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Risk factors and prognosis for acute progression of myelopathic symptoms in patients with ossification of the posterior longitudinal ligament after minor trauma

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Abstract

Study design

Retrospective Cohort study.

Objective

To identify the risk factors for acute progression of myelopathic symptoms (PMS)associated with ossification of the posterior longitudinal ligament (OPLL) after minor trauma and to compare the prognosis between an acute PMS group and a chronic PMS group.

Summary of Backgroud Data

Although the prevalence of OPLL among patients with cervical myelopathy is high, few studies have been published regarding the risk factors for acute PMS associated with OPLL after minor trauma.

Methods

Patients with OPLL who had histories of minor trauma and had undergone surgery were divided according to clinical course into an acute (within 48 hours, n=38) and a chronic PMS group (n=32). The type of trauma and the clinical and radiologic characteristics were compared. The clinical outcomes were also compared at admission and at 1 and 2 years post-operatively.

Results

The types of trauma were significantly different between the two groups (p<0.05). Univariate analysis revealed that older age, a narrower space available for the cord and a higher rate of stenosis in the spinal canal were associated with acute PMS after minor trauma (p=0.014, 0.020

and 0.006, respectively). However, the rate of stenosis in the spinal canal was the only risk factor that was identified in a multivariate analysis (p=0.023; OR, 0.872; 95% CI, 0.774-0.982). The Japanese Orthopedic Association scores at the initial visit and at post-operative years 1 and 2 were significantly lower in the acute PMS group than in the chronic PMS group (p<0.001, <0.001 and <0.001, respectively).

Conclusion

One risk factor for acute PMS in patients with OPLL after minor trauma is a higher rate of stenosis of the spinal canal. Patients with acute PMS exhibited unfavorable neurologic outcomes. Preventive surgical treatment may be recommended for patients with significant OPLL with mild cervical myelopathy.

Keywords: cervical spine; ossification of the posterior longitudinal ligament; spinal canal stenosis; trauma; cervical myelopathy; spinal cord injury; open-door laminoplasty

Level of Evidence: 3

Introduction

Ossification of the posterior longitudinal ligament (OPLL) is common in the elderly Asian population and may lead to significant neurologic disabilities. Previous observational studies of the natural course of OPLL have revealed that the development of ossification does not always lead to myelopathy.[1,2] However, OPLL tends to predispose patients to the progression of myelopathic symptoms (PMS) after trauma. Trauma is clearly hazardous for individuals with cervical OPLL, and recent research has reported an alarmingly high prevalence of OPLL (34%) in patients with cervical spinal cord injuries (SCIs).[3,4,5] Additionally, the surgical outcomes for such patients are not comparable to those of patients without histories of trauma. However, prophylactic surgery for patients who are asymptomatic or have mild myelopathy has been a point of controversy among surgeons.[4,6,7] Some surgeons have suggested that prophylactic surgery is indicated for patients with mild myelopathy,[8] whereas others have recommended conservative treatment for the majority of patients who exhibit mild myelopathy due to OPLL.[9]

The present study was performed to determine the risk factors for acute PMS associated with OPLL after minor trauma and to identify the clinical courses and neurologic recovery characteristics by comparing patients with acute PMS and those with chronic PMS.

Materials and Methods

Between January 2003 and October 2014, 321 patients with OPLL underwent surgical treatment in our department. One hundred eight patients had histories of trauma in their medical records. Ninety-one patients experienced motor and/or sensory changes in the upper and lower extremities or gait disturbances. Eight patients with cervical fractures or dislocations, congenital deformities or chronic systemic illnesses, such as rheumatoid arthritis and neurodegenerative

diseases, were excluded. Among the remaining patients, those with a minimum follow-up period of 2 years were included in the present analysis. Ultimately, 70 patients were included in the study, including 38 in the acute PMS group (within 48 hours) and 32 in the chronic PMS group.

The present study was approved by the Institutional Review Board of the hospital (H-1612-003-809).

Clinical and Radiologic Evaluations

The medical records and radiologic images were reviewed at admission and at post-operative years 1 and 2. The type of trauma, gender, age, surgical approach and duration of follow-up were investigated. The surgical treatments were divided into anterior, posterior and combined approaches. The neurological status was assessed using the Japanese Orthopedic Association (JOA) score, which assesses the degree of cervical myelopathy. Radiographic parameters included the type of OPLL, ossified levels, ossification thickness, diameter of the spinal canal, narrowest space available for the cord (SAC), rate of stenosis of the spinal canal, and presence of the snake eyes (SE) sign. The rate of stenosis of the spinal canal was calculated as the ratio of the maximum thickness of the OPLL to the diameter of the spinal canal at the narrowest level on an axial computed tomography (CT) image (Fig. 1). The presence of the SE sign was evaluated based on the patients' initial T2-weighted axial magnetic resonance images (MRIs; Fig. 2).

Statistical Analysis

The statistical analyses were performed using Student's t test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. A two-sided *p*-value of <0.05 was considered significant.Logistic regression analysis was used for the multivariate analysis. To reduce the risk of type II errors due to the modest sample size, variables were considered for the

logistic regression analysis only if they were associated with a dependent variable at the level of $p<0.250$ in each of the analyses.

Repeated-measures analysis of variance was used to compare the JOA scores of the acute PMS group to those of the chronic PMS group at admission and at post-operative years 1 and 2. The SPSS statistical software package version 21.0 (IBM Corporation, New York, New York, United States) for Windows was used for the statistical analyses.

Results

The type of trauma significantly differedbetween acute and chronic PMS groups (p=0.006; Table 1). Falling was the most common type of trauma in both the acute and chronic PMS groups (57.9% and 53.1%, respectively). However, falling (13.2%) and bike (motorcycle and bicycle) accidents (10.5%) were more common in the acute PMS group, whereas traffic accidents (28.1%) and massages (9.4%) were more common in the chronic PMS group.

No significant differences were identified between the acute and chronic PMS groups in terms of gender, type of OPLL, ossified levels, ossification thickness, diameter of the spinal canal, presence of the SE sign, surgical approach or follow-up period (p=0.522, p=0.077, p=0.888, p=0.076, p=0.444, p=0.890, p=0.495 and p=0.592, respectively; Table 2). Compared to the chronic PMS group, the acute PMS group was significantly older, exhibited a significantly smaller narrowest SAC and had a higher rate of stenosis of the spinal canal (p=0.014, p=0.020 and p=0.006, respectively).

In the multivariate analysis, the rate of stenosis of the spinal canal (p=0.023; odds ratio=0.872; 95% confidence interval, 0.774-0.982) was the only significant risk factor for acute PMS after minor trauma (Table 3).

The initial JOA scores were lower in the acute PMS group (7.05±2.847, range, 3 to 11) than in the chronic PMS group (9.50±2.286, range, 5 to 13; p<0.001; Fig. 3). The 1-year post-operative JOA scores were lower in the acute PMS group (9.08±2.917, range, 5 to 14) than in the chronic PMS group (12.22±2.282, range, 7 to 16; p<0.001), and the 2-year post-operative JOA scores were also lower in the acute PMS group (10.42±2.777, range, 6 to 15) than in the chronic PMS group (13.41±2.108, range, 8 to 15; p<0.001). Overall changes in the JOA scores occurred in both groups over time, but the changes were significantly different at every measurement.

Illustrative Case

A previously healthy 87-year-old man fell on the floor at home. Although he remained conscious, he noted the immediate onset of quadriplegia. A neurological evaluation in the emergency department documented an incomplete cervical spinal cord injury. The patient's motor grades were decreased to 3/5 for the strength of the upper extremities and to 2/5 for the strength of the lower extremities. Cervical spine MRIs revealed central canal stenosis and compressive myelopathy at the C3-4 level (Fig. 4A). A cervical spine CT scan revealed extremely large ossified processes consistent with OPLL at the levels of C1-7 with central canal stenosis (Fig. 4B). Furthermore, on axial studies, the OPLL mass occupied 51.3% of the cross-sectional area of the spinal canal (Fig. 4C). The patient underwent C3-6 plate-only, open-door laminoplasty with undercutting of the C2 lamina.[10] After the operation, the patient was still unable to stand unassisted. He was transferred to the rehabilitation department. His initial chest

X-ray showed no specific findings (Fig. 4d). However, 2 weeks after the operation, a chest X-ray and CT revealed pneumonia and pleural effusion (Fig. 4e, 4f). Thoracentesis was performed, and the patient was started on intravenous antibiotics. These symptoms fluctuated for 4 months. Despite active treatment, the patient eventually died.

Discussion

Neurological symptoms may not be apparent in the daily activities of many patients with OPLL; therefore, the risk of disability may be underestimated. However, OPLL is highly prevalent (34-38%) in SCI patients without bone injuries.[5,11]These results indicate that OPLL is a major risk factor for the development of acute cervical SCI. Patients with OPLL have relatively smaller canals than the normal population, which may contribute to the development of cervical SCIs.[12,13] The injuries are often caused by a sudden force that results in the subsequent compression of the cord by a bony posterior ligament in a narrow canal.[14] In the present study, 47 patients developed new symptoms, and 19 experienced transient, short-term quadriparesis. Concomitant injuries were relatively rare, and the primary cause of SCI was a minor trauma, such as that caused by falling down (55.7%). Individuals with OPLL are extremely vulnerable to trauma.

It is established that a narrow canal space is an important risk factor for the development of cervical myelopathy associated with OPLL. Cervical myelopathy usually develops in patients in whom the cervical spinal canal is compromised by 60% or greater and in those in whom the SAC is less than 8 mm.[1,15]However, in the present study, the rates of stenosis in both the acute and chronic PMS groups were less than 60% (39.63% and 35.96%, respectively), but the

myelopathic symptoms still progressed after minor trauma. This phenomenon was likely due to trauma. A portion of the spinal canal (2 to 3 mm) is compromised by the hyperextension of the cervical spine with an overlapping of the laminae and buckling of the ligamentum flavum.[16] Considering the average spinal canal diameter, a compromise of 2 to 3 mm equates to a 20 to 30% decrease in the SAC. The rate of stenosis in the spinal canal could be greater than 60% at the time of the trauma. **The optimal cut-off value 34.4 of stenosis rate was determined using the Youden's index , defined as (sensitivity + specificity) - 1. However, because the number of patients included in this study is small, further validation of the cut-off value should be separately verified later in large-scale studies.**

Trauma-induced cervical SCI in patients with OPLL could be decreased by informing patients of the risk. Therefore, prophylactic surgery may not always be necessary.[2] An earlier study suggested that once patients are made aware of OPLL and its potential risk, they generally are more careful to avoid high-risk behaviors, such as walking on slippery slopes or drinking too much alcohol.[6] These findings underscore the importance of patient awareness and indicate the effectiveness of patient education in reducing cervical SCIs among those with OPLL. However, minor trauma can develop during one's lifetime, and the intent to prevent injury alone cannot prevent trauma-induced cervical myelopathy. Once elderly patients sustain a cervical SCI, their quality of life can seriously deteriorate, and their lives can be threatened in some cases.[4,17] We have experienced such situations as demonstrated by the illustrative case. Controversy exists regarding the role of surgery in patients who are asymptomatic and those with only mild myelopathy due to cervical OPLL.[2,6,7]However, cervical SCIs and related disabilities are more likely to occur in patients with OPLL, and conservative treatment of OPLL increases the risk of SCI (4.8 per 1000 person-years).[18]**Concerning the proper timing of the surgery, we**

recommend early surgical decompression for OPLL because the outcome of this procedure is better for younger patients and for those with higher JOA scores.[19] However, this remains a matter of ongoing debate, especially in elderly patients. The risk as well as the benefits of surgery should be considered.

Limitations of the present study

Several limitations of our study warrant mention. First, this study had a retrospective design and included a relatively small number of study subjects, which resulted in a low statistical power. Additional long-term follow-up studies with substantially larger patient populations than that of the present study are required to more accurately clarify the risk factors and prognoses for acute PMS in patients with OPLL after minor trauma. **Second, this study included only patients who underwent surgery. This may represent a selection bias that may overestimate the severity in progression of myelopathic symptoms when patients with OPLL are managed without surgery after minor trauma.** Despite these limitations, our study contains valuable and clinically important information and provides a basis for future research.

Conclusions

Minor trauma can lead to PMS in patients who are not aware of their cervical OPLL status. The acute PMS group exhibited a higher rate of stenosis of the spinal canal than the chronic PMS group. The initial JOA score was correlated with a good recovery status at the final follow-up. Early surgical treatment might be an excellent option if the rate of stenosis of the spinal canal is severe.

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Figure Legends

Figure 1. Rate of stenosis of the spinal canal

The measurements of spinal canal stenosis (%) were calculated based on axial computed tomography. The rate of stenosis of the spinal canal (%)=A/B×100. A=the ossification thickness. B=the diameter of the spinal canal.

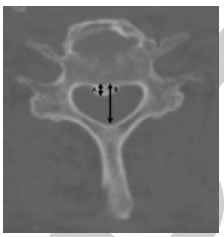


Figure 2. Snake eyes sign

On a T2 axial magnetic resonance image, the gray matter is seen as edematous and hyper-intense and thus produces the ‘snake eyes’ sign.

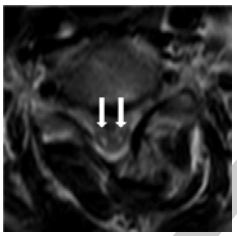


Figure 3. Clinical outcomes

The Japanese Orthopedic Association (JOA) scores upon the initial and 1- and 2-year post-operative evaluations were significantly lower in the acute progression of myelopathic symptoms (PMS) group than in the chronic PMS group.

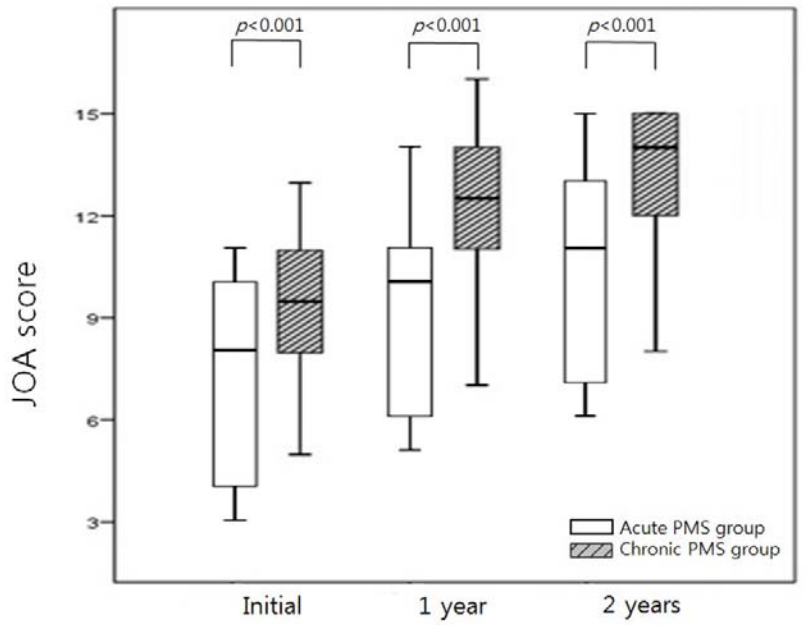
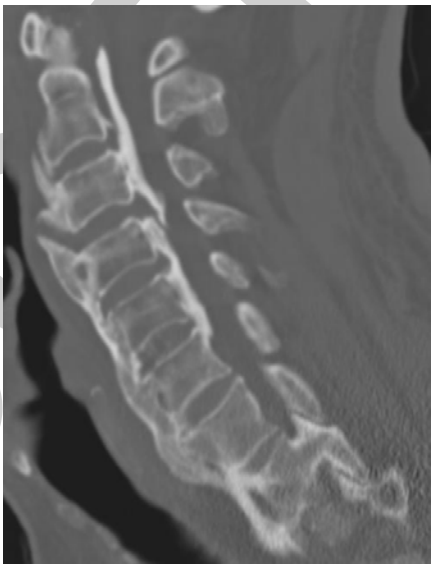
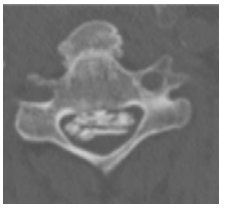


Figure 4. Illustrative case

A. Magnetic resonance images showing central canal stenosis and compressive myelopathy at the C3-4 level. B. Computed tomography (CT) scan showing ossification of the posterior longitudinal ligament (OPLL) at the C1-7 levels and ossification of the anterior longitudinal ligament. C. On an axial CT image, the OPLL mass occupies the majority of the cross-sectional area of the spinal canal. D. Chest X-ray showing no abnormality at admission. E. F. Two weeks after the operation, a chest X-ray and CT revealed pneumonia and pleural effusion.





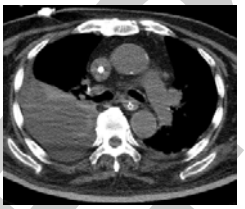


Table 1. Types of trauma in the acute and chronic PMS groups

	Acute PMS group (n=38)	Chronic PMS group (n=32)	*p*-value
Type of trauma			**0.006**
Slip down	22	17	
Falling	5	1	
Bike accidents (motorcycle + bicycle)	4	0	
Head trauma with neck extension	3	2	
Rear-end auto accident	2	9	
Pedestrian TA	2	0	
Massages	0	3	

Abbreviations: PMS, progression of myelopathic symptoms; TA, traffic accident.