Diabetes and smoking as prognostic factors after cervical laminoplasty


From Yonsei University College of Medicine, Seoul, Korea

We reviewed 87 patients who had undergone expansive cervical laminoplasty between 1999 and 2005. These were divided into two groups: those who had diabetes mellitus and those who did not. There were 31 patients in the diabetes group and 56 in the control group. Although a significant improvement in the Japanese Orthopaedic Association score was seen in both groups, the post-operative recovery rate in the control group was better than that of the diabetic group. The patients’ age and symptom duration adversely affected the rate of recovery in the diabetic group only. Smoking did not affect the outcome in either group. A logistic regression analysis found diabetes and signal changes in the spinal cord on MRI to be significant risk factors for a poor outcome (odds ratio 2.86, 3.02, respectively). Furthermore, the interaction of diabetes with smoking and/or age increased this risk.

We conclude that diabetes mellitus, or the interaction of this with old age, can adversely affect outcome after cervical laminoplasty. However, smoking alone cannot be regarded as a risk factor.

Expansive open-door laminoplasty, pioneered by Hirabayashi et al. and Hirabayashi, Toyama and Chiba, is a useful surgical treatment for cervical myelopathy with satisfactory long-term results. The possible risk factors for a poor outcome include age, duration of symptoms, signal changes in the spinal cord on MRI and pre-operative sagittal alignment. However, the validity of these risk factors has been questioned.

Diabetes mellitus is a chronic systemic disease that may damage nerves and small blood vessels. This is thought to adversely affect the outlook of decompressive surgery in the lumbar spine. Diabetic neuropathy is also associated with risk factors for macrovascular disease and microvascular complications, such as smoking. Furthermore, smoking itself is known to have an adverse effect on the rate of lumbar spinal fusion. Hilibrand et al. have shown that smoking slows both healing and clinical recovery after anterior cervical fusion using autogenous interbody graft.

Nonetheless, there have been few studies that explore the relationship between diabetes mellitus, smoking and the outcome of surgery for cervical myelopathy. This study was designed to assess the effect of such risk factors on the outcome of cervical laminoplasty, while also investigating the interaction between the various prognostic factors.

Patients and Methods

We reviewed 87 patients who had undergone expansive cervical laminoplasty for the treatment of cervical myelopathy between 1999 and 2005. Only those who had been followed up for more than two years were included. The origin of the cervical myelopathy was either cervical spondylosis or ossification of the posterior longitudinal ligament. Each operation was carried out by one of two spinal surgeons (HML, SHM), both of whom had more than ten years of specialist experience. The mean age of the patients was 62.3 years (42 to 76) and the mean duration of symptoms was ten months (4 to 36).

Patients were divided into two groups, a diabetes mellitus group of 31, and a control group of 56. Each surgeon operated on a similar proportion of diabetic and control patients (10:21 of the diabetes group vs 18:38 of the control group). Every patient with diabetes had been symptomatic for more than five years. Of the 31 patients with diabetes, 27 (87.1%) were non-insulin dependent, and four (12.9%) were insulin dependent. All were well-controlled at the time of surgery.

Pre-operative prognostic factors, including age, duration of illness, signal changes in the spinal cord on MRI, pre-operative Japanese Orthopaedic Association (JOA) score, diabetes mellitus and smoking history were
noted. Signal changes on MRI in both T₁- and T₂-weighted images were evaluated by a single independent observer (MJ). Only an increased signal on T₂ with a decreased signal on T₁ was regarded as a signal change (Table I). We measured the C2-C7 angle, determined by tangential lines on the posterior edges of the C2 and C7 body. The angles were measured on the lateral radiographs in the neutral position.

The severity of myelopathy was assessed using the JOA scoring system. Outcome was evaluated using the recovery rate described by Hirabayashi et al., as follows:

\[ \text{recovery rate} (\%) = \frac{\text{post-operative JOA score} - \text{pre-operative JOA score}}{17 - \text{pre-operative JOA score}} \times 100 \]

The patient’s post-operative condition was assessed after two years using the JOA scoring system. The recovery rate was graded as ‘success’ (> 50% recovery rate), ‘improvement’ (> 0% but < 50% recovery rate), or ‘failure’ (no improvement or worse), and the outcome in the two groups was compared. For the purposes of logistic regression analysis for risk factors for a poor outcome, which was defined as a post-operative recovery rate of less than 50%, and a good outcome was defined as a recovery rate exceeding 50%, as previously described.\(^7,8,17\)

**Statistical analysis.** Prognostic factors and outcomes were compared using the Mann-Whitney U test. For each group, Wilcoxon’s signed-ranks test was used to compare the pre- and post-operative JOA scores. In order to evaluate whether each risk factor was correlated with surgical outcome, Pearson’s correlation test was used to calculate a correlation coefficient between recovery rate and each risk factor.

For patients with a poor outcome, the odds ratio with 95% confidence interval (CI) of each risk factor was calculated using univariate logistic regression analysis. Age, duration of symptoms, and pre-operative JOA score were assigned as continuous independent covariates. Diabetes, smoking history, and signal changes on MRI were assigned as categorical independent covariates. In order to identify their interactions for those with a poor outcome, risk factor analysis was performed by multivariate logistic regression using a forward stepwise procedure (p < 0.1 for entry) using the statistical package SPSS 12.01.1 (SPSS Inc., Chicago, Illinois). A value of p > 0.05 was considered significant.

**Results**

**Surgical outcome and prognostic factors.** The mean pre-operative JOA score was 10.4 (8 to 13) in the diabetic group and 10.6 (2.2) in the control group. There was no statistically significant difference between the prognostic factors in the two groups (Table I). The JOA score improved significantly in both groups. The mean recovery rate was 52.3% (0% to 100%) in the diabetic group and 70.4% (50% to 100%) in the control group. In the diabetic group, the percentage recovery rates of the four patients who were insulin dependent were 72.1%, 62.4%, 47.3% and 38.7%. When the recovery rates were graded as success, improvement and failure, four patients (12.9%) in the diabetic group (non-insulin dependent) were graded failure, with no JOA score improvement, but all patients in the control group showed some improvement (Table II). Both the mean post-operative score and the mean rate of recovery of the control group were significantly higher than those of the diabetic group (Table III). In addition within each group there was a significant improvement in the mean pre- and post-operative scores (p = 0.0002 and p = 0.001 respectively). Before surgery, the mean pre-operative cervical lordosis from C2 to C7 was 15.4° (7° to 41°). Two years after their surgery the post-operative lordosis was preserved in 85 patients, with a mean post-operative lordosis of...
lordosis angle of 13.9° (10° kyphosis to 35° lordosis). A cervical kyphosis was noted in one patient from each group.

Overall, age was the only factor that had a significant correlation with rate of recovery. There was no significant correlation between any prognostic factor and rate of recovery in the control group. By contrast, however, both age and duration of symptoms had a significant inverse relationship with recovery rate in the diabetic group (Table IV). Furthermore, a history of smoking had no effect on the outcome in either group (Fig. 1).

Univariate logistic regression analysis showed that age (odds ratio, 95% confidence interval (CI), 1.07, 1.09 to 1.14, diabetes (odds ratio, 95% CI, 2.86, 1.29 to 5.48), and signal changes in the spinal cord on MRI (odds ratio, 95% CI 3.02, 1.56 to 5.32) were risk factors for a poor outcome (Table V).

With multivariate logistic regression analysis, diabetes and signal changes on MRI proved to be significant risk factors for a poor outcome (diabetes odds ratio, 95% CI 2.92, 1.32 to 6.12, signal changes: 3.53, 1.67 to 5.95). Furthermore, the interaction of diabetes with smoking or with age increased the risk of a poor surgical outcome (diabetes with age odds ratio, 95% CI 2.21, 1.15 to 4.23, diabetes with smoking odds ratio, 95% CI 94.01, 1.89 to 8.32) (Table VI).

Discussion
Expansive cervical laminoplasty has been widely used for the treatment of cervical myelopathy.1-2 It achieves its effect by two different mechanisms: first, by direct decompression of the back of the spinal cord, and second, indirectly, by a posterior shift of the cord away from any anterior compressive lesion. Consequently, a post-operative cervical lordosis is essential, and many reports have emphasised the importance of cervical alignment as a prognostic factor.3-8

In each group there was a significant post-operative improvement in JOA score, and the degree of improvement was comparable with that reported in the literature.3,5-11,18 However, in contrast to a previous study by Kawaguchi et al,11 who reported similarly favourable outcomes in each group, we found that the outcome of the diabetic group was significantly inferior to that of the control group. One possible explanation may be that the diabetic patients in our study had symptoms for at least five years, whereas those in Kawaguchi et al11 study had been symptomatic for a

<table>
<thead>
<tr>
<th>Table III. Comparison of Japanese Orthopaedic Association (JOA) scores between pre-operative and post-operative states in the two groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetic group (n = 31)</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Pre-operative JOA score</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Post-operative JOA score</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Recovery rate (%)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>p-value*</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

* Mann-Whitney U test

<p>| Table IV. Correlation coefficient between prognostic factors and recovery rate |</p>
<table>
<thead>
<tr>
<th>All patients</th>
<th>Diabetic group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r value</td>
<td>p-value</td>
</tr>
<tr>
<td>Age</td>
<td>-0.46</td>
<td>0.01</td>
</tr>
<tr>
<td>Duration</td>
<td>-0.11</td>
<td>0.49</td>
</tr>
<tr>
<td>Pre-operative JOA* score</td>
<td>0.15</td>
<td>0.33</td>
</tr>
</tbody>
</table>
| * JOA, Japanese Orthopaedic Association

The relationship between smoking history and rates of recovery in the diabetes and control groups.

Fig. 1
minimum of one year. Alternatively, it may be the result of differences in sample size. This less-favourable outcome in diabetic patients has been reported in the lumbar spine. Several studies have described the changes that occur in the spinal cord and peripheral nerves in diabetic patients. These include infarcts, demyelination, atrophy, and softening of the posterior columns in the cord.12 Our results are also supported by previous reports of poor outcomes after decompressive surgery of the lumbar spine in diabetics.12 Clearly, if the nervous system is directly damaged by diabetes, decompression would not be expected to improve the resultant symptoms.19

Previous studies have suggested that the spinal cord is vulnerable in elderly patients as a result of age-related degeneration of its motor neurons and myelinated fibres.20,21 Our results support these findings, in that age and duration of symptoms had a negative effect on the rate of recovery in the diabetic group, although not in the control group. We think our results suggest a synergistic interaction of risk factors, which was not apparent in previous studies whereby the interplay between age and/or symptom duration and diabetes can adversely affect the surgical. In order to confirm an interaction between these risk factors we used logistic regression analysis, which supported our hypothesis. The interaction between diabetes and age and smoking history generated a significant odds ratio in patients with a poor outcome.

Smoking history failed to correlate with an increased risk of a poor outcome, whereas diabetes and smoking had an adverse effect when combined. However, it may be that our study was insufficiently powered to identify a significant difference between smokers and non-smokers. Although some clinical data support a correlation between the incidence of diabetic neuropathy and smoking and a harmful effect on peripheral circulation,22,23 its negative effect on the circulation of the spinal cord and peripheral nerves has yet to be determined.

Our study has several shortcomings. Firstly, we did not subdivide our cervical myelopathy group into a cervical spondylolisthesis group and an ossification of the posterior longitudinal ligament group. We do not think this affected our results, as a previous study showed that there was no short-term difference in surgical outcome between the two.6 Secondly, as the present study was retrospective, we could not fully evaluate the extent of the patients’ diabetic neuropathy. This study shows that patients with diabetes mellitus who have a cervical myelopathy can benefit from cervical laminoplasty. However, their rate of recovery is expected to be inferior to that of the patients without diabetes. Furthermore, the interaction of risk factors (diabetes and age, diabetes and smoking) can adversely affect the outcome after cervical laminoplasty. Further research is needed to evaluate smoking history as a risk factor after laminoplasty. The risk factors for an adverse outcome after laminoplasty should be considered collectively because of the evident interplay that we found between them.

This study was partly supported by a grant from the AO Spine Research Fund. We would like to thank E.-H. Choi for her assistance with the statistical analysis.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


