Thoracic myelopathy caused by ossification of the ligamentum flavum: clinical features and surgical results in the Japanese population

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Object. Data obtained in patients with thoracic myelopathy caused by ossification of the ligamentum flavum (OLF) were retrospectively reviewed to clarify clinical features and surgical outcomes in the Japanese population.

Methods. Seventy-two patients who underwent surgery for OLF-induced myelopathy in the Miyagi Prefecture, Japan, between 1988 and 2002 were observed for at least 2 years. Clinical data were collected from medical and operative records. The patients were evaluated pre- and postoperatively using the modified Japanese Orthopaedic Association (JOA) scale (maximum score 11). The relationships among various factors (age, sex, and preoperative duration of symptoms) affecting the preoperative severity of myelopathy and postoperative improvement were also examined.

Conclusions. In this series the surgical outcome was relatively good and depended on the severity of myelopathy; thus early and correct diagnosis is required to avoid poorer results. The male/female ratio was 3.2 and the mean patient age at surgery was 61 years for men and 68 for women. The patients commonly noticed numbness or pain in their lower legs or gait disturbances. In a total of 104 decompressed intervertebral disc levels, more than 80% of the ossified ligaments were at the T9–10 level or lower. The mean preoperative JOA score of 5.1 improved to 7.9 after an average of 46 months. The postoperative results statistically depended on the preoperative severity of myelopathy. Among studies of patients with OLF-related myelopathy, the present study had the largest sample size, which should help clarify the clinical features of OLF myelopathy.

KEY WORDS • myelopathy • ossification • thoracic spine • ligamentum flavum • surgical outcome

Thoracic myelopathy caused by a degenerative process of the spine is rare. Unlike cervical myelopathy, its symptoms are not well recognized, even by spine surgeons, and it has often been overlooked or misdiagnosed as lumbar spinal disorder. Ossification of the ligamentum flavum is one of the causes of thoracic myelopathy. However, this is not widely accepted outside Japan, and previous studies on OLF myelopathy have involved only 50 or fewer patients. As a result of the paucity of research on the subject matter, the clinical features of OLF-induced myelopathy remain unclear.

Since 1988, all spine surgeries at orthopedic departments in the Miyagi Prefecture, a province in northeastern Japan with a population of approximately 2.3 million, have been enrolled in the registration system of the Department of Orthopaedic Surgery at the Tohoku University School of Medicine. This medical school is the only one in the province, and all of the hospitals in this prefecture are affiliated with this university. Historically, patients with compressive myelopathy in Japan have been mostly treated by spine surgeons in orthopedic departments, not by neurosurgeons. Sato and colleagues reported epidemiological data on 81 patients with thoracic myelopathy based on this registration system for 7 years between 1988 and 1994, including 42 patients with OLF-induced myelopathy. As the registry continued, more than 250 patients with thoracic myelopathy including 139 patients with OLF were surgically treated during the 15 years up to 2002. Of the 139 patients, 72 underwent follow up for 2
years or longer. Data obtained in these 72 patients were retrospectively reviewed to clarify the clinical features and surgical results of OLF-related myelopathy in the Miyagi Prefecture. Additionally, we examined the various factors affecting the preoperative severity of myelopathy and postoperative improvement.

Clinical Material and Methods

Patient Population

Between 1988 and 2002, 15,714 surgeries for spinal disorders performed at 30 hospitals in the Miyagi Prefecture were registered with the Department of Orthopaedic Surgery, Tohoku University School of Medicine. Of these operations, 14,458 were performed in residents of the prefecture and involved 278 operations for thoracic myelopathy caused by degenerative spinal disorders such as OPLL, OLF, and posterior spurs and intervertebral disc herniations. One hundred forty-two operations in 139 patients were performed to treat OLF-induced myelopathy, which accounted for 51% of all the operations for thoracic myelopathy caused by spinal degeneration. Three patients underwent revision surgeries, such as evacuation of a postoperative hematoma and posterior spinal fusion. During the 15 years of the study, the number of operations for OLF-related myelopathy increased from four to 22 annually, and the annual operative rate in the last 5 years was 0.6 per 100,000 inhabitants.

In 139 patients a diagnosis of OLF myelopathy was made based on neurological status and imaging studies, including CT scans and magnetic resonance images. The patients were surgically treated at 15 hospitals by highly experienced spine surgeons in the Miyagi Prefecture. Patients who had OLF combined with other compression-related factors (such as OPLL or a posterior spur) were excluded from this study because it was not decided which factor was responsible for the myelopathy. Of the 139 patients, 72 were evaluated preoperatively and observed for a minimum of 2 years postoperatively. These 72 patients form the basis of the present study.

Preoperative Clinical Features

The following data were collected from medical records to define the preoperative clinical features of OLF myelopathy patients: sex and age, initial symptoms, and duration from onset of initial symptoms to surgery (based on patients’ statements). Patients were divided into one of four groups to analyze the relationship between the preoperative duration and the severity of myelopathy. The groups were as follows, with symptom duration: 1) shorter than 6 months, 2) 6 months to 1 year, 3) 1 to 2 years, and 4) longer than 2 years. Each patient’s neurological condition was evaluated using the modified JOA scale, an 11-point scale measuring lower-extremity motor function and sensory and bladder functions. In this study, a JOA score of 3 or less was regarded as severe neurological impairment, 4 to 6 as moderate, and 7 or more as mild.

Perioperative and Postoperative Findings and Surgical Results

Localization of the surgically decompressed ossified ligamenta flava in relation to the intervertebral disc level, surgical procedures, and intraoperative findings—including the existence of the ossified dura mater that could not be excised—was determined from the operative records. Postoperative complications and the severity of myelopathy were also established by reviewing medical records. Surgical outcomes were represented by the postoperative JOA score and the recovery rate calculated as follows: (postoperative JOA score − preoperative JOA score)/(11 − preoperative JOA score) × 100.

Statistical Analysis

For statistical analysis, an analysis of variance was conducted using either the Fisher or chi-square test. A probability value less than 0.05 was considered significant.

Results

Preoperative Clinical Features

There were 55 men and 17 women whose mean ages at surgery were 61 and 68 years, respectively. Approximately 85% of the patients were older than 50 years of age. Most of the men were in their seventh decade of life; this was followed by those in their sixth decade and those in their eighth decade. Most of the women, however, were in their seventh and eighth decades of life. The most common initial symptom was a tingling sensation, numbness, or pain in the lower extremities, which was present in 49% of the patients. Twenty-five percent of patients complained of gait disturbance due to lower-limb weakness or spasticity, and 11% complained of back pain. The mean preoperative duration of symptoms was 22 months (Table 1).

The mean preoperative JOA score was 5.1 (range 0–9). The relationships between the preoperative neurological status and various factors are shown in Table 2. There were no statistically significant differences between the preoperative JOA score and sex, age, or preoperative duration of symptoms, although the scores documented in

<p>| TABLE 1 |
| Summary of data obtained in patients with thoracic myelopathy caused by OLF |</p>
<table>
<thead>
<tr>
<th>Factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>male/female</td>
<td>55:17</td>
</tr>
<tr>
<td>mean age (yrs) at surgery (range)</td>
<td>61 (38–79) - 68 (46–78)</td>
</tr>
<tr>
<td>initial symptoms (%)</td>
<td>49</td>
</tr>
<tr>
<td>tingling, numbness, or pain in legs</td>
<td>25</td>
</tr>
<tr>
<td>gait disturbance</td>
<td>11</td>
</tr>
<tr>
<td>back pain</td>
<td>15</td>
</tr>
<tr>
<td>mean preop duration of symptoms (mos)</td>
<td>22</td>
</tr>
<tr>
<td>range</td>
<td>1–132</td>
</tr>
<tr>
<td>surgical procedure</td>
<td>42</td>
</tr>
<tr>
<td>laminectomy</td>
<td>27</td>
</tr>
<tr>
<td>fenestration</td>
<td>3</td>
</tr>
<tr>
<td>laminectomy &amp; fenestration</td>
<td>8 (11)</td>
</tr>
</tbody>
</table>


515
The laminectomy procedure was most frequently located at the T2–3 segment. In the upper thoracic region, the ligamentum flavum did not fuse at the middle of the spinal canal or exist unilaterally. Thus, the ossified ligament could be removed by either fenestration or French-door laminectomy. On the other hand, in the latter two types, the ossifications of both sides fused so that they were removed by en bloc laminectomy. Through fenestration, the entire ligamentum flavum was removed through partial laminectomy and partial resection of the medial margin of the facet joint.19 The laminectomy procedure was most common followed by fenestration (Table 1). Before 1992, decompression in all 13 patients was accomplished via a laminectomy. Thereafter, fenestration was increasingly used and accounted for approximately half of all OLF surgeries. In nine patients, dural tears occurred during surgery. Eight of these had an ossified dura mater that could not be dissected from the ossified ligamentum flavum (Fig. 3). The disrupted dura mater was repaired by either primary suture or by placing an artificial dural patch. No patient needed additional treatment for cerebrospinal fluid leakage.

Postoperatively, the JOA scores improved to 7.9 (range 0–11) and the recovery rate averaged 47% (range 38 to 100%) at the last follow-up examination, which was, on average, 46 months (range 3 months–14 years) after surgery. The relationships between the postoperative neurological conditions and the recovery rate and various patient factors are shown in Table 3. The postoperative JOA scores obtained in patients with severe preoperative myelopathy were significantly lower than those documented in patients with moderate and mild myelopathy. Patients in whom the duration of myelopathy was longer as well as elderly male patients tended to have lower postoperative scores.


discussion

Thoracic spinal disorders are less common than those in the cervical and lumbar regions. Surgical treatment of these lesions accounted for 7% of all spinal surgeries in the Miyagi Prefecture and its surrounding area.21 The number of operations for thoracic myelopathy due to degenerative processes of the spine was even smaller, accounting for only 2% of all spinal surgeries. Ossification of the ligamentum flavum caused more than half of these.
Several previous studies on OLF myelopathy involved fewer than 50 patients, and thus OLF myelopathy’s clinical features remain unclear. In the present study, we collected data in 72 cases, which represents the largest population reported to date. Most reports of OLF myelopathy have originated from Japan, and this fact may suggest that the number of patients might be fewer outside Japan. Recently, however, several investigators have reported on Caucasian, Indian, North African, and Chinese patients.

The reason for the high incidence of OLF in the Japanese population is not clear. Authors of several recent studies have indicated that the development of OPLL is associated with certain genetic factors. These factors may also play a specific role in the origin of OLF.

In the present study we found that OLF-induced myelopathy frequently developed in the lower thoracic region in elderly males. The authors of previous studies have also indicated that OLF-related myelopathy most commonly occurred in the lower one third of the thoracic spine. The symptoms of OLF-induced myelopathy mimic those of lumbar disorders, resulting in misdiagnosis. Half of our patients first noticed lower-extremity tingling and numbness or pain; these symptoms can be the chief complaints among patients with lumbar disorders. Interestingly, 11% of the patients complained of back pain, which is in contrast to patients with cervical myelopathy who rarely experienced neck pain first. To establish a correct diagnosis of OLF-related myelopathy, a detailed neurological examination should be performed. In addition, a lower thoracic region magnetic resonance imaging study should be conducted once OLF-related myelopathy is suspected due to spasticity or multisegmental neurological deficits in the lower extremities.

Because OLF-related myelopathy affects the posterior part of the spinal canal, a laminectomy is indicated. Some technical modifications, however, have been developed during the 15 years of the study, based on the conditions of OLF. The ligamentum flavum bilaterally has two portions: medially, the interlaminar portion and, laterally, the capsular portion. Ossification usually begins in the capsular portion and spreads to the laminar portion. Ossification enlarges anteriorly toward the spinal cord. Bilateral ossifications then fuse in the middle of the lamina and thicken to form a central tuberous mass. These fused or
The current subse-

9

Cerebrospinal fluid leakage followed by the dis-

3,15,17,22

A postoperative

In the present study, the mean preop-

Neurological deterioration can

develop. The postoperative neurological condition de-


relationship between the JOA score and the preoperative severity of myel-

ossification of dura mater

central tuberous types of OLF frequently adhere to the dura mater or fuse with its ossification.3,8,15,17,22 The current procedure of choice involves fenestration involving all ligamenta flava for uni- or bilateral OLF at a single level without fusion in the middle. Fenestration, or French-door laminectomy, is performed for nonfused-type OLF at two levels or more. En bloc laminectomy is chosen to treat the fused or central tuberous types of OLF.3,9,17

Several peri- and postoperative complications have been reported in patients with OLF-induced myelopa-

th.19,22 Cerebrospinal fluid leakage followed by the dis-

ruption of dura is one of the major intraoperative complications. In this series, dural tears occurred in nine patients and most of them showed the ossified dura. In such cases, the ossified ligamentum flavum needs to be excised together with the ossified dura, keeping the arachnoid intact to avoid iatrogenic spinal cord damage.3,15,17,22 Subsequently, duraplasty is required, usually with the placement of artificial dura.3,5,15,17,22 Neurological deterioration can occur immediately after surgery because of unintended intraoperative spinal cord manipulation. A postoperative epidural hematoma can also cause dense paralisis, which was seen in one of our cases. Increased kyphotic spinal deformity after laminectomy can cause late-onset neuro-

degenerative disorder or localized back pain.3

Myelopathy caused by OLF is generally believed to progress slowly.16,24 In the present study, the mean preoperative duration of initial symptoms was nearly 2 years. Forty percent of the patients in whom the preoperative duration of symptoms was shorter than 6 months, howev-

er, had severe myelopathy, which suggests that in some cases, myelopathy progresses rapidly. Surgical decom-

pression has been the treatment of choice for compressive myelopathy, and the results of this study indicate that outcomes after decompression for OLF-induced myelopathy are stable.11 The postoperative neurological condition depended on the preoperative severity of myelopathy; patients with a shorter preoperative duration of symptoms tended to fare better than those in whom the duration of myelopathy was longer. Thus, patients who present early in the course of OLF with fewer disabilities should undergo surgery quickly to avoid deterioration of myelopathy and poorer results, which are highly possible if surgery is delayed.

Conclusions

Myelopathy caused by OLF is uncommon, particularly outside Japan. We have presented the clinical features and surgical results obtained in 72 patients with this disorder; this is the largest population reported to date. The surgical outcome was relatively good and depended on the severity of myelopathy; thus, early and correct diagnosis is required to avoid poorer results. Further education and study of OLF-induced myelopathy are necessary, not only for spine surgeons in Japan but also for neurosurgeons all over the world.

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