusion combined with fixation was performed for salvage (Fig. 2C), thereafter, the symptom of low back pain and radiculopathy relieved thoroughly.](image-url)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Whole group</th>
<th>Recovery group</th>
<th>Non-recovery group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preoperation</td>
<td>Final follow-up</td>
<td>Preoperation</td>
</tr>
<tr>
<td>Total JOA score</td>
<td>14.80 ± 5.05</td>
<td>21.59 ± 5.51*</td>
<td>14.73 ± 4.95</td>
</tr>
<tr>
<td>JOA LBP score</td>
<td>1.59 ± 0.96</td>
<td>2.21 ± 0.33</td>
<td>1.34 ± 0.72</td>
</tr>
<tr>
<td>Lumbar lordosis</td>
<td>38.41 ± 11.64</td>
<td>30.65 ± 2.04*</td>
<td>38.41 ± 11.64</td>
</tr>
</tbody>
</table>

JOA: Japanese Orthopaedic Association, LBP: low back pain, ROM: range of motion. All values represent as the mean ± standard deviation; *intra-group comparison with P value<0.05.
Forty-nine patients were classified in the recovery group and 20 cases who had no improvement of LBP during follow-up periods were involved in the non-recovery group. Preoperative demographics data including age, sex and general medical condition did not have significant difference between two groups. Statistical analysis demonstrated that the postoperative mean JOA scores in both groups significantly improved, compared to the preoperative JOA scores (P values were 0.001 and 0.002, respectively). Comparison between two groups revealed that the mean final JOA score in the recovery group was higher than that in the non-recovery group even though there was no significant difference (22.06 ± 5.23 points vs (20.80 ± 5.24 points, P=0.741). However, the mean final LBP score in the recovery group was significantly higher than that in the non-recovery group (2.33 ± 0.264) points vs (1.51 ± 0.23) points, (P=0.015).

### Results of binary logistic regression analysis

Binary logistic regression analysis revealed that most of parameters including preoperative JOA scores, sex, the duration of symptoms, % slip, IRA and the presence of preoperative scoliosis were not significantly correlated with residual LBP after surgery. In contrast, the significant prognostic factors of residual LBP were interestingly detected in the preoperative lumbar lordosis angle and ROM with odds ratio of 0.817 and 0.771 (P value being 0.001 and 0.003, respectively, Table 3).

Table 3. Binary logistic regression analysis for predictors of residual LBP (n=49)

<table>
<thead>
<tr>
<th>Variable</th>
<th>t</th>
<th>P</th>
<th>Odds ratios</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.910</td>
<td>0.236</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>0.270</td>
<td>0.850</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of symptom</td>
<td>0.377</td>
<td>0.268</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative JOA score</td>
<td>0.014</td>
<td>0.150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% slip</td>
<td>0.355</td>
<td>0.595</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With or without scoliosis</td>
<td>0.306</td>
<td>0.822</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative lordosis °</td>
<td>7.243</td>
<td>0.001</td>
<td>0.817</td>
<td>0.730-0.914</td>
</tr>
<tr>
<td>Preoperative ROM °</td>
<td>7.465</td>
<td>0.003</td>
<td>0.771</td>
<td>0.650-0.915</td>
</tr>
<tr>
<td>IRA of decompressed level</td>
<td>0.475</td>
<td>0.055</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Radiographic findings

In all patients, the mean preoperative lumbar lordosis angle and ROM were 38.41° ± 11.64° and 28.45° ± 1.55°, respectively. These parameters decreased after surgery and were roughly maintained over the follow-up periods (data not shown). At the final follow up, the mean lumbar lordosis angle and ROM were 30.65° ± 2.04° and 28.39° ± 1.51°, respectively. Statistical analysis have revealed no statistical significance between pre- and post-operation (P=0.052 and 0.796, respectively). In each group, the lumbar lordosis angle before operation and at the final follow-up revealed no statistical significance (paired t test, P=0.077 in recovery group and 0.156 in non-recovery group, respectively). In the recovery group, the lumbar ROM decreased from 30.51° ± 9.46° to 26.14° ± 10.17° (P=0.018), whereas, the lumbar ROM in non-recovery group developed from 22.45° ± 10.74° to 31.70° ± 9.66° (P=0.009). Inter-group comparison of preoperative lumbar lordosis and lumbar ROM indicated that both of this two parameters were significantly lower in the non-recovery group than that in the recovery group (lordosis: 22.00° ± 15.28° vs 38.41° ± 11.64°, P<0.001 and ROM: 22.45° ± 10.74° vs 30.51° ± 9.46°, P= 0.003). In addition, postoperative alternation of lumbar ROM was significantly larger in non-recovery group than in the recovery group (P=0.012).

### DISCUSSION

Decompressive laminectomy without spinal fusion has been widespread surgical procedure for degenerative spinal disorders such as LCS. Despite findings that in previous long-term follow-up studies had shown excellent or good results in more than 50% of patients with either LBP or sciatica, residual LBP after laminectomy for LCS is becoming one of the problems that need adequate attention. Datta et al noted that approximately 30% to 40% of patients continue to complain of severe back pain for long-term period after primary lumbar operation. This has been ascribed to the progression of degenerative disease of the spine and the onset of spondylolisthesis and also, Guyer et al noted that the etiology of the residual LBP could be due to poor patients selection such as incorrect diagnosis, suboptimal selection of surgery, and poor surgical technique. Independent from so many hypotheses mentioned above, preoperative radiographic analysis and evaluation are the most elemental and essential factors, which have been well studied previously.
Although there have been a number of discussions on the relationship between residual LBP after laminectomy and radiographic abnormalities such as vertebrae slippage and IRA,12,17 the correlation between residual LBP and sagittal radiographic parameters of the whole lumbar spine has rarely been studied. Furthermore, many authors have noted that the treatment of this residual LBP is often formidable.6,7 Therefore, the best management should be prevention and it is important to understand the mechanism of genesis and detect prognostic factors for the persistent LBP. The objective of present study was to conduct a statistical analysis to evaluate the influence of suspected clinical and radiographic factors so that the predictors of the occurrence of post-surgical residual LBP could be identified.

Current study showed that the minimal 6-year follow-up outcomes of laminectomy for LCS were favorable. Both the average JOA score and LBP score improved during follow-up. Our findings confirm that although decompressive laminectomy in patients with LCS can improve back pain, its main benefit is to alleviate the symptoms of neurogenic claudication, leg pain and disabilities associated with radiculopathy. According to our clinical data, 20 cases (28.99%) suffered from refractory residual LBP in which 8 cases underwent secondary salvage operation, and this incidence is concordant with many studies before.2,16 In some previous analysis, the clinical elements including patients’ age, gender, duration of symptoms and radiographic parameters such as IRA12 and whether combined with spondylolisthesis or scoliosis18 with poor results after laminectomy alone for treatment of LCS. In the current study, the lumbar lordosis and ROM were found to be prognostic factors for residual LBP. Both of these factors were thought to be correlated with sagittal plane alignment and balance of lumbar spine. The mean preoperative lumbar lordosis and ROM in the non-recovery group were significantly lower than those in the recovery group, which means that patients with flat back and limited lumbar mobility before surgery tend to have poor results in terms of LBP. Additionally, increase of the lumbar ROM after surgery was significantly larger in the non-recovery group. Patients who suffered from refractory residual LBP displayed anomalous higher ROM during follow-up periods. This paradoxically increased ROM on the flat lumbar spine whose mobility had been obviously limited before operation was thought to be correlated with postoperative residual LBP. It is presumed that multiple structural damages of the posterior elements in the vertebrae after laminectomy increased the load on the whole lumbar spine. If the lumbar has proper lordosis and adequate ROM observed in the cases of the recovery group preoperatively, the load might be shared and compensate by the reduction of mobility. In contrast, increased load on the lumbar spine without sufficient compensational reservation observed in the non-recovery group might break the global balance of lumbar spine and induce paradoxical increase of the ROM. Therefore, sagittal plane lumbar instability developed and stimulated nerve endings in and around the fibrous tissue of the disc and facet joint,1,19 generating severe residual LBP.

Recently, there is an increasing trend on recognition of the clinic importance of sagittal plane alignment and balance of lumbar spine.9,20,21 Many authors have found distinct differences in lumbar lordosis when comparing LBP patients with healthy patients.22,23 Post-surgical evaluations have also increasingly focused on the relationship between lumbar lordotic curvature and rehabilitative goals.24,25 However, the correlation between residual LBP after laminectomy and sagittal radiographic parameters of the whole lumbar spine has rarely been studied. In the current study, preoperative lordosis angle and lumbar ROM were found to be risk factors of the radiographic predictors for residual LBP after laminectomy for LCS. Statistical analysis demonstrates that patients with flat back and limited lumbar mobility before surgery tend to develop paradoxical increase of the ROM and get poor result of residual LBP, but interestingly, the lordosis angles show no statistical difference pre- and post-operation in either group. This result suggests that preoperative lordosis only combined with ROM of lumbar spine, can act as self-adjustment factors to play an important role in compensation to the instable tendency after laminectomy which will lead to severe residual LBP.

In conclusion, although an acceptable clinical result has been obtained by decompressive laminectomy alone in treatment of LCS in this minimal 6-year follow-up study, there are still 28.99% patients suffer from severe ongoing LBP. It is therefore crucial to identify potential risk factors before the operation to conduct optimal surgical selection. The results of the present study suggest that preoperative lordosis angle and lumbar ROM are the radiographic predictors for residual
LBP, therefore, these sagittal radiographic parameters should be taken into account when choosing laminectomy as the surgical option for LCS.

REFERENCES


(Received November 28, 2007)
Edited by SONG Shuang-ming