Expansive Open-door Laminoplasty for Cervical Compressive Myelopathy due to Multisegmental Spondylotic Canal Stenosis and OPLL: Evaluation of Clinical Outcome and Prognostic Factors

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ABSTRACT

Expansive laminoplasty has been widely used for treatment in patients with cervical compressive myelopathy. We evaluated the usefulness of expansive laminoplasty for patients with cervical canal stenosis due to multisegmental cervical spondylosis (CS) and ossification of the posterior longitudinal ligament (OPLL), and analyzed how the preoperative prognostic factors affect the outcome in both diseases. The authors reviewed 57 patients with CS and 25 patients with OPLL, who underwent expansive open-door laminoplasty. Pre- and post-operative clinical symptoms were evaluated by the Japan Orthopedic Association (JOA) disability score. The influences of predictive factors on the clinical outcome were analyzed by evaluating the recovery rate.

The mean functional recovery rate in JOA score was 60.5% in the CS group and 63.8% in the OPLL group, showing no significant difference between the two groups. While improvement in the lower limbs' motor function was better than that in the upper limbs in both groups, all the patients showed an improvement or reduction in symptoms of myelopathy. The mean recovery rate of sensory function was approximately 50% in both groups. In the CS group, the duration of symptoms and severity of preoperative disability significantly (p < 0.05) affected the operative outcome. In the OPLL group, the severity of preoperative disability and severity of canal stenosis showed significant influences on the operative outcome.

Open-door expansive laminoplasty in patients with cervical compressive myelopathy due to multisegmental CS or OPLL showed promising improvement of myelopathy. In order to improve the patient’s disability, early decompressive surgery following proper diagnosis must be done in these patients.

Key word: laminoplasty, cervical myelopathy, cervical canal stenosis, OPLL

INTRODUCTION

For the surgical treatment of cervical compressive myelopathy due to the multisegmental spondylotic canal stenosis (CS) or the ossification of the posterior longitudinal ligament (OPLL), posterior decompression by means of expansive laminoplasty has been used more frequently than anterior decompression or laminectomy [8, 9, 13, 21, 26]. While several expansive laminoplasty techniques have been developed, there seem to be no differences in the degree of the clinical outcome among them [18]. On
the other hand, some predictive or pre-operative factors are known to affect the clinical outcome: age [3, 12, 13, 15, 22]; duration of clinical symptoms before the operation [3, 4, 20]; severity of the pre-operative neurological disabilities [20]; presence of a minor trauma [1, 6]. However, the influence of each factor on the operative outcome showed controversial results among the studies. Furthermore, it is still unclear whether there is a significant difference in operative outcome and predictive factors between cases with CS and OPLL when the same operative method of posterior decompression was performed. In the present study, we retrospectively studied the clinical outcome in patients who underwent expansive open-door laminoplasty for cervical myelopathy due to multisegmental spondylotic canal stenosis (CS) and OPLL. The pre- and post-operative symptoms and their recovery rates were calculated using a scoring system. The correlation between each prognostic factor and recovery rate was analyzed in each group. Based on the results, we discussed how useful expansive laminoplasty is in improving the neurological ability with cervical compressive myelopathy both in the CS and OPLL groups.

MATERIALS AND METHODS

< Patient population >

The subjects were 82 consecutive patients with cervical compressive myelopathy due to multisegmental spondylotic canal stenosis or OPLL who underwent expansive open-door laminoplasty between January 1990 and December 1999, and were able to have a follow-up examination for more than twelve months. The patients with multisegmental spondylotic canal stenosis (CS Group) consisted of 57 cases and the patients with OPLL (OPLL group) consisted of 25 cases. The average age of the patients was 62.9 ± 11.9 years old (mean ± standard deviation) in the CS group and 61.4 ± 8.1 years old in the OPLL group.

The pre-operative and post-operative (12 months after operation) clinical symptoms were evaluated using a scoring scale by the Japanese Orthopedic Association (JOA). Seventeen points are accorded to patients with full function: four points (0 to 4) each for motor function of the lower or upper limbs; two points (0 to 2) each for sensory function of the lower limbs, upper limbs or trunk; three points (0 to 3) for urinary function. To assess the efficacy of the operation, percent recovery rate was calculated by the following formula: recovery rate (%) = ([postoperative score – preoperative score] ÷ [full score (17) – preoperative score] x 100.

< Patient selection >

In our department, surgical treatment for degenerative spinal disorders is considered in patients with progressing or unimproved myelopathy and/or radiculopathy, which made it difficult for the patients to work or perform their daily routine. Pre-operative imaging studies routinely consisted of plain cervical spine roentgenogram, computed tomography (CT) scan and magnetic resonance imaging (MRI). In the cases of cervical spondylosis, posterior decompression by expansive open-door laminoplasty...
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was selected as the surgical procedure for patients who showed myelopathy, with or without radiculopathy, due to multisegmental canal stenosis of more than three intervertebral levels on the imaging studies. Otherwise, patients who showed spondylotic lesions of less than two intervertebral levels were considered for anterior decompression and fusion. In the cases of OPLL, the patients with compressive myelopathy due to OPLL of more than three vertebral body lengths were selected for expansive laminoplasty rather than anterior decompression.

< Operative technique >

We used a method of en-block open-door laminoplasty described by Itoh and Tsuji [11] with the following modification. When the radiculopathy was accompanied with myelopathy, the open-door was made on the side of the radiculopathy and foraminotomy was performed on the involved root(s) at the open side. Through a conventional posterior midline approach, the spinous processes were cut at their bases. The lamina was exposed so that an opening could be made from one level caudal to one level rostral beyond the involved levels. Two gutters were made bilaterally in the laminae just medial to the auricular process using a high-speed drill. On the open side, each inner cortex of the lamina was almost completely cut. On the hinged side, each inner cortex was only partially cut to preserve the thin wall of the inner cortex. Then the laminae were elevated en-block by gently rolling toward the hinged side. Removed spinous process or hydroxyapatite spacer (Boneceram-P, Sumitomo Pharmaceutical Co., Ltd., Osaka, Japan) was used to fix the open door. (Fig. 1)

< Analysis of the prognostic factors >

The following prognostic factors possibly influencing the clinical outcome were evaluated: age at the time of operation, duration of the symptoms (in months), pre-operative narrowest antero-posterior spinal canal diameter (in mm) on CT, pre-operative JOA score as severity of preoperative symptoms. The duration of symptoms was estimated from the period of onset of the main neurological symptoms to the operation. All numerical data for each factor and recovery rate according to the JOA scoring system were entered in a computer. The correlation coefficient between numerical data in each factor and the recovery rate was calculated by regression analysis (Pearson's test). A p value less than 0.05 was regarded as significant in the analysis of all data.

RESULTS

< Pre-operative prognostic factors >

The mean values of age at the operation, duration of symptoms, cervical canal diameter and pre-operative JOA score were not significantly different between the two groups.

< Operative outcome >

The pre- and post-operative mean JOA total score, subscore and recovery rate in the two groups are shown in Table 1. Each pre- and postoperative subscore and total score showed no significant difference between the two groups. The mean recovery rate was 60.5% in the CS group and 63.8% in the OPLL group, and there was no significant difference between the two groups. Concerning the motor function of the extremities, the preoperative mean subscore in the lower limbs was smaller than that in the upper limbs, while the percent recovery was greater in the lower limbs (approximately 60%) than in the upper limbs (approximately 50%) in both groups. The pre-operative subscore of the sensory function in the upper limbs was smaller and the improvement was less than that in the lower limbs in both groups. However, no case presented worsening of the sensory functions of the upper limbs after the operation. (Table 1)

< Influences of predicting factors >

In the CS group, the duration of symptoms and severity of the pre-operative symptoms (JOA score) significantly influenced the clinical outcome. Regression analysis revealed a significant correlation coefficient between the recovery rate and the duration of symptoms (p = 0.041) and preoperative JOA score (p = 0.009). (Table 2) (Fig. 2, 3) In the OPLL group, the severity of pre-operative symptoms (p = 0.017) and the severity of canal stenosis (p = 0.039) showed a significant correlation coefficient between the
Table 1: Pre-operative and post-operative JOA score and recovery rate

<table>
<thead>
<tr>
<th>JOA score</th>
<th>Multisegmental Cervical spondylosis</th>
<th>OPLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full score</td>
<td>Pre-operative</td>
<td>Post-operative</td>
</tr>
<tr>
<td>Motor function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>upper limbs</td>
<td>4</td>
<td>3.14 ± 0.81</td>
</tr>
<tr>
<td>lower limbs</td>
<td>4</td>
<td>2.72 ± 0.98</td>
</tr>
<tr>
<td>Sensory function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>upper limbs</td>
<td>2</td>
<td>0.59 ± 0.67</td>
</tr>
<tr>
<td>lower limbs</td>
<td>2</td>
<td>1.17 ± 0.77</td>
</tr>
<tr>
<td>trunk</td>
<td>2</td>
<td>1.91 ± 0.29</td>
</tr>
<tr>
<td>Bladder function</td>
<td>3</td>
<td>2.81 ± 0.44</td>
</tr>
<tr>
<td>Total score</td>
<td>17</td>
<td>12.3 ± 2.38</td>
</tr>
<tr>
<td>Recovery rate (%)</td>
<td></td>
<td>60.5 ± 30.1</td>
</tr>
</tbody>
</table>

Values are mean ± standard deviation.

Table 2: Regression analysis between preoperative prognostic factors and recovery rate in the CS and OPLL group

<table>
<thead>
<tr>
<th>Factor</th>
<th>CS Group (n = 57)</th>
<th>OPLL Group (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regression analysis</td>
<td>Regression analysis</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>p</td>
</tr>
<tr>
<td>Age</td>
<td>0.100</td>
<td>0.456</td>
</tr>
<tr>
<td>Duration of symptoms (month)</td>
<td>0.228</td>
<td>0.041</td>
</tr>
<tr>
<td>Preoperative JOA score</td>
<td>0.333</td>
<td>0.009</td>
</tr>
<tr>
<td>Canal diameter (mm)</td>
<td>0.077</td>
<td>0.558</td>
</tr>
</tbody>
</table>

recovery rates. (Fig. 3, 4) In contrast, age at the time of the operation did not show a significant influence on the recovery rate in both groups. (Table 2)

DISCUSSION

Cervical spondylosis with the development of disc space narrowing, production of osteophytes, and ligamentous hypertrophy results in a circumferential narrowing of the cervical canal. The development of cervical myelopathy due to multisegmental spondylotic canal stenosis is suspected to involve two factors: a static factor due to stenotic compression of the spinal cord and a dynamic factor due to excessive movement or instability of the cervical spine [9]. The natural course of the symptoms in these patients with myelopathy remains unclear because most patient underwent the surgical treatment. However, it is true that most patients show insidious onset of myelopathy followed by incomplete recovery or intermittent decline [5, 19, 27]. Hence, surgical treatment must be considered when a precise diagnosis is being established. It has been well recognized that there is a significant correlation between aging and the development of myelopathy in surgically treated cases [12, 16]. A few studies have focused on the clinical outcome in elderly patients [17, 23]. One study revealed that elderly patients showed a significantly longer duration of symptoms that influenced the severity of symptoms and followed poorer surgical outcome in comparison to younger patients [17]. On the other hand, in the present study, the age at the time of operation did not significantly influence the operative outcome. In another study in our department, in which we reviewed an operative series of multisegmental cervical canal stenosis in the
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Fig. 2: Graphs showing the correlation between duration of symptoms and recovery rate in the two groups.

Fig. 3: Graphs showing the correlation between pre-operative JOA score and recovery rate in the two groups.

Fig. 4: Graphs showing the correlation between pre-operative canal diameter and recovery rate in the two groups.

Fig. 5: Graphs showing the correlation between age at the operation and recovery rate in the two groups.
elderly (70 years old and more), the mean value of the
duration of symptoms and severity of symptoms in
the elderly was not significantly different compared to
those in the younger patients [10]. The statistical
analysis revealed that the significant predictive factors
were the severity of canal stenosis and the duration of
symptoms in the elderly, and only severity of pre-
operative symptoms in the younger patients [10].
Those results indicated that a static factor rather than
a dynamic factor was involved in the development of
myelopathy in the elderly, and a dynamic factor was
involved in the younger patients. In contrast, in the
present study, the predictive factors in a series of
patients of all ages were longer duration and severer
pre-operative symptoms, which must be influenced by
both static and dynamic factors. These results indicate
that a precise diagnosis and operation must be done as
early as possible when patients present myelopathy,
especially in the elderly.

While, in patients with OPLL, severe stenosis of
the spinal canal may assist in prognostication
regarding recovery potential, a dynamic factor by
excessive movement rather than pure compressive
effects is recognized to be more important, especially
in patients with the segmental type of OPLL [2, 14].
A previous study revealed that, in OPLL patients with
myelopathy, the duration of myelopathy has been
found to be a most significant predictive factor for a
poor operative result [4]. The present study, however,
revealed that a significant predictive factor was not
only the severity of pre-operative symptoms but also
the severity of canal stenosis in our series, most of
who showed the continuous type of OPLL. It is well
recognized that, in such a continuous type of OPLL,
only a static factor may strongly influence the
development of myelopathy because of the lesser
instability of the entire cervical column. Furthermore,
it is well recognized that some OPLL patients show
no or less symptoms and the myelopathy appears as
an insidious onset [2]. It is easily suspected that the
spinal canal has become too narrow to cause the
spinal cord damage easily at the time when
myelopathy occurs. Hence, the present result
indicated that decompressive surgery must be done
before the development of the severe canal stenosis
and severe myelopathy presenting irreversible injury
of the spinal cord by possibly expanding OPLL
lesion.

Several operative techniques or modifications of
expansive laminoplasty have by now been developed
for the treatment of cervical canal stenosis. As
mentioned above, a previous study revealed that there
were no significant differences in the clinical results
among different types of operation [18]. The present
clinical outcome in each patient group was fairly
similar to those in other studies: the mean recovery
rate was approximately 60% or more according to the
JOA scoring system [7, 17, 21]. Comparing the
improvements between upper and lower legs in the
present series, both the motor and sensory functions
in the lower legs showed a higher percent recovery
than those in the upper legs in both groups. However,
no patient revealed a worsening of radiculopathy or
segmental symptoms in the upper legs after operation.
On the contrary, it has been reported that
approximately 5% of patients developed neurological
signs in the upper legs after decompressive
laminoplasty [21, 25]. The development of these signs
are suggested to be caused not only by a direct injury
but also by excessive or inappropriate widening of the
canal causing tethering of the nerve root [24] or
damaging the anterior horn region [7]. It is easily
suspected that the appearance of such a severe
segmental neurological deficit in the upper legs
seriously affects the patient's ADL even when
myelopathy has been ameliorated. For preventing
these mal-conditions, we added the foraminotomy
and did not expand the canal diameter excessively
more than 3 mm. The present results revealed a
promising clinical outcome after open-door expansive
laminoplasty in patients with compressive
myelopathy due to both spondylotic canal stenosis
and OPLL. To obtain a better outcome, we must
consider that the importance of the predictive
factor(s) in each patient group and also an appropriate
technique of expansive laminoplasty.

REFERENCES


Reviewer's comment：小山 素麿（大津市民病院 脊髄疾患臨床研究施設）

率直に言わせていただくと、長期の術後成績を調査する論文としては約10年間で82例では諸外国のものと比較すると例数が少ないことが残念です。しかし、調査の方法、成績の解析法には問題の付かれない学術的には非常に優れた論文であると思います。あえて疑問を言わせていただくと、OPLLの成績が狭窄の程度に大きく影響を受けているのであれば、なぜ高齢者の言うarticolo pillar lineとspinalaminal lineの間隔の狭い本来のbony canal stenosis（頚部脊椎管狭窄症）と正常の前後径を持ってい個体がmultisegamental spondylosisのため二次的狭窄症となった症例を区別されなかったかです。私は先天性、発育性のbony canal stenosisと椎間板、椎間板、黄色縁帯等の、すなわち転移組織も関与する頚部脊柱管狭窄症とは別のentityに入れる疾患と思えるからです。

日整会の腰痛疾患治療判定基準に比べると、頚髄治療判定基準は改定17（－2）点法、（100点法）とともに客観性はあるが、この論文でも両者とも平均年齢が手術時で60歳を超えており、これがもし10年後の調査ではどうだったかは疑問です。この点でも本論文が術後12ヶ月に調査を限定されたことが信頼性を増したと思います。加齢の要因を判定基準にどのように取り入れるか、高齢社会の現在、判定基準を考え直す時期がきたと思います。

Reviewer's comment: Kimihiko Mii, M.D.
Department of Neurosurgery, National Sagamihara Hospital, Kanagawa, Japan

The authors analysed the prognostic factors of the cervical spondylosis and cervical OPLL. Age, duration from onset, myelopathy grade and diameter of the spinal canal were analysed. For the past 20 years, the cervical spondylotic and OPLL patients were analysed in this manner. 10 years ago, the diameter, area and shape of the compressed spinal cord on CT myelograms were discussed. Recently, T2 high intensity areas on MRI were analysed. The authors method is outdated, but it may be beneficial to analyse again. They are neuro-surgeons, therefore, I regret that their viewpoint was not on the spinal cord.