Ⅲ．研究成果の刊行に関する一覧表

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書籍

著者氏名	論文タイトル名	書籍全体の編集者名	書籍名	出版社名	出版地	出版年	ページ
濃沼信夫、川島孝一郎、伊藤道哉、武吉宏典	在宅医療の医療経済		高齢者の退院支援と在宅医療	メジカルビュー	東京	2006	210-217

雑誌

発表者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
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濃沼信夫	国際比較にみる日本の医療システム	ジェロントロジー New Horizon	18(3)	14-24	2006
Koinuma N, Monma Y, Ito M, Kaneko S	Comparison of habits of fracture group due to osteoporosis and non-fracture group using EQ-5D	QOL Journal	A	49	2006
濃沼信夫	がん医療の経済的評価	公衆衛生	71(2)	108-112	2006
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Aizawa T, Sato T, Sasaki H, Kusakabe T,	Thoracic Myelopathy Caused by Ossification of the Ligamentum Flavum: Clinical Features and	J. Neurosurg (Spine 2)	5	514-519	2006

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萩野 浩	高齢者の転倒の結果とその予後	高齢者に役立つ転倒予防の知識と実践プログラム		12-17	2006
片桐浩史、萩野 浩	骨折予防からみたEBM	CURRENT THERAPY	24(9)	775-778	2006
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Sakamoto K, Hagino H, et al	Report on the Japanese orthopaedic association's 3-year project observing hip fracture at fixed-point hospitals.	J Orthop Sci	11	127-134	2006
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大黒一司、	脳梗塞における入院リハ	病院管理	43	250	2006

濃沼信夫	ビリテーションの費用効果の検討		(Suppl)		
門馬靖武、大黒一司	骨粗鬆症関連骨折に関与する可能性のある生活習慣の検討	病院管理	43 (Suppl)	199	2006
門馬靖武、大黒一司	運動習慣に関する骨粗鬆症関連骨折と非骨折群との比較研究	第55回東北公衆衛生学会誌		26	2006

Ⅳ. 研究成果の刊行物・別刷

1739 /Comparison of Habits of Fracture Group Due to Osteoporosis and Non-Fracture Group Using EQ-5D

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AIMS: Osteoporosis is the main cause of fracture of the elderly and is a disease which has a possibility of spoiling the QOL greatly, by long-term treatment, concurrence of other diseases, deterioration of ADL, bedridden, and loss of a definite aim in life etc. This study is aimed at clarifying the preventive effect against fracture due to osteoporosis by improvement of the eating habits from a viewpoint of QOL. METHODS: The group of fracture due to osteoporosis and the non-fracture group using the pair-mach method. The questionnaire was distributed to the local residents of three areas aged 55 and over, and patients with fracture due to osteoporosis admitted in 40 hospitals. The questionnaire consists of about 90 items concerning eating habits in the age of 20 years old, 40 years old, and the present. As investigation of QOL, we used Euro QOL and VAS. RESULTS: The data from 2,076 local residents (response rate: 60.9%) and 55 inpatients (100%) was analyzed with the adjustment of sex and age. The items as which the significant difference was regarded between the fracture group and the non-fracture group are weight, menopause age, the number of years after menopause, apoplexy, the medicine against osteoporosis, depressor, milk, fermented soybeans, bread, meat, sesame oil, seaweed, and polished rice. It is a level of movement and usual activity that there was a significant difference statistically by the five items of Euro QOL. In the value of utility or VAS, there was no significant difference between two groups. It is reported that there is no significant difference in utility in two groups and our study is equal to the previous studies. However, there might be a limit in catching QOL of patient with fracture in respect of sensitivity since EQ-5D is not a tool to measure QOL of the disease specifically. CONCLUSIONS: We carried out a field survey to compare habits with fracture group with non-fracture group. In EQ-5D, it is movement and usual activity that the significant difference was observed in two groups and there was no difference in utility.

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J Neurosurg Spine 5:514–519, 2006

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.[3,12,18] 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.[16] Ossification of the ligamentum flavum is one of the causes of thoracic myelopathy.[3,24] 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.[1,3,8,9,12,14,16,18,22,24]

Abbreviations used in this paper: CT = computed tomography; JOA = Japanese Orthopaedic Association; OLF = ossification of the ligamentum flavum; OPLL = ossification of the posterior longitudinal ligament.

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.[7,16] 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.[7,16] Sato and colleagues[16] 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.[5] 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.[5]

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

TABLE 1

Summary of data obtained in patients with thoracic myelopathy caused by OLF

Factor	Value
male/female	55:17
mean age (yrs) at surgery (range)	
male	61 (38–79)
female	68 (46–78)
initial symptoms (%)	
tingling, numbness, or pain in legs	49
gait disturbance	25
back pain	11
other	15
mean preop duration of symptoms (mos)	22
range	1–132
surgical procedure	
laminectomy	42
fenestration	27
laminectomy & fenestration	3
no. of patients w/ ossified dura (%)	8 (11)

TABLE 2

Relationship of preoperative JOA score to various patient factors

Factors	No. of Patients	JOA Score (range)
sex		
male	55	5.2 (1–9)
female	17	4.8 (0–8)
age (yrs)		
≤65	39	5.3 (1–9)
>65	33	4.6 (0–8)
sex & age (yrs)		
male ≤65	34	5.3 (1–9)
male >65	21	5.0 (1–9)
female ≤65	5	5.2 (0–8)
female >65	12	4.6 (2–7)
preop duration of symptoms (mos)		
≤6	25	4.3 (0–8)
6–12	14	5.7 (3–8)
12–24	11	5.7 (3–9)
≥24	20	5.6 (2–9)
unknown	2	
ossification of dura mater		
present	8	4.5 (1–8)
absent	64	5.2 (0–9)
preop severity of myelopathy*		
mild (JOA score ≥7)	18	7.4
moderate (JOA score 4–6)	36	5.3
severe (JOA score ≤3)	18	2.4

* Statistically significant difference ($p < 0.05$) was detected only for the preoperative severity of myelopathy.

the patients in whom symptom duration was shorter than 6 months tended to be lower in patients in whom symptoms had been present for a longer duration. Of the 25 patients in whom symptoms had been present for 6 months or less, 40% had severe myelopathy whereas in the other symptom-duration groups, 14 to 18% of the patients suffered severe myelopathy.

Perioperative and Postoperative Findings and Surgical Results

Surgically decompressed levels considered to be responsible for OLF-induced myelopathy are shown in Fig. 1. There were 104 affected intervertebral disc levels in total: the T10–11 and T11–12 segments in 62%, the T9–10 level or lower in 75%. In the upper thoracic spine, OLF was mostly located at the T2–3 level, which accounted for 10% of all the decompressed ligamenta flava.

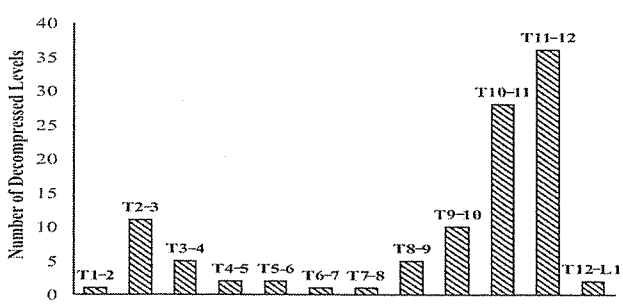

FIG. 1. Bar graph showing the distribution of OLF in relation to the intervertebral disc level considered responsible for the myelopathy. More than half of the ossified ligamenta flava are at the T10–11 and T11–12 levels. In the upper thoracic region, the lesions were most frequently located at the T2–3 segment.

The choice of surgical procedure was based on the CT classification of OLF; the lesion was categorized as lateral, extended, enlarged, fused, or tuberous (Fig. 2).[15,17] In the first three types, the ossifications in the bilateral 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. Scores in 66 patients (92%) improved, whereas in three (4%) the score either did not change or had decreased (Fig. 4). One patient suffered complete paralysis because of a postoperative epidural hematoma. The score in two patients decreased by one because they required support for walking on a level plane or on stairs after surgery. Four patients underwent further spinal surgery: two for OLF myelopathy at different thoracic levels, one for cervical spondylotic myelopathy, and one for lumbar spinal canal stenosis. No patient experienced thoracic myelopathy caused by the regrowth of OLF or spinal kyphotic deformity.

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.

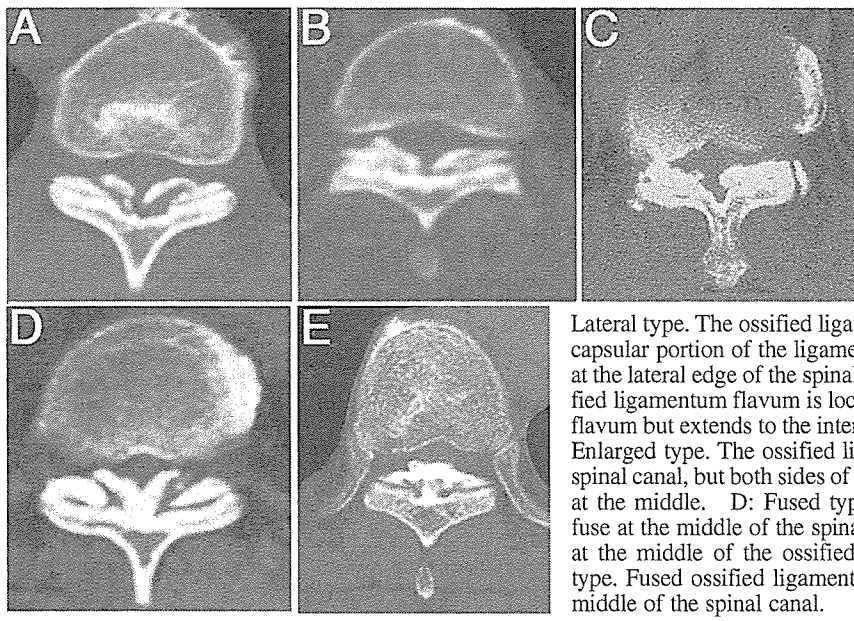

FIG. 2. The CT classification of OLF, with scans obtained at the middle of the facet joint. A: Lateral type. The ossified ligamentum flavum is located only in the capsular portion of the ligamentum flavum, which can be detected at the lateral edge of the spinal canal. B: Extended type. The ossified ligamentum flavum is located at the surface of the ligamentum flavum but extends to the interlaminar portion of the ligament. C: Enlarged type. The ossified ligamentum flavum protrudes into the spinal canal, but both sides of ossified ligamenta flava are not fused at the middle. D: Fused type. Bilateral ossified ligamenta flava fuse at the middle of the spinal canal, but an incision can be found at the middle of the ossified ligamentum flavum. E: Tuberous type. Fused ossified ligamenta flava make a tuberous mass at the middle of the spinal canal.

Several previous studies on OLF myelopathy involved fewer than 50 patients, and thus OLF myelopathy's clinical features remain unclear.[1,3,8,9,12,14,16,18,22,24] 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.[3,15–18,24] Recently, however, several investigators have reported on Caucasian, Indian, North African, and Chinese patients.[1,3,9,12,14,22]

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.[6,10,20,23] 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.[13,19] The symptoms of OLF-induced myelopathy mimic those of lumbar disorders, resulting in misdiagnosis.[12,16,24] 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.[2,4,7] 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.[15,17] The ligamentum flavum bilaterally has two portions: medially, the interlaminar portion and, laterally, the capsular portion.[22] 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.[15,22] These fused or

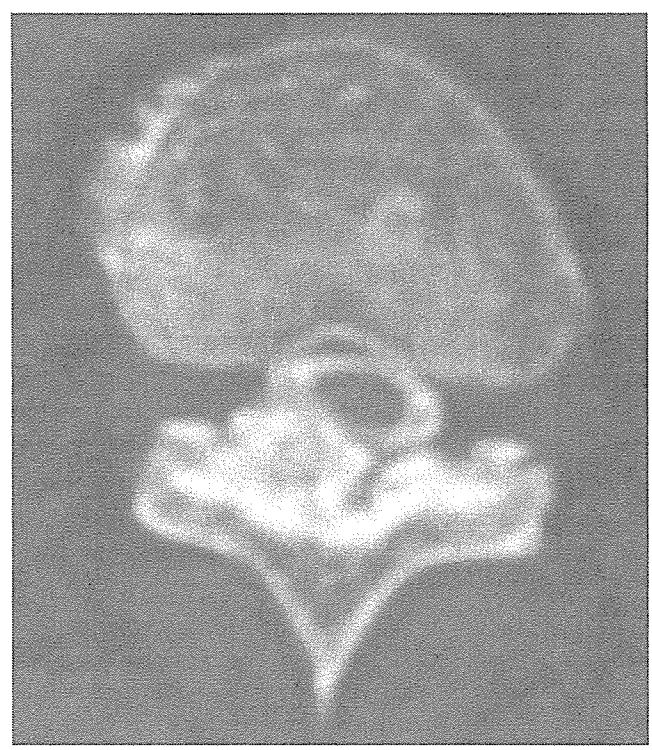

FIG. 3. Preoperative CT myelogram obtained in a patient with OLF and ossified dura mater at the T10–11 level. The ossified ligamentum flavum adheres to the ossified dura on the right side of the spinal cord, and little contrast medium between the cord and ossified ligamentum flavum is detected.

TABLE 3

Relationship of postoperative JOA score and recovery rate to various patient factors

Factor	Postop Variable (range)	
	JOA Score	Recovery Rate (%)
sex		
male	7.7 (0–11)	46 (−38 to 100)
female	8.3 (4–10)	54 (0 to 88)
age (yrs)		
≤65	8.0 (0-11)	46 (−38 to 100)
>65	7.7 (2-11)	48 (0 to 100)
sex & age		
male ≤65	8.0 (0–11)	47 (−38 to 100)
male >65	7.3 (2–11)	42 (0 to 100)
female ≤65	8.0 (6–9)	43 (0 to 60)
female >65	8.4 (4–10)	60 (22 to 88)
preop duration of symptoms (mos)		
≤6	8.0 (4–11)	54 (−25 to 100)
6–12	8.3 (5–11)	47 (0 to 100)
12–24	7.6 (0–11)	43 (−38 to 100)
≥24	7.7 (4–10)	41 (−25 to 75)
ossification of dura mater		
present	6.5 (0–11)	30 (−38 to 100)
absent	8.0 (4–11)	49 (−25 to 100)
preop severity of myelopathy*		
mild (JOA score ≥7)	9.0 (6–11)	45 (−38 to 100)
moderate (JOA score 4–6)	8.2 (4–11)	51 (0 to 100)
severe (JOA score ≤3)	5.9 (0–11)	41 (−25 to 100)

* A statistically significant difference ($p < 0.05$) was detected only in the relationship between the JOA score and the preoperative severity of myelopathy.

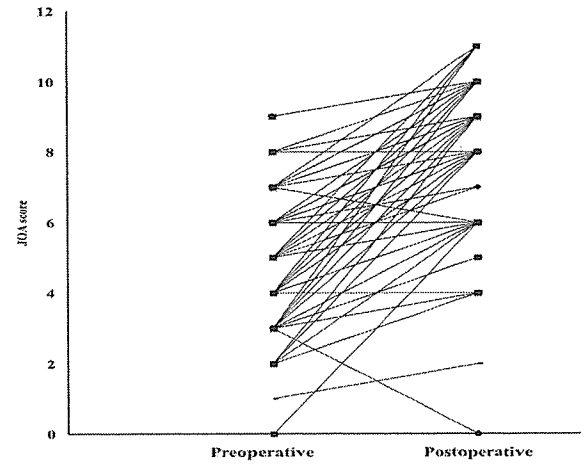

FIG. 4. Line graph showing the pre- and postoperative JOA scores obtained in 72 patients. The score improved in 66 patients during a mean follow-up period of 46 months.

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.[15,17]

Several peri- and postoperative complications have been reported in patients with OLF-induced myelopathy.[3,9,22] Cerebrospinal fluid leakage followed by the disruption 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.[3,15,17,22] Neurological deterioration can occur immediately after surgery because of unintended intraoperative spinal cord manipulation.[9] A postoperative epidural hematoma can also cause dense paralysis, which was seen in one of our cases. Increased kyphotic spinal deformity after laminectomy can cause late-onset neurological deterioration or localized back pain.[3]

Myelopathy caused by OLF is generally believed to progress slowly.[18,24] 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, however, had severe myelopathy, which suggests that in some cases, myelopathy progresses rapidly. Surgical decompression 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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Thoracic Myelopathy in Japan: Epidemiological Retrospective Study in Miyagi Prefecture during 15 Years

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Aizawa, T., Sato T., Tanaka, Y., Ozawa, H., Hoshikawa, T., Ishii, Y., Morozumi, N., Ishibashi, K., Kasama F., Hyodo, H., Murakami, E., Nishihira T. and Kokubun, S. *Thoracic Myelopathy in Japan: Epidemiological Retrospective Study in Miyagi Prefecture during 15 Years.* Tohoku J. Exp. Med., **210** (3), 199-208 —— Thoracic myelopathy is defined as spinal cord compression in the thoracic region, leading to sensory and motor dysfunctions in the trunk and lower extremities, and can be caused by various degenerative processes of the spine. Thoracic myelopathy is rare, and there are many unsolved problems including its epidemiological and clinical features. We have established a registration system of spinal surgeries, which covered almost all surgeries in Miyagi Prefecture, and enrolled the data of 265 patients with thoracic myelopathy from 1988 to 2002. The annual rate of surgery gradually increased and averaged 0.9 per 100,000 inhabitants, which was less than 1/10 of that for cervical myelopathy. About 20 patients with thoracic myelopathy are operated on in Miyagi Prefecture each year. It frequently develops in middle-aged males. About half of the cases were caused by ossification of the ligamentum flavum, followed by ossification of the posterior longitudinal ligament, intervertebral disc herniation and posterior spur. Patients usually noticed numbness or pain in the legs and the preoperative duration was long, averaging 2 years. Its symptomatic similarities to lumbar disorders might cause difficulty in making a correct diagnosis. Since thoracic myelopathy can markedly restrict the activities of daily life, even general physicians should recognize this entity. ——
thoracic myelopathy; epidemiological study; ossification of the ligamentum flavum; ossification of the posterior longitudinal ligament

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Thoracic myelopathy is defined as spinal cord compression in the thoracic region, leading to sensory and motor dysfunctions in the trunk and lower extremities and urinary disturbance, and can be caused by various degenerative processes of the spine such as intervertebral disc herniation (HE), ossification of the posterior longitudinal ligament (OPLL) and the ligamentum flavum (OLF), and posterior spur (SP) (Smith and Godersky 1987; Yonenobu et al. 1987; Otani et al. 1988; Mitra et al. 1996; Sato et al. 1997a; Fong and Wong 2004). The posterior longitudinal ligament connects the posterior aspects of the vertebral body while the ligamentum flavum is located in the interlaminar space. OPLL, HE and SP can compress the spinal cord from the anterior and OLF from the posterior.

Unlike cervical myelopathy, the symptomatology of thoracic myelopathy is not well recognized by orthopedists or even by spine surgeons or neurosurgeons. It has often been overlooked or misdiagnosed as lumbar spinal disorders as the symptoms involve mainly the lower extremities (Mitra et al. 1996; Sato et al. 1997a). The number of the patients with thoracic myelopathy is much smaller than that of those with cervical or lumbar disorders (Mitra et al. 1996; Sato et al. 1997a). Most previous studies reviewed fewer than 100 patients, usually 30 patients or less (Yonenobu et al. 1987; Shiokawa et al. 2001; Hamouda et al. 2003). Thus, few epidemiological studies have assessed the true incidence of thoracic myelopathy necessitating surgery compared with cervical or lumbar disorders. In addition, the clinical features of thoracic myelopathy including the prevalence, age distribution, initial symptoms and the rate of corresponding spinal factors remain unclear.

Since 1988, all spine surgeries at the orthopedic departments in Miyagi Prefecture, a province in northeastern Japan with a population of about 2.3 million, have been enrolled in the registration system of the Department of Orthopaedic Surgery, Tohoku University School of Medicine (Kokubun et al. 1996; Sato et al. 1997a). Historically in Japan, patients with compressive myelopathy have been usually treated by orthopedic surgeons rather than by neurosurgeons. Therefore, the data from this registration system should be reliable and, based on these data, we have reported several epidemiological studies (Kokubun et al. 1996; Sato et al. 1997a; Tanaka et al. 2003). Sato et al. (1997a), reported the epidemiological data on 81 patients with thoracic myelopathy based on this registration system for the 7 years between 1988 and 1994. To our knowledge, no other epidemiological studies on it have been reported from Japan or other countries. As the registry continued, more than 250 patients were surgically treated for thoracic myelopathy during the 15 years to 2002. Using these data, the purpose of this study was to define the epidemiological and clinical features of thoracic myelopathy in the Japanese. This paper focuses on the epidemiological findings of this myelopathy in Miyagi Prefecture and not on the surgical outcomes nor on an analysis of the factors affecting the postoperative improvement.

Materials and Methods

This study was approved by the Ethical Committee of Tohoku University School of Medicine. Between 1988 and 2002, 15,714 surgical operations at 30 hospitals in Miyagi Prefecture were enrolled by the registration system of the Department of Orthopaedic Surgery, Tohoku University School of Medicine (Kokubun et al. 1996; Sato et al. 1997a). Two hundreds and sixty five patients with thoracic myelopathy required surgical intervention among the 14,458 patients in total who were the residents of this prefecture and underwent spinal surgeries within the prefecture. These 265 patients were the subjects of this study. Ten patients required 2 to 3 revisions, secondary posterior fusion, dura mater repair, addition decompression, and therefore, totally 278 surgical operations were performed, which accounted for 2% of all the spinal surgeries.

Neurological deficits attributed to thoracic myelopathy mostly included lower-extremity hyperreflexia, plank paraparesis, and/or sphincter dysfunction. Neurodiagnostic studies confirming this disorder included abnormal myelograms, computed tomograms (CT) and/or magnetic resonance imaging (MRI) studies. The diagnoses and subsequent surgical operations were performed by highly experienced spinal surgeons at 15 of the 30 hospitals in Miyagi prefecture. Cases of thoracic

myelopathy caused by spinal cord tumor, primary or metastatic bone tumor, infection, spinal cord herniation (Aizawa et al. 2001), and fracture or fracture dislocation, were excluded from the current study.

The number of operations in each year was counted and the annual rate per 100,000 inhabitants in Miyagi Prefecture was calculated using the annual population of this prefecture. Variables contributing to the clinical features of thoracic myelopathy were assessed for the 265 patients: the gender and age, the initial symptoms, the preoperative duration from the onset of the initial symptoms, the compressive factors for the spinal cord and the locations in relation to the intervertebral disc levels, and the types of surgical procedures. In addition, operative findings on ossification of the dura mater that could not be dissected from OLF, which is closely related to the difficulty of the surgery, were investigated in the OLF patients. The preoperative disease period was divided into four: shorter than 6 months, from 6 months to 1 year, from 1 to 2 years, and 2 years or longer.

Results

The annual rate of surgery for thoracic myelopathy in Miyagi Prefecture gradually increased and the average rate per 100,000 inhabitants for 5-year periods was 0.5 between 1988 and 1992, 0.8 between 1993 and 1997 and 0.9 between 1998 and 2002 (Fig. 1). The last rate was thus almost double that of the earliest period.

Of the 265 patients undergoing thoracic decompressions, males significantly outnumbered females (2.2 ratio), and were younger on average than their female counterparts (Table 1). The highest prevalence was for male patients in their sixties, followed by those in their fifties and seventies. On the other hand, the prevalence was almost similar for female patients in their fifties, sixties and seventies and they together accounted for about 80% of all patients (Fig. 2).

OLF, OPLL, HE, and SP were most consistently contributing spinal factors to thoracic myelopathy, with half showing OLF, followed by OPLL, HE, and OLF with OPLL and SP (Fig. 3). Three patients had a combination of two of OLF, HE or SP. The remaining 13 patients had rare factors such as kyphoscoliosis (Sato et al. 1997b), spondylolisthesis, or spinal canal stenosis in association with achondroplasia.

The most common initial symptoms included numbness and tingling or pain in the lower extremities, followed by spastic gait and/or weakness. A handful (5%) of patients complained of back pain. A few patients noted atrophy/cramping of the lower extremities first. The preoperative duration from the onset of the initial symptoms averaged 2 years and about half of the patients showed symptoms longer than 1 year while one third were less than 6 months. HE patients showed the shortest preoperative durations while those of the SP patients were relatively long. The mean age at surgery of the SP and HE patients

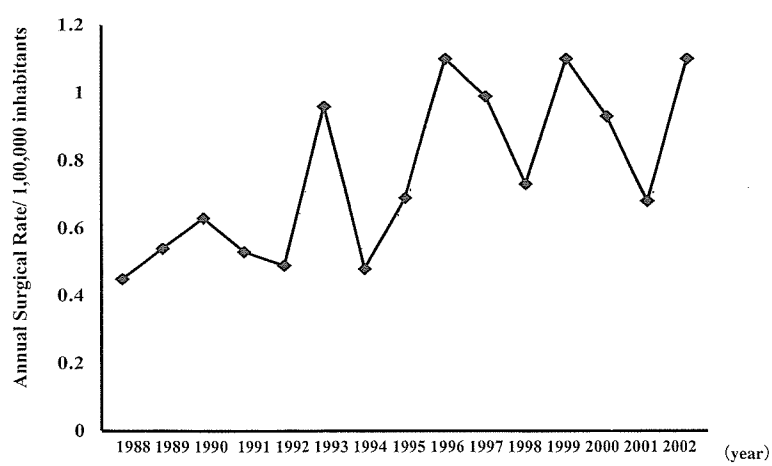


Fig. 1. Yearly changes in the surgical rate for patients with thoracic myelopathy in Miyagi Prefecture from 1988 to 2002.

TABLE 1. Summary of the patients with thoracic myelopathy.

Male: Female	182: 83*
Mean age at surgery	
Male (n = 182)	59 yrs (range; 29-84)
Female (n = 83)	63 yrs (range; 32-85)
OLF (n = 139)	64 yrs (range; 38-85)
OPLL (n = 33)	58 yrs (range; 39-84)
OLF + OPLL (n = 25)	58 yrs (range; 36-73)
HE (n = 30)	56 yrs (range; 38-79)
SP (n = 22)	49 yrs (range; 29-72)
Initial symptoms (n = 178)	
Tingling, numbness or pain in legs	56% (n = 100)
Gait disturbance	35% (n = 62)
Back pain	5% (n = 9)
Others	4% (n = 7)
Averaged preoperative duration of symptoms	2 yrs (range; 1 month-18 yrs)
≦ 6 month	49 patients
6 months < ≦ 1yr	34 patients
1 yr ≦ < 2 yrs	29 patients
≧ 2 yrs	43 patients
Unknown or not decidable	110 patients
OLF (n = 139)	1.8 yrs (range; 1 month-11 yrs)
OPLL (n = 33)	2.1 yrs (range; 1 month-17 yrs)
OLF + OPLL (n = 25)	2.4 yrs (range; 2 month-14 yrs)
HE (n = 30)	1.0 yrs (range; 1 month-6 yrs)
SP (n = 22)	3.0 yrs (range; 2 month-18yrs)

OLF, ossification of the ligamentum flavum; OPLL, ossification of the posterior longitudinal ligament; HE, intervertebral disc herniation; SP, posterior spur.

Statistically significant differences can be detected only in the male/ female ratio. $^{*}p < 0.05$.

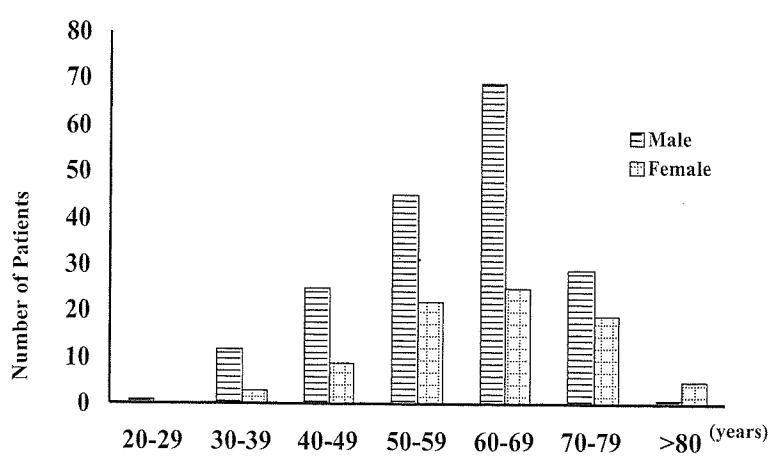


Fig. 2. Age distribution of the patients with thoracic myelopathy in Miyagi Prefecture. Among males, the patients in their sixties show the highest prevalence, and among females, those in the fifties, sixties and seventies show almost equal prevalences.

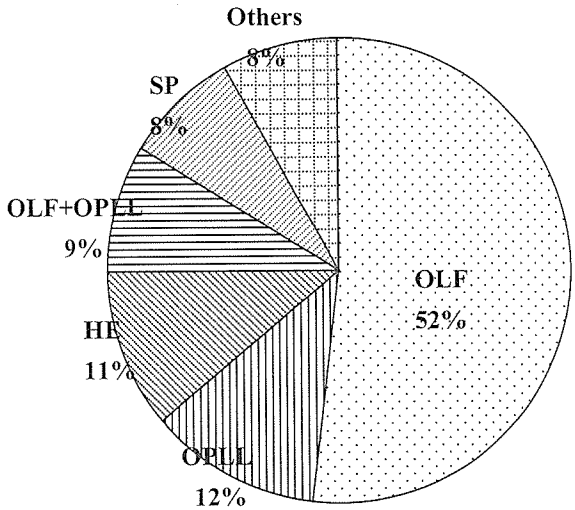


Fig. 3. Spinal factors compressing the spinal cord leading to thoracic myelopathy.
OLF, ossification of the ligamentum flavum; OPLL, ossification of the posterior longitudinal ligament; HE, intervertebral disc herniation; SP, posterior spur.

was lower than that of those with the other compressive spinal factors (Table 1).

The decompression levels for the four major factors, OLF, OPLL, HE and SP, considered to be responsible for the thoracic myelopathy are shown in Fig. 4. The patients having a combination of two of those factors were excluded as it was uncertain which factor was responsible for the myelopathy. The surgical levels for OLF were between T10/11 and T11/12 in 65%, for OPLL they were between T1/2 and T6/7 in 84%, for HE at T7/8 or lower in 90%, and for SP between T10/11 and T12/L1 in 64%.

The surgical procedures for the four major compressing factors are summarized in Table 2. Laminectomy was most frequently performed for OLF followed by fenestration, partial resection of the lamina with the spinous process and upper part of the lamina kept intact. Before 1993, laminectomy was performed in 24 of 27 patients and hemilaminectomy in the others. Thereafter, OLF at a single level without fusion in the middle of the spinal canal was usually removed by fenestration and laminectomy, and fenestration was performed with equal frequency (Sato et al. 1998). Ossified dura mater that could not be dissected

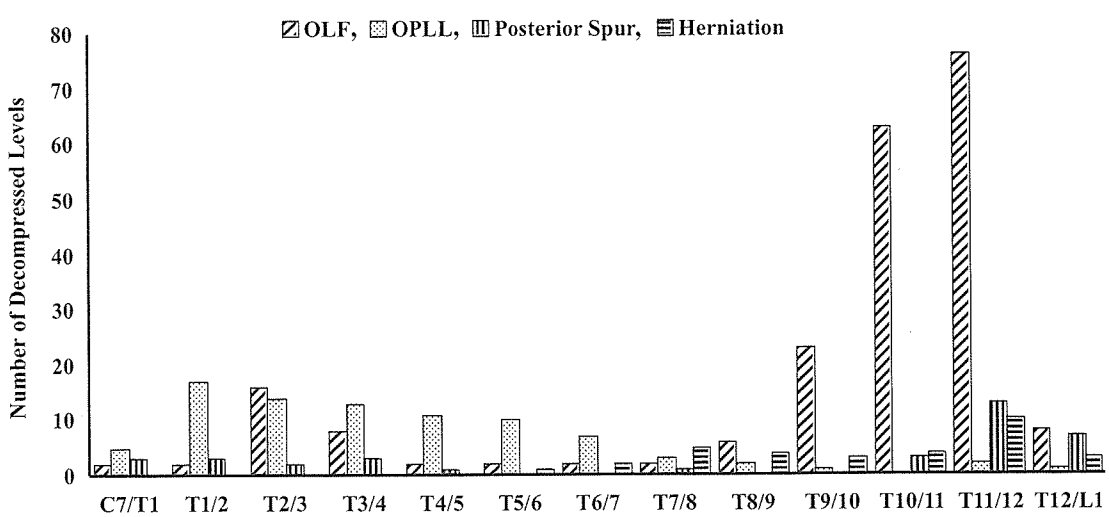


Fig. 4. Distribution of the four major compressive factors in the spinal cord in relation to the intervertebral disc level.
OLF is most common in the lower thoracic spine while OPLL is frequently distributed in the upper to middle thoracic. Intervertebral disc herniation is mainly detected in the middle and lower thoracic spine and posterior spur in the lower thoracic spine.

TABLE 2. Surgical procedures for the common compressing spinal factors in thoracic myelopathy.

OLF	139 patients
Laminectomy	78
Fenestration	45
Laminectomy + fenestration	9
Hemilaminectomy	3
Others	4
OPLL	33 patients
Laminectomy	24
Anterior decompression through posterior approach "Otsuka"	2
Anterior decompression & spinal fusion	2
Anterior decompression through a diagonal anterior and posterior approach	2
Others	3
OLF + OPLL	25 patients
Laminectomy	18
Laminoplasty + laminectomy	3
Fenestration	2
Anterior decompression through posterior approach "Otsuka"	2
Disc herniation	30 patients
Anterior decompression & spinal fusion	13
Hemilaminectomy	6
Transverso-arthro-pediculectomy	6
Others	5
Posterior spur	22 patients
Anterior decompression & spinal fusion	12
Laminectomy	6
Others	4

OLF, ossification of the ligamentum flavum; OPLL, ossification of the posterior longitudinal ligament; HE, intervertebral disc herniation; SP, posterior spur.

from the OLF was observed in 12 (9%) of 139 patients who had OLF alone (Fig. 5). Thick or beak-like OPLL combined with or without OLF (Fig. 6) usually compressed the spinal cord very severely and laminectomy alone could not achieve sufficient decompression. In such cases, anterior decompression through a diagonal anterior and posterior approach was done for two patients before 1994 (Kokubun et al. 1991), and anterior decompression through posterior approach described by Otsuka et al. (1983) was adopted for four patients after 1997. HE was treated by anterior decompression and spinal fusion (ASF) through an extrapleural or thoracotomy approach before 1996 and mainly by discectomy through a transverso-arthro-pediculectomy approach from the posterior afterwards (Sato 2003).

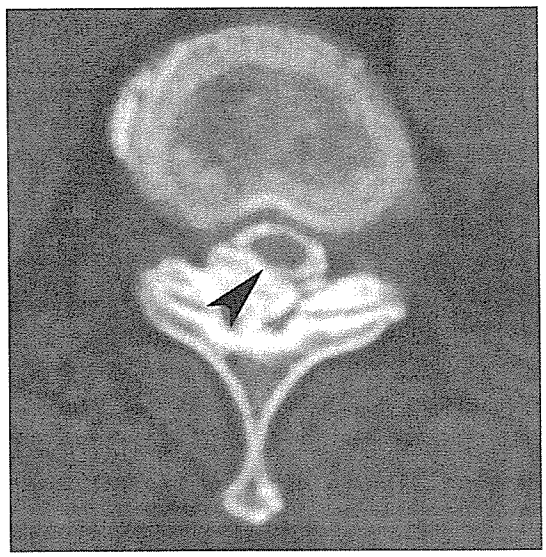
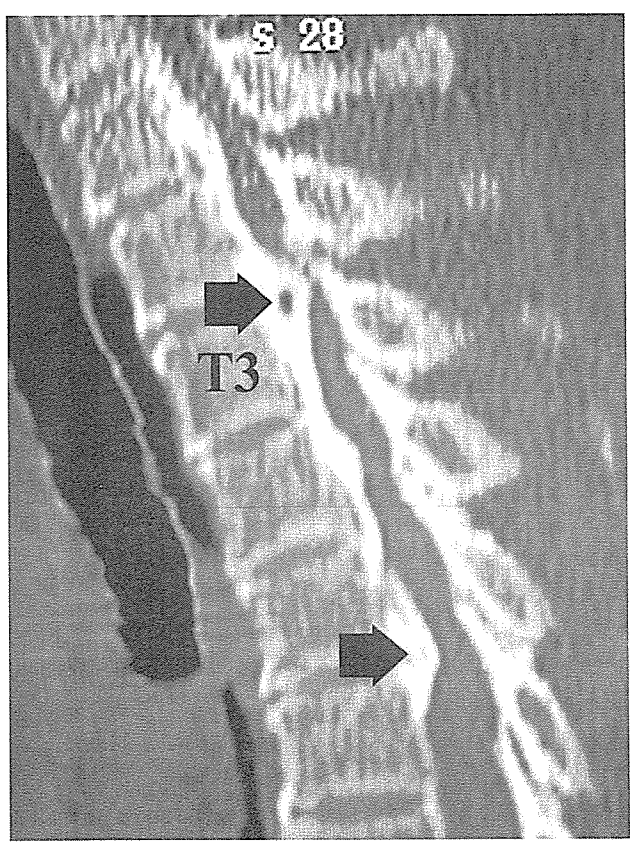


Fig. 5. Preoperative CT-myelogram of OLF with ossified dura mater at T10/11.
OLF protrudes right-ventrally and the contrast medium between the spinal cord and OLF can not be detected (arrowhead).

A



B

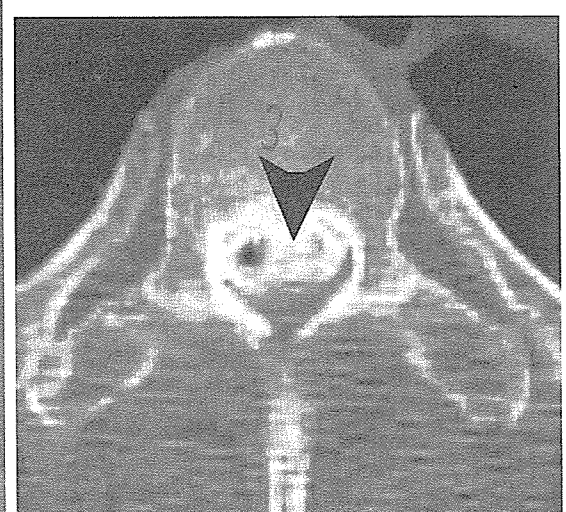


Fig. 6. Preoperative CT of a patient with OPLL.
A: Sagittal plane. Continuous OPLL can be found in the upper thoracic spine including beak-like regions (arrows).
B: Axial plane. Thick OPLL occupies the spinal canal at T3 level (arrowhead).

Discussion

Thoracic spinal disorders including tumors and fractures warranting surgical intervention constituted only 7% of all spinal procedures performed in the registration system of the Department of Orthopaedic Surgery, Tohoku University School of Medicine (Tanaka et al. 2003). Cases of thoracic myelopathy caused by degenerative processes of spine were even fewer, representing only 2% of all the spinal surgeries in this study. The annual rate of surgery was 0.9 per 100,000 inhabitants from 1998 to 2002 in Miyagi Prefecture, which was less than 1/10 of that for cervical myelopathy (10.9) in the same prefecture in the same period, but nearly doubled during those 15 years (Tanaka et al. 2003). This increase might be attributed to advances in neurodiagnostic imaging including CT and MRI and in the training of spinal surgeons.

The present study showed that thoracic myelopathy more frequently develops in middle-aged males. Previous studies also indicated that male cases were more common than female cases (Sato et al. 1997a; Shiokawa et al. 2001; Hamouda et al. 2003). Thoracic myelopathy patients were younger at operation than those with cervical myelopathy. The patients in the latter group were more frequently in their sixties to seventies (Tanaka et al. 2003). It is unclear why thoracic myelopathy more often develops in middle-aged people compared to cervical myelopathy patients. OLF and OPLL, the major causes of thoracic myelopathy, might be associated with some genetic factors (Koga et al. 1998; Yamamoto et al. 2002). The thoracic spine is naturally kyphotic and the spinal cord runs anterior of the spinal canal, which suggests the cord is more easily damaged from the anterior side. Additionally, the spinal cord in the thoracic spine has a particularly vulnerable region called the "watershed zone" due to poor blood supply and the ratio of the cord to the canal is larger than in other parts of the spine (Stillerman and Weiss 1991). Since the cord is debilitated more easily by compressive spinal factors, thoracic myelopathy might develop earlier than in the cases of cervical myelopathy.

The symptomatology of thoracic myelopathy is similar to that of lumbar disorders (Mitra et al. 1996; Sato et al. 1997a). It usually appears first in the lower extremities (Sato et al. 1997a). In the current study, more than one half of the patients initially noticed tingling, numbness or pain in the lower legs. Interestingly enough, 5% of the patients complained of back pain, which was in contrast to patients with cervical myelopathy who rarely presented with neck pain (Smith and Godersky 1987; Bernhardt et al. 1993; Kokubun et al. 1996; Mitra et al. 1996; Sato et al. 1997a). Thoracic myelopathy usually progresses slowly (Shiokawa et al. 2001; Fong and Wong 2004). In the present study, the preoperative duration from the initial onset of symptoms until surgery was also relatively long, 2 years on average, which might result from by this slow progression and the difficulty of the diagnosis because of similarities with lumbar disorders. However, the fact that about one third of the patients showed preoperative durations of less than 6 months suggests that thoracic myelopathy sometimes progresses rapidly (Otani 1988; Shiokawa et al. 2001; Fong and Wong 2004). Careful observation is necessary in order to avoid deterioration of the myelopathy.

OLF is the most common compressive factor contributing to thoracic myelopathy in the Japanese (Yonenobu et al. 1987; Sato et al. 1997a), and was responsible for 60% of all thoracic cord compression diseases in this series, either alone or in combination with OPLL. As for the location of the ossification of spinal ligaments, OLF and OPLL showed contrasting appearances. OLF is hardly found in the cervical spine (Kokubun et al. 1996). On the other hand, OPLL is one of the most frequent compressive factors of cervical myelopathy and was found in 20% of such patients (Kokubun et al. 1996). OPLL was found mostly in the upper to middle thoracic spine, whereas OLF was mostly in the lower thoracic in the current study as previously described (Yonenobu et al. 1987; Sato et al. 1997a). For the development of OLF, mechanical stress also plays an important role. Higher mechanical forces cause more pronounced degenerative changes of the facet joints and intervertebral discs at the