TABLE 3: Surgical outcomes and preoperative factors*

Factor (no. of patients w/ available data)	Mean Recovery Rate (%)	OR (95% CI) by Logistic Regression Analysis	p Value
sex			
M (34)	45.4 ± 45.0		
F (42)	45.5 ± 34.2	0.65 (0.18–2.43)	0.53
age in yrs			
<60 (48)	48.5 ± 40.5		
≥60 (28)	40.2 ± 36.7	0.70 (0.19–2.51)	0.58
morbidity period in yrs			
<1 (40)	46.5 ± 42.1		
1–3 (19)	47.9 ± 37.7		
>3 (12)	44.0 ± 28.9	1.25 (0.50–3.13)	0.64
preop JOA score			
<5 (33)	47.1 ± 33.5		
≥5 (43)	44.1 ± 43.2	1.64 (0.47–5.73)	0.43
type of OPLL			
beaked (17)	46.2 ± 53.6		
continuous wave form (28)	49.7 ± 23.6		
continuous cylindrical (13)	41.3 ± 41.7		
mixed (18)	41.1 ± 43.3	0.78 (0.41–1.49)	0.45
anteroposterior diameter of OPLL in mm			
<5 (2)	50.0 ± 0.0		
5–10 (60)	44.3 ± 42.2		
≥10 (12)	49.7 ± 22.5	1.47 (0.31–7.06)	0.45
kyphosis angle on MRI			
<30° (28)	46.1 ± 32.8		
≥30° (37)	47.8 ± 43.9	1.10 (0.33–3.69)	0.88
level of OPLL			
T1–4 (24)	44.0 ± 38.9		
T5–8 (41)	46.5 ± 34.5		
T9–12 (11)	44.7 ± 56.9	0.94 (0.33–2.74)	0.92
DM			
no (55)	53.4 ± 32.0		
yes (19)	23.0 ± 49.1	0.18 (0.04–0.78)	0.02†
T2 high-intensity lesion			
no (14)	63.5 ± 28.4		
yes (59)	43.2 ± 40.1	0.69 (0.14–3.46)	0.65
surgical method			
pst decompression & fusion (47)	38.5 ± 37.8		
ant decompression & fusion via ant approach (12)	65.0 ± 35.6		
ant decompression via pst approach & fusion (4)	28.8 ± 41.2		
circumferential decompression & fusion (13)	57.5 ± 41.1	1.55 (0.88–2.72)	0.13
use of instrumentation			
no (7)	39.6 ± 49.9		
yes (69)	46.0 ± 38.3	0.41 (0.03–5.47)	0.50
no. of surgeries			
1 (64)	44.7 ± 39.1		
≥2 (12)	49.2 ± 40.8	0.60 (0.10–3.61)	0.58

* Mean values are presented ± SDs.
† Statistically significant.

logical complications, and requires less intensive patient care after surgery than the anterior approach.[10] When choosing a surgical method, surgeons should weigh the technical demands, surgical invasiveness, and predictable surgical outcomes of each surgical approach.

The outcome of anterior decompression via a posterior approach (28.8% recovery rate) was the poorest as compared with the other methods in this study, although the difference was not statistically significant because of the sample size.

Diabetes mellitus is known to be closely associated with both the genesis of OPLL and a poor outcome of decompression surgery for the myelopathy caused by cervical OPLL.[3,5] Of the patients in this series, 25% had DM; these patients had a significantly poorer outcome than those without DM. This finding may be attributable to preoperative diabetic neuropathy, although we did not assess the severity of preoperative DM. Furthermore, DM can increase the risk of postoperative complications, including infection and cardiopulmonary events. Therefore, patients with DM should be informed of these problems, and their DM should be well controlled prior to the start of surgery, as asserted by Kawaguchi et al.[3]

The complication rate of 40.8% for this series of surgeries treating T-OPLL is rather high compared with the complication rates for surgeries for other compressive spinal diseases, especially considering that these surgeries were conducted at spine centers adept at treating T-OPLL. These results clearly illustrate the difficulty associated with the surgical treatment of T-OPLL, even in an era of advanced surgical techniques for spinal disorders. To prevent intraoperative neurological events, neurophysiological monitoring may be mandatory, although its effectiveness should be clarified by additional larger studies.

The present study had several limitations, including its retrospective study design, relatively small sample size, and differing preferences in surgical methods at the various institutions. This selection bias in surgical methods may have had some impact on the surgical outcomes. Nonetheless, these limitations may be inevitable because of the rarity of T-OPLL.

Regardless, this study contains the largest case series to clarify the factors associated with surgical outcomes among patients with T-OPLL undergoing fusion surgery.

Conclusions

This retrospective multicenter review of 76 patients who underwent fusion surgery for T-OPLL showed favorable surgical outcomes and identified a factor—no preoperative DM comorbidity—that was associated with a good outcome.

Disclosure

This multiinstitutional study was supported by a grant from the Japanese Ministry of Health, Labour and Welfare (Grant No. H20-Nanchi-Ippan-032).

Author contributions to the study and manuscript preparation include the following. Conception and design: all authors. Acquisition of data: Matsumoto, Toyama, Chikuda, Takeshita, Shindo, Abumi, Takahata, Nohara, Taneichi, Tomita, Kawahara, Imagama, Matsuyama, Yamazaki, Okawa. Analysis and interpretation of data: Matsumoto. Drafting the article: Matsumoto. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Matsumoto. Statistical analysis: Matsumoto. Secured funding: Toyama.

References

1. Bradford DS, McBride GG: Surgical management of thoracolumbar spine fractures with incomplete neurologic deficits. **Clin Orthop Relat Res 218:**201–216, 1987
2. Fujimura Y, Nishi Y, Nakamura M, Watanabe M, Matsumoto M: Myelopathy secondary to ossification of the posterior longitudinal ligament of the thoracic spine treated by anterior decompression and bony fusion. **Spinal Cord 35:**777–784, 1997
3. Kawaguchi Y, Matsui H, Ishihara H, Gejo R, Yasuda T: Surgical outcome of cervical expansive laminoplasty in patients with diabetes mellitus. **Spine (Phila Pa 1976) 25:**551–555, 2000
4. Matsumoto M, Chiba K, Toyama Y, Takeshita K, Seichi A, Nakamura K, et al: Surgical results and related factors for ossification of posterior longitudinal ligament of the thoracic spine: a multi-institutional retrospective study. **Spine (Phila Pa 1976) 33:**1034–1041, 2008
5. Ogawa Y, Toyama Y, Chiba K, Matsumoto M, Nakamura M, Takaishi H, et al: Long-term results of expansive open-door laminoplasty for ossification of the posterior longitudinal ligament of the cervical spine. **J Neurosurg Spine 1:**168–174, 2004
6. Ohtsuka K, Terayama K, Tsuchiya T, Wada K, Furukawa K, Ohkubu M: [A surgical procedure of the anterior decompression of the thoracic spinal cord through the posterior approach.] **Orthop Surg Traumatol 26:**1083–1090, 1983 (Jpn)
7. Ohtsuka K, Terayama K, Yanagihara M, Wada K, Kasuga K, Machida T, et al: A radiological population study on the ossification of the posterior longitudinal ligament in the spine. **Arch Orthop Trauma Surg 106:**89–93, 1987
8. Takahata M, Ito M, Abumi K, Kotani Y, Sudo H, Minami A: Clinical results and complications of circumferential spinal cord decompression through a single posterior approach for thoracic myelopathy caused by ossification of posterior longitudinal ligament. **Spine (Phila Pa 1976) 33:**1199–1208, 2008
9. Tomita K, Kawahara N, Baba H, Kikuchi Y, Nishimura H: Circumspinal decompression for thoracic myelopathy due to combined ossification of the posterior longitudinal ligament and ligamentum flavum. **Spine (Phila Pa 1976) 15:**1114–1120, 1990
10. Yamazaki M, Okawa A, Fujiyoshi T, Furuya T, Koda M: Posterior decompression with instrumented fusion for thoracic myelopathy caused by ossification of the posterior longitudinal ligament. **Eur Spine J 19:**691–698, 2010

Manuscript submitted November 25, 2010.

Accepted June 8, 2011.

Please include this information when citing this paper: published online July 8, 2011; DOI: 10.3171/2011.6.SPINE10816.

Address correspondence to: Morio Matsumoto, M.D., Department of Orthopaedic Surgery, School of Medicine, Keio University, 35 Shinanomachi, Shinjuku-ku, Tokyo, 160-8582, Japan. email: morio@sc.itc.keio.ac.jp.

Spine

SPINE Volume 36, Number 15, pp E998–E1003
©2011, Lippincott Williams & Wilkins

CLINICAL CASE SERIES

Neurological Complications of Cervical Laminoplasty for Patients With Ossification of the Posterior Longitudinal Ligament—A multi-Institutional Retrospective Study

Atsushi Seichi, MD,[a] Yuichi Hoshino, MD,[a] Atsushi Kimura, MD,[a] Shinnosuke Nakahara, MD,[b] Masahiko Watanabe, MD,[c] Tsuyoshi Kato, MD,[d] Atsushi Ono,[e] Yoshihisa Kotani, MD,[f] Mamoru Mitsukawa, MD,[g] Kosei Ijiri, MD,[h] Norio Kawahara, MD,[i] Satoshi Inami, MD,[j] Hirotaka Chikuda, MD,[k] Katsushi Takeshita, MD,[k] Yukihiro Nakagawa, MD,[l] Toshihiko Taguchi, [m] Masashi Yamazaki, MD,[n] Kenji Endo, MD,[o] Hironobu Sakaura, MD,[p] Kenzo Uchida, MD,[q] Yoshiharu Kawaguchi, MD,[r] Masashi Neo, MD,[s] Masahito Takahashi, MD,[t] Katsumi Harimaya, MD,[u] Hideo Hosoe, MD,[v] Shiro Imagama, MD,[w] Shinichiro Taniguchi, MD,[x] Takui Ito, MD,[y] Takashi Kaito, MD,[z] Kazuhiro Chiba, MD,[aa] Morio Matsumoto, MD,[aa] and Yoshiaki Toyama, MD,[aa]

Study Design. Retrospective multi-institutional study.

From the [a]Department of Orthopaedics, Jichi Medical University, Shimotsuke, Japan; [b]Department of Orthopaedic Surgery, National Okayama Medical Center, Okayama, Japan; [c]Department of Orthopaedic Surgery, Tokai University, Isehara, Japan; [d]Department of Orthopaedic Surgery, Tokyo Medical and Dental University, Tokyo, Japan; [e]Department of Orthopaedic Surgery, Hirosaki University, Hirosaki, Japan; [f]Department of Orthopaedic Surgery, Hokkaido University, Sapporo, Japan; [g]Department of Orthopaedic Surgery, Kurume University, Kurume, Japan; [h]Department of Orthopaedic Surgery, Kagoshima University, Kagoshima, Japan; [i]Department of Orthopaedic Surgery, Kanazawa University, Kanazawa, Japan; [j]Department of Orthopaedic Surgery, Dokkyo Medical University, Shimotsuga, Japan; [k]Department of Orthopaedic Surgery, the University of Tokyo, Tokyo, Japan; [l]Department of Orthopaedic Surgery, Wakayama Medical University, Wakayama, Japan; [m]Department of Orthopaedic Surgery, Yamaguchi University, Ube, Japan; [n]Department of Orthopaedic Surgery, Chiba University, Chiba, Japan; [o]Department of Orthopaedic Surgery, Tokyo Medical University, Tokyo, Japan; [p]Department of Orthopaedic Surgery, Osaka University, Osaka, Japan; [q]Department of Orthopaedic Surgery, the University of Fukui, Fukui, Japan; [r]Department of Orthopaedic Surgery, University of Toyama, Toyama, Japan; [s]Department of Orthopaedic Surgery, Kyoto University, Kyoto, Japan; [t]Department of Orthopaedic Surgery, Kyorin University, Tokyo, Japan; [u]Department of Orthopaedic Surgery, Kyushu University, Fukuoka, Japan; [v]Department of Orthopaedic Surgery, Gifu University, Gifu, Japan; [w]Department of Orthopaedic Surgery, Nagoya University, Nagoya, Japan; [x]Department of Orthopaedic Surgery, Kochi University, Nangoku, Japan; [y]Department of Orthopaedic Surgery, Niigata University, Niigata, Japan; [z]Department of Orthopaedic Surgery, National Hospital Organization Osaka Minami Medical Center, Kawachi-Nagano, Japan; [aa]Department of Orthopaedic Surgery, Keio University, Tokyo, Japan.

Acknowledgment date: March 30, 2010; First Revision: September 14, 2010; Accept: September 18, 2010.

The manuscript submitted does not contain information about medical device(s)/drug(s).

Federal funds were received to support this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

Conflict of interest: This work was supported by a Health Labor Sciences Research Grant. All study protocols were approved by the institutional review board at the Japanese Society for Spine Surgery and Related Research.

Address correspondence and reprint requests to Atsushi Seichi, MD, Department of Orthopaedics, Jichi Medical University, 3311-1 Yakushiji, Shimotsuke, Tochigi 329-0498, Japan; E-mail: seichi-spine@jichi.ac.jp

DOI: 10.1097/BRS.0b013e3181fda7fa

Objective. To investigate the incidence of neurological deficits after cervical laminoplasty for ossification of the posterior longitudinal ligament (OPLL).

Summary of Background Data. According to analysis of long-term results, laminoplasty for cervical OPLL has been reported as a safe and effective alternative procedure with few complications. However, perioperative neurological complication rates of laminoplasty for cervical OPLL have not been well described.

Methods. Subjects comprised 581 patients (458 men and 123 women; mean age: 62 ± 10 years; range: 30–86 years) who had undergone laminoplasty for cervical OPLL at 27 institutions between 2005 and 2008. Continuous-type OPLL was seen in 114, segmental-type in 146, mixed-type in 265, local-type in 24, and not judged in 32 patients. Postoperative neurological complications within 2 weeks after laminoplasty were analyzed in detail. Cobb angle between C2 and C7 (C2/C7 angle), maximal thickness, and occupying rate of OPLL were investigated. Pre- and postoperative magnetic resonance imaging was performed on patients with postoperative neurological complications.

Results. Open-door laminoplasty was conducted in 237, double-door laminoplasty in 311, and other types of laminoplasty in 33 patients. Deterioration of lower-extremity function occurred after laminoplasty in 18 patients (3.1%). Causes of deterioration were epidural hematoma in 3, spinal cord herniation through injured dura mater in 1, incomplete laminoplasty due to vertebral artery injury while making a trough in 1, and unidentified in 13 patients. Prevalence of unsatisfactory recovery not reaching preoperative level by 6-month follow-up was 7/581 (1.2%). Mean occupying rate of OPLL for patients with deteriorated lower-extremity function was 51.2 ± 13.6% (range, 21.0%–73.3%), significantly higher than the 42.3 ± 13.0% for patients without deterioration. OPLL thickness was also higher in patients with deterioration (mean, 6.6 ± 2.2 mm) than in those without deterioration (mean, 5.7 ± 2.0 mm). No significant difference in C2/C7 lordotic angle was seen between groups.

Conclusion. Although most neurological deterioration can be expected to recover to some extent, the frequency of short-term neurological complications was higher than the authors expected.

Key words: cervical spine, complications, laminoplasty, ossification of the posterior longitudinal ligament. **Spine 2011;36:E998–E1003**

The anterior approach for cervical ossification of the posterior longitudinal ligament (OPLL) is theoretically reasonable since the lesion is anterior.[1–4] However, anterior surgery for multisegmental OPLL is considered technically demanding, and the potential for complications is reportedly higher than with posterior surgery.[5,6] On the basis of analyses of long-term results, laminoplasty has been reported as a safe and effective alternative procedure with few complications.[7–11] However, except for C5 motor palsy,[12,13] perioperative neurological complication rates in laminoplasty for cervical OPLL have not been well described,[14,15] although late deterioration after laminoplasty for thick cervical OPLL has been reported.[8]

As neurological sequelae after surgery lead to nonroutine discharges and patient dissatisfaction even if recovery occurs, preoperative information on potential risks of laminoplasty should be included in the informed consent. To investigate the frequency of severe deficits, particularly worsening of lower-extremity function after laminoplasty for cervical OPLL, a Research Group for Ossification of the Spinal Ligament sponsored by the Japanese Ministry of Health, Labor and Welfare conducted a multi-institutional retrospective survey of patients who had undergone laminoplasty for cervical OPLL.

MATERIALS AND METHODS

Methods

The survey pertained to all cervical OPLL patients who had undergone laminoplasty during the 3-year period from April 2005 to March 2008 at any of the 27 institutions to which members of the research group belonged. In January 2009, questionnaires were sent to each institution and a total of 581 operated cases were collected. To assess the medical status of patients on admission and complications after laminoplasty, participating physicians reviewed the medical records. Patients who received laminoplasty down to the first thoracic spine were included, and patients with traumatic spinal cord injury within 3 weeks of surgery and patients who had undergone simultaneous anterior cervical surgery or spinal surgery below T2 were excluded. Subjects comprised 458 men and 123 women, with a mean age of 62 ± 10 years (range, 30–86 years). Continuous-type OPLL was seen in 114, segmental-type in 146, mixed-type in 265, local-type in 24, and not judged in 32 patients.

The items investigated were demographic data, radiographic findings (radiograph, computed tomography [CT], and magnetic resonance imaging [MRI]), surgical methods and surgical results, complications, and surgical outcomes as of 6 months after the surgery. Outcomes were assessed by motor function scores of the upper and lower extremities for cervical myelopathy as defined by the Japanese Orthopedic Association.[7] Postoperative neurological complications within 2 weeks after laminoplasty were described in detail. Cobb angle between C2 and C7 (cervical lordotic angle; C2/C7 angle), maximal thickness, and occupying rate of OPLL were investigated. Pre- and postoperative MRI were investigated in patients with postoperative neurological complications.

All study protocols were approved by the institutional review board at the Japanese Society for Spine Surgery and Related Research.

Statistical Analysis

SPSS version 17 software (SPSS, Chicago, IL) was used for all statistical analyses. Means, standard deviations, and 95% confidence intervals of differences were calculated for continuous variables, and comparisons were made using Student *t* test. Values of $P < 0.05$ were considered significant.

RESULTS

Open-door laminoplasty was conducted in 237, double-door laminoplasty in 311, and other types of laminoplasty including skip-laminectomy in 33 patients.[16] Preoperative Japanese Orthopedic Association score for lower-extremity function was 4 in 78, 3 in 109, 2 in 237, 1 in 121, and 0 in 36 patients. Deterioration of lower-extremity function after laminoplasty was seen in 18 patients (3.1%). The prevalence of unsatisfactory recovery not reaching preoperative level by 6-month follow-up was thus 1.2% (7/581) (Table 1). These deteriorations were discovered on the same day as laminoplasty in 13, postoperative day 1 in 1, postoperative day 2 in 1, postoperative day 3 in 1, postoperative day 5 in 1, and postoperative day 12 in 1 patient (see Table 1). Causes of deterioration were epidural hematoma in 3, spinal cord herniation through injured dura mater in 1 (Figure 1), incomplete laminoplasty due to vertebral artery injury while making a trough in 1 (Figure 2), and unidentified in 13 patients (Figure 3). Of the 13 cases, newly developed high-intensity areas on T2-MRI were identified in only 1 case (see Figure 3). In the case with vertebral artery injury, laminoplasty was not completed and second-round surgery was not performed because of postoperative deep wound infection and poor general condition. Three cases with epidural hematoma were diagnosed on the day of surgery. All these cases underwent emergent surgery and showed recovery. Spinal cord herniation was diagnosed on postoperative day 5 and repair surgery was performed, resulting in improved lower-extremity function, although preoperative level was not reached. One patient with deterioration on postoperative day 12 due to an unidentified cause underwent additional anterior corpectomy and fusion, improving to the preoperative level. Intraoperative cerebrospinal fluid leak was encountered in 37 patients (6.4%), and 1 patient showed worsened myelopathy due to spinal cord herniation through a split dura mater, as mentioned previously. In 3 of the 13 cases with deterioration due to an unidentified cause, cerebrospinal fluid leak occurred after intraoperative dural tear. No significant differences in neurological complication rates were seen between representative laminoplasties (double-door type *vs.* open door type) (see Table 1).

Postoperative unilateral motor paresis of an upper extremity occurred in 23 patients (4%), with proximal paresis (C5 palsy) in 16 and distal paresis in 7 patients. At the 6-month

TABLE 1. Demographic Characteristics and Clinical Data of Patients with Deterioration of the Lower-Extremity Function After Laminoplasty

No.	Age at Surgery (yrs)	Sex	OPLL Type	O ccupy-ing Rate (%)	OPLL Thick-ness (mm)	Operative Levels	Method	Postoperative Date of Deterio-ration (Days)	Motor JOA of Lower Extremities				Causes of Compli-cations
									Preoperative at deteriora-tion	At dete-rioration	Postop-erative (6 months)	Dural tear	
1	79	M	Segmental	42.2	5.7	C3–C7	Double	0	1	0	0	–	VA injury
2	59	M	Mixed	61.5	8.0	C2–C6	Open	2	0	0	0	–	Unknown
3	47	M	Continu-ous	53.6	7.5	C3–C7	Z-plasty	0	1	0	2	+	Unknown
4	47	M	Not judged	55.2	8.3	C3–C5	Open	0	4	1	4	–	Unknown
5	74	M	Mixed	60.6	7.1	C3-T1	Double	0	1	0	0	–	Unknown
6	56	M	Continu-ous	53.6	11.9	C3–C6	Open	0	2	0	1	–	Unknown
7	70	F	Segmental	54.8	6.9	C3–C7	Open	3	2	0	4	–	Unknown
8	53	M	Mixed	41.7	6.0	C2–C6	Open	1	2	1	2	+	Unknown
9	58	M	Mixed	30.5	5.0	C3–C7	Double	0	2	1	2	–	Hematoma
10	67	M	Segmental	38.0	4.5	C3–C7	Open	0	4	0	4	–	Hematoma
11	79	M	Mixed	50.0	6.0	C3–C7	Open	0	0	0	2	–	Hematoma
12	72	M	Mixed	63.6	9.6	C3–T1	Open	12	0	0	1	–	Unknown
13	76	M	Mixed	64.9	8.5	C3–T1	Double	0	2	0	1	–	Unknown
14	58	F	Continu-ous	60.0	6.0	C2–T1	Double	0	2	0	1	–	Unknown
15	47	F	Mixed	59.1	6.5	C2–T1	Double	5	3	1	2	+	Cord her-niation
16	46	M	Continu-ous	73.3	11.0	C2–C7	Double	0	1	0	2	–	Unknown
17	39	M	Mixed	30.8	4.0	C2–T1	Double	0	1	0	2	–	Unknown
18	43	M	Mixed	21.0	3	C3–C7	Open	0	2	0	1	–	Unknown

Double, double-door laminoplasty; JOA, Japanese Orthopedic Association; open, open-door laminoplasty; OPLL, ossification of the posterior longitudinal ligament; VA, vertebral artery.

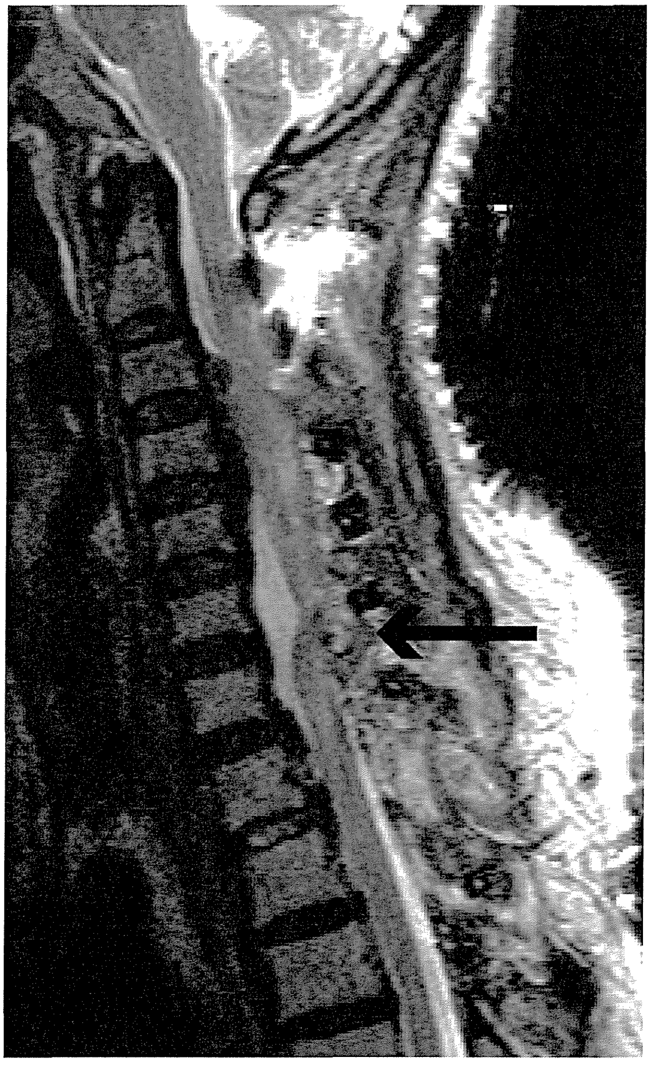

Figure 1. Postoperative T2-weighted imaging of a case with spinal cord herniation through injured dura mater (arrow).

follow-up, one patient with proximal paresis showed little recovery. In two patients with proximal paresis and four patients with distal paresis, partial recovery was achieved, with muscle power rated at 3/5. The remaining 16 patients showed full recovery. Nonspinal complications included superficial wound infection in 13, transient postoperative delirium in 12, urinary tract infection in 4, mild cerebrovascular accident in 4, pneumonia in 3, angina pectoris in 2, and gastric ulcer in 2 patients. All these complications were treated conservatively, and full recovery was achieved.

Mean occupying rate of OPLL for patients with deterioration of lower-extremity function was 51.2 ± 13.6% (range, 21.0%–73.3%), significantly higher than the 42.3 ± 13.0% for patients without deterioration (unpaired *t* test, $P = 0.003$; 95% confidence interval of the difference, 3.0–15.0%). OPLL thickness was also higher in patients with deterioration (mean, 6.6 ± 2.2 mm) than in those without deterioration (mean, 5.7 ± 2.0 mm; $P = 0.04$; 95% confidence interval of the difference, 0.4–1.9 mm). No significant difference in C2/C7 angle was seen between the groups.

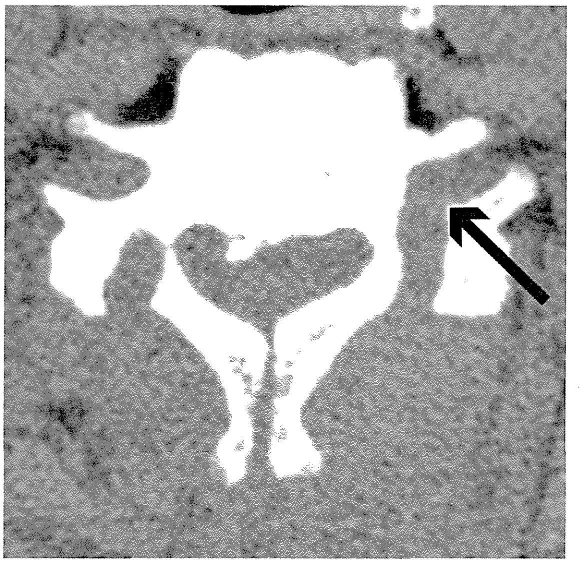

Figure 2. Postoperative CT of a case with vertebral artery injury due to an excessively deep trough (arrow).

DISCUSSION

Laminoplasty has been considered to result in insufficient decompression for patients with kyphotic cervical spine or very large OPLL[3,4,15] but has become the first option in the place of anterior surgery not only for cervical spondylotic myelopathy but also for OPLL in Japan due to the technical simplicity and reduced risk of complications.[6,7] Several studies of long-term results for laminoplasty in cervical OPLL have reported the efficacy and safety of this procedure, and laminoplasty for cervical OPLL has generally been considered successful.[8–10] However, previous reports of long-term results for laminoplasty have not completely addressed short-term neurological complications and few articles have addressed the incidence of short-term neurological complications other than motor paresis of the upper extremities.[13,14] This study

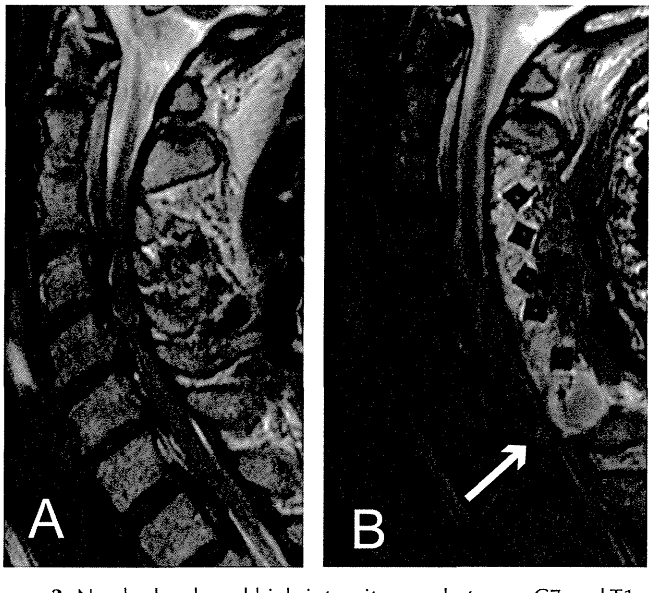

Figure 3. Newly developed high-intensity area between C7 and T1 on T2-weighted imaging (arrow). (**A**) Preoperative and (**B**) postoperative.

therefore focused on worsening lower-extremity function after laminoplasty. A small proportion of patients developed permanent deficits of lower-extremity function, even though the majority of neurological deficits proved transient or salvageable.

Some causes of neurological deficit can be identified on careful examination by the surgeon.[17,18] Of particular note is the fact that postoperative worsening caused by epidural hematoma can be salvaged by quick response of the surgeon. However, we could not identify the causes of deterioration of lower-extremity function in 10 patients without cerebrospinal fluid leakage or other evident causes. Possible mechanisms for postoperative worsening of myelopathy may be incorrect positioning of the neck during surgery, edema, or reperfusion of the decompressed spinal cord.[13,18] As Chiba *et al*[11] suggested, the spinal cord in patients with very thick OPLL may be too fragile to withstand rapid decompression and intramedullary reperfusion may represent a contributing factor. However, the retrospective nature of this survey did not allow us to reach any conclusion in this regard. When causes cannot be identified from intraoperative findings and postoperative investigations, diverse explanations can be proposed to explain neurological deterioration. As a whole, the greater the occupying rate of the OPLL, the higher the risk of postoperative neurological sequelae. However, some cases show no specific cause and cervical alignment has not been identified as a significant contributing factor.

Postoperative migration of the cervical spinal cord between split laminae has been reported as a cause of worsening myelopathy.[19] In this study, one such case was seen after dural tear. Exacerbation of neurological symptoms soon or immediately after the surgery and identification of the presence or absence of cerebrospinal fluid leakage after dural injury are major issues of concern. Of the 13 cases with deterioration due to an unidentified cause, 3 showed cerebrospinal fluid leaks. Iatrogenic factors including direct spinal cord injury might also have caused neurological sequelae. Definite technical error was confirmed in another case with vertebral injury through a posterior approach when making a lateral trough (see Figure 2). This complication has not been reported in the past literatures, and surgeons should be aware of this unacceptable technical error.

The majority of previous studies have come from single institution series. This study described surgical outcomes on a national scale from representative samples of hospitals that performed laminoplasty for cervical OPLL from 2005 to 2008. This relatively large study showed that two types of laminoplasty (bilateral and unilateral types) were equally popular in Japan. Neurological complications appear equally likely with either type.

Our analysis did not take into account patient satisfaction after surgery. Despite this limitation, information on complications is critical for counseling patients with cervical OPLL about the risk of laminoplasty. Benefits of surgery and risks of complications must be carefully considered to avoid patient disappointment and unrealistic expectations.

In conclusion, although most neurological worsening can be expected to recover to some extent, the frequency of short-term neurological complications was higher than we expected. Given the retrospective nature of this study, cases showing complications could have been selectively excluded if the complications were mild. The number and type of complications could thus be even higher than reported here.

➢ Key Points

- ❑ Deteriorated lower-extremity function occurred in 18 of the 581 patients (3.1%) who underwent laminoplasty for cervical OPLL.
- ❑ Unsatisfactory recovery not reaching preoperative levels was seen in 7 of the 581 patients (1.2%).
- ❑ Causes of deterioration were epidural hematoma in 3, spinal cord herniation through injured dura mater in 1, vertebral artery injury while making a trough in 1, and unidentified in 13 patients.

References

1. Yamaura I, Kurosa Y, Matsuoka T. Anterior floating method for cervical myelopathy caused by ossification of the posterior longitudinal ligament. *Clin Orthop* 1999;359:27–34.
2. Matsuoka T, Yamaura I, Kurosa Y, et al. Long-term results of the anterior floating method for cervical myelopathy caused by ossification of the posterior longitudinal ligament. *Spine* 2001;26:241–8.
3. Iwasaki M, Okuda S, Miyauchi A, et al. Surgical strategy for cervical myelopathy due to ossification of cervical posterior longitudinal ligament. Part 1: Clinical results and limitations of laminoplasty. *Spine* 2007;32:647–53.
4. Iwasaki M, Okuda S, Miyauchi A, et al. Surgical strategy for cervical myelopathy due to ossification of cervical posterior longitudinal ligament. Part 2: Advantages of anterior decompression and fusion over laminoplasty. *Spine* 2007;32:654–60.
5. Yonenobu K, Hosono N, Iwasaki M, et al. Neurological complication of surgery for cervical compression myelopathy. *Spine* 1991;16:1277–82.
6. Wada E, Suzuki S, kanazawa A, et al. Subtotal corpectomy *versus* laminoplasty for multilevel cervical spondylotic myelopathy. *Spine* 2001;26:1443–8.
7. Hirabayasahi K, Miyakawa J, Satomi K, et al. Operative results and postoperative progression of ossification among patients with ossification of cervical posterior longitudinal ligaments. *Spine* 1981;6:354–64.
8. Seichi A, Takeshita K, Ohishi I, et al. Long-term results of double-door laminoplasty for cervical stenotic myelopathy. *Spine* 2001;26:479–87.
9. Iwasaki M, Kawaguchi Y, Kimura T, et al. Long-term results of expansive laminoplasty for ossification of the posterior longitudinal ligament of the cervical spine: more than 10 years follow up. *J Neurosurg* 2002;96:180–9.
10. Ogawa Y, Toyama Y, Chiba K, et al. Long-term results of expansive open-door laminoplasty for ossification of the posterior longitudinal ligament of the cervical spine. *J Neurosurg* (Spine 1) 2004;2:168–74.
11. Chiba K, Ogawa Y, Ishii K, et al. Long-term results of expansive open-door laminoplasty for cervical myelopathy—average 14-year follow-up study. *Spine* 2006;31:2998–3005.
12. Sakaura H, Hosono N, Mukai Y, et al. C5 palsy after decompression surgery for cervical myelopathy. *Spine* 2003;28:2447–51.
13. Chiba K, Toyama Y, Matsumoto M, et al. Segmental motor paralysis after expansive open-door laminoplasty. *Spine* 2002;27:2108–12.

14. Satomi K, Ogawa J, Ishii Y, et al. Short-term complications and long-term results of expansive open-door laminoplasty for cervical stenotic myelopathy. *Spine J* 2001;1:26–30.
15. Tani T, Ushida T, Ishida K, et al. Relative safety of anterior microsurgical decompression *versus* laminoplasty for cervical myelopathy with a massive ossified posterior longitudinal ligament. *Spine* 2002;27:2491–8.
16. Shiraishi T, Fukuda K, Yato Y, et al. Results of skip laminectomy—minimum 2-year follow-up study compared with open-door laminoplasty. *Spine* 2003;28:2667–72.
17. Seichi A, Takeshita K, Kawaguchi H, et al. Postoperative expansion of intramedullary high-intensity areas on T2-weighted magnetic resonance imaging after cervical laminoplasty. *Spine* 2004;29: 1478–82.
18. Liu G, Buchowski JM, Bunmaprasert T, et al. Revision surgery following cervical laminoplasty. Etiology and treatment strategies. *Spine* 2009;34:2760–8.
19. Kimura S, Homma T, Uchiyama S, et al. Postoperative migration of cervical spinal cord between split laminae as a complication of laminoplasty. *Spine* 1995;20:1284–88.

Spine

SPINE Volume 36, Number 18, pp 1453–1458
©2011, Lippincott Williams & Wilkins

CERVICAL SPINE

Acute Cervical Spinal Cord Injury Complicated by Preexisting Ossification of the Posterior Longitudinal Ligament

A Multicenter Study

Hirotaka Chikuda, MD, PhD,* Atsushi Seichi, MD, PhD,† Katsushi Takeshita, MD, PhD,* Shunji Matsunaga, MD, PhD,‡ Masahiko Watanabe, MD, PhD,§ Yukihiro Nakagawa, MD, PhD,¶ Kazuya Oshima, MD, PhD,|| Yutaka Sasao, MD, PhD,** Yasuaki Tokuhashi, MD, PhD,†† Shinnosuke Nakahara, MD,‡‡ Kenji Endo, MD, PhD,§§ Kenzo Uchida, MD, PhD,¶¶ Masahiko Takahata, MD,|||| Toru Yokoyama, MD,*** Kei Yamada, MD, PhD,††† Yutaka Nohara, MD,‡‡‡ Shiro Imagama, MD,§§§ Hideo Hosoe, MD,¶¶¶ Hiroshi Ohtsu, MS,|||||| Hiroshi Kawaguchi, MD, PhD,* Yoshiaki Toyama, MD, PhD,**** and Kozo Nakamura, MD, PhD,*

From the *Department of Orthopaedic Surgery, Faculty of Medicine, the University of Tokyo, Tokyo, Japan; †Department of Orthopaedics, Jichi Medical University, Tochigi, Japan; ‡Department of Orthopaedic Surgery, Imakiire General Hospital, Kagoshima, Japan; §Department of Orthopaedic Surgery Surgical Science Tokai University School of Medicine, Kanagawa, Japan; ¶Department of Orthopaedic Surgery, Wakayama Medical University, Wakayama, Japan; ||Department of Orthopaedic Surgery, Osaka University Graduate School of Medicine, Osaka, Japan; **Department of Orthopeadic Surgery, St. Marianna School of Medicine, Kanagawa, Japan; ††Department of Orthopaedic Surgery, Nihon University School of Medicine, Tokyo, Japan; ‡‡Department of Orthopaedic Surgery, National Okayama Medical Center, Okayama, Japan; §§Department of Orthopedic Surgery, Tokyo Medical University, Tokyo, Japan; ¶¶Department of Orthopaedics and Rehabilitation Medicine, Fukui University Faculty of Medical Sciences, Fukui, Japan; ||||Department of Orthopaedic Surgery, Graduate School of Medicine, Hokkaido University, Hokkaido, Japan; ***Department of Orthopaedics Surgery, Hirosaki University Graduate School of Medicine, Aomori, Japan; †††Department of Orthopaedic Surgery, Kurume University, Fukuoka, Japan; ‡‡‡Department of Orthopaedic Surgery, Dokkyo Medical University, Tochigi Japan;, §§§Department of Orthopaedic Surgery, Nagoya University Graduate School of Medicine, Aichi, Japan; ¶¶¶Department of Orthopaedic Surgery, Gifu University School of Medicine, Gifu, Japan; ||||||Department of Clinical Trial Data Management, Graduate School of Medicine, the University of Tokyo, Tokyo, Japan; and ****Departments of Orthopaedic Surgery, School of Medicine, Keio University, Tokyo, Japan.

Acknowledgment date: March 30, 2010. Revision date: July 19, 2010. Acceptance date: July 20, 2010.

The manuscript submitted does not contain information about medical device(s)/drug(s).

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

This study was performed with the aid of the Investigation Committee on the Ossification of the Spinal Ligaments of the Japanese Ministry of Health, Labor and Welfare.

Address correspondence and reprint requests to Hirotaka Chikuda, MD, PhD, Department of Orthopaedic Surgery, Faculty of Medicine, the University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan; E-mail: chikuda-tky@umin.ac.jp

DOI: 10.1097/BRS.0b013e3181f49718

Study Design. Retrospective multicenter study.

Objective. To review the clinical characteristics of traumatic cervical spinal cord injury (SCI) associated with ossification of the posterior longitudinal ligament (OPLL).

Summary of Background Data. Despite its potentially devastating consequences, there is a lack of information about acute cervical SCI complicated by OPLL.

Methods. This study included consecutive patients with acute traumatic cervical SCI (Frankel A, B, and C) who were admitted within 48 hours of injury to 34 spine institutions across Japan. For analysis of neurologic outcome, patients who had completed at least a 6-month follow-up were included. Neurologic improvement was defined as at least one grade conversion in Frankel grade.

Results. A total of 453 patients were identified (367 men, 86 women; mean age, 59 years). OPLL was found in 106 (23%) patients (87 men, 19 women; mean age, 66 years). Most of the patients with OPLL (94 of 106) were without bone injury, presenting with incomplete SCI. The prevalence of OPLL reached 34% in SCI without bone injury. The cause of SCI was predominantly falls (74%). Only 25% of the patients were aware of OPLL. Half of the OPLL patients reported gait disturbance before injury. Forty-eight (52%) OPLL patients without bone injury underwent surgery (median, 13.5 days after injury), mostly laminoplasty. Overall, no significant difference was noted in neurologic improvement between surgery group and conservative group. However, further stratification showed that surgery was associated with greater neurologic recovery in patients who had gait disturbance before injury ($P = 0.04$).

Conclusion. Prevalence of OPLL among cervical SCI was alarmingly high, especially in those without bone injury. Most of cervical SCI associated with OPLL were incomplete, without bone injury, and caused predominantly by low-energy trauma. The majority of the patients were unaware of OPLL. Surgery produced better neurologic recovery in patients who had gait disturbance before injury.

Key words: canal stenosis, myelopathy, ossification of the posterior longitudinal ligament, patient awareness, spinal cord injury, surgery, trauma, treatment. **Spine 2011;36:1453–1458**

Ossification of the posterior longitudinal ligament (OPLL) affects about 2% of Japanese[1,2] and is a major cause of cervical canal stenosis in Japan. Although individuals with OPLL often remain asymptomatic, chronic cord compression may lead to myelopathy, especially in those with severe canal compromise.

OPLL is also known to predispose these individuals to severe neurologic deterioration after trauma. Despite its potentially devastating consequences, there is a lack of information about acute cervical spinal cord injury (SCI) complicated by OPLL. Except for a few case series, reports on this subgroup of SCI patients remain largely anecdotal.[3,4] The prevalence of OPLL among patients with acute cervical SCI has not been determined, and the clinical characteristics of SCI patients with OPLL remain unclear as well. In particular, little attention has been paid to a patient's status before injury such as his or her awareness of OPLL. In addition, optimum treatment of SCI complicated by OPLL remains controversial; a dilemma reflected by the wide variations in current treatment options, ranging from emergency surgery to conservative treatment. Although surgical decompression is widely believed to have a beneficial role for those with persistent cord compression, there is no comparative study supporting this hypothesis.

Here, we conducted a retrospective multicenter study to determine the prevalence of OPLL among cervical SCI and clarify the clinical characteristics of SCI patients with OPLL, and further evaluated the efficacy of surgical treatment.

MATERIALS AND METHODS

This multicenter study was conducted by a Research Group for Ossification of the Spinal Ligament sponsored by the Japanese Ministry of Health, Labor and Welfare. This study included all consecutive patients with acute traumatic cervical SCI (Frankel A, B, and C) who were admitted within 48 hours of injury from January 2000 to June 2006. Thirty-four institutions to which the members of the research group belong joined this study. Severity of SCI was assessed by Frankel grade classification.[5] Presence of OPLL was confirmed using plain radiographs or computed tomography (CT). On the basis of the criteria established by the Japanese Ministry of Public Health and Welfare, OPLL was classified into the following types: continuous, segmental, localized, and mixed.[6] The maximum percentage of spinal canal stenosis was evaluated using plain radiographs as previously reported.[7]

To assess patients' medical status at admission and complications after the injury, we consulted medical charts and nursing summaries. Complications that occurred within 1 month after injury were included in this study. The charts were also evaluated for patient status before injury including awareness of OPLL and preexisting gait disturbance. For analysis of neurologic recovery, patients who had completed a 6-month follow-up were included.

Neurologic improvement was defined as one grade or greater improvement in Frankel grade. The ratio of patients who achieved neurologic improvement was calculated. Patients were stratified by whether they had gait disturbance before injury.

Continuous variables were compared using Student *t* test or Dunnett test, and categorical data were analyzed using the χ^2 test. Fisher exact test was used when appropriate. All statistics were calculated using SPSS, version 13.0 (SPSS Inc, Chicago, IL). Values were considered statistically significant for P less than 0.05.

RESULTS

A total of 453 patients were initially identified (Table 1), including 367 men and 86 women with a mean age of 59 years. OPLL was found in 106 patients (87 men, 19 women; mean age: 66 years), accounting for 23% of all patients. Peak incidence of SCI in patients with OPLL occurred between 70 and 75 years of age, and about 80% of OPLL-associated SCI patients (85 of 106) were classified as incomplete. Of the 453 patients, 274 (60%) were without bone injury, such as fracture or dislocation, and nearly 90% of the patients with OPLL (94 of 106) were also without bone injury. The prevalence of OPLL was 34% among this subgroup of patients.

Clinical characteristics of SCI patients with OPLL were further examined (Table 2). The primary cause of SCI in OPLL patients was predominantly falls, followed by motor vehicle accidents. Influence of alcohol use was reported in 19 patients (18%). Of note, among patients who were aware of OPLL, only one was under the influence of alcohol at the time of injury. Concurrent fractures at other sites or visceral organ injuries were relatively rare in this subgroup of SCI patients. Only 25% of patients were aware of OPLL before their injury, and even fewer patients (17%) were regularly visiting a physician

TABLE 1. Characteristics of Enrolled Patients

	SCI With OPLL	SCI Without OPLL	Total
No. (% of total) of patients	106 (23%)	347	453
Sex (men/women)	87/19	280/67	367/86
Mean age at injury (yrs, mean ± SD)	66.2 ± 11.5*	57.0 ± 18.6	59.2 ± 17.6
Frankel grade at admission			
A	21	125	146
B	29	76	105
C	56	146	202
SCI without fracture or dislocation (%)	94 (34%)	180	274

**Between-group difference was significant (P < 0.01).*

SCI indicates spinal cord injury; OPLL, ossification of the posterior longitudinal ligament; SD, standard deviation.

TABLE 2. Clinical Characteristics of SCI Patients With OPLL

	SCI Patients With OPLL (n = 106)
Cause of SCI	
Falling (% of total)	78 (74%)
Falling on one's rear	9
Falling on a flat surface	42
Falling down stairs	16
Falling from a height	11
Motor vehicle accident	19
Sports-related	3
Not specified	6
Alcohol involvement (% of total)	19 (18%)
Concurrent fracture at other site	4
Concurrent visceral organ injury	2
Awareness of OPLL before injury (% of total)	26 (25%)
Regular doctor visit for OPLL (% of total)	18 (17%)
Gait disturbance before injury (% of total)	47 (44%)

SCI indicates spinal cord injury; OPLL, ossification of the posterior longitudinal ligament.

for OPLL at the time of injury. Approximately half of patients (44%) reported preexisting gait disturbance of varying degrees.

On radiographic evaluation, ossification type was found to be continuous in 46 patients, mixed in 38, segmental in 12, localized in 5, and unclassified in 5. Mean maximum percentage of spinal canal stenosis was 46 ± 13% (mean ± SD; range: 19%–85%). No significant difference was noted in maximal canal compromise between Frankel grade groups at admission (Dunnett test).

We also evaluated the use of corticosteroids for treatment of SCI. Of the 106 SCI patients with OPLL, 76 (72%) received intravenous administration of corticosteroids. The Second National Acute Spinal Cord Injury Study protocol[8] was applied in 57 patients, whereas intermittent administration of a lower dosage was performed in the remaining 19. Complications associated with intravenous corticosteroid administration were reported in 10 patients, including gastrointestinal bleeding or ulcer in 6, pulmonary complications in 2, and wound infection and exacerbation of diabetes mellitus in 1 each.

We then examined the efficacy and safety of surgical treatment, focusing on patients without bone injury (Table 3). Of the 94 patients in this category, 48 (52%) underwent surgery (median: 13.5 days after injury) whereas the remaining 46 received some form of nonoperative treatment. Clinical characteristics of the two groups were comparable with regard to age, sex, maximum canal stenosis, and severity of SCI. Most of the surgery group patients (43 of 48) received laminoplasty.

TABLE 3. Characteristics and Complications* of OPLL Patients Without Bone Injury

	Surgery Group (n = 48)	Conservative Group (n = 46)
Age (yrs; mean [SD])	64 (10)	68 (13)
Sex (men/women)	38/10	40/6
Severity of SCI (no. of patients [%])		
Complete	8 (17)	8 (17)
Incomplete	40 (83)	38 (83)
Maximum canal stenosis (%; mean [SD])	46 (13)	46 (14)
Corticosteroid (no. of patients [%])	29 (60)	39 (85)†
Complications		
Tracheotomy	7 (15)	6 (13)
Pneumonia	9 (19)	11 (24)
Sepsis	2 (7)	3 (7)
Gastrointestinal bleeding	3 (6)	2 (4)
Urinary tract infection	8 (17)	13 (28)
Wound infection	3 (6)	2 (4)

**Complications occurring within 1 month of injury were included.*

†significantly higher in conservative group (P < 0.01); continuous variables were compared using Student t test; categorical data were analyzed using Fischer exact test.

The conservative group was more likely to receive intravenous corticosteroids ($P < 0.01$). No significant difference was noted in documented complications between the surgery and conservative groups.

Neurologic improvement was then examined in patients who had completed at least 6 months of follow-up (Table 4). Overall, 72 of the 106 patients with OPLL underwent follow-up at 6 months postinjury. Of the 94 OPLL patients presented with SCI without bone injury, 64 (68%) were followed up for at least 6 months after injury (mean: 25 months; range: 6–27 months). Of these 64 patients, 41 showed neurologic recovery at follow-up, as defined by one grade or greater improvement in Frankel grade. No significant difference was noted in neurologic improvement between the surgery and conservative groups (surgery group: 71%, conservative group: 52%; P = 0.13).

We then stratified patients according to presence or absence of gait disturbance before injury (Table 5). In this preplanned analysis, surgery was associated with better neurologic recovery in those who had gait disturbance before injury (surgery group: 82%, conservative group: 44%; P = 0.04).

DISCUSSION

Our study had three major findings. First, we found an alarmingly high prevalence of OPLL among cervical SCI, particularly in those without bone injury. Second, we also identified

TABLE 4. Neurological Outcome of OPLL Patients Without Bone Injury*

Surgery (n = 41)						Conservative (n = 23)					
	Grade at follow-up						Grade at follow-up				
	A	B	C	D	E		A	B	C	D	E
Grade at admission						Grade at admission					
A	3	2	2			A	3			1	
B		3	5	4	1	B			1	2	
C		1	5	11	4	C		2	6	8	

Frankel grade was used as outcome measure.

**Patients who had completed at least 6 mo of follow-up were included.*

the clinical characteristics of these patients: most of cervical SCI associated with OPLL were incomplete, without bone injury, and caused primarily by low-energy trauma. The vast majority of patients were elderly and unaware of OPLL. Last, we also found that surgery was associated with greater neurologic recovery than conservative treatment in patients who had gait disturbance before injury.

In this study, we focused on patients who had lost ambulatory ability immediately after injury (Frankel A, B, and C). From a practical point of view, traumatic SCI is intellectually indistinguishable from aggravation of preexisting myelopathy in individuals with OPLL, particularly when presented with mild symptoms. Our sample of more than 100 patients with OPLL represents the largest study of its subject matter ever reported.

OPLL was found to be highly prevalent in patients with acute traumatic cervical SCI: in particular, OPLL was found in 34% of cervical SCI patients without bone injury. Our findings underscore the important role of OPLL in occurrence of acute traumatic cervical SCI. In line with our present finding, Koyanagi *et al*[9] also previously reported that OPLL was highly prevalent (38%) in SCI patients without bone injury. The prevalence of OPLL among cervical SCI patients appears to be increasing because prevalence values reported in earlier studies have historically been less than 10%.[3,10]

TABLE 5. Neurological Outcome of Patients Stratified by Presence of Gait Disturbance Before Injury*

Patients who had gait disturbance before injury (n = 31)

Surgery (n = 19)					Conservative (n = 12)				
	Grade at follow-up					Grade at follow-up			
	A	B	C	D/E		A	B	C	D
Grade at admission					Grade at admission				
A	3	1	1		A	2			1
B		3	1	2	B				2
C		1	1	6	C		2	2	3

Patients without gait disturbance before injury (n = 31)

Surgery (n = 22)					Conservative (n = 9)				
	Grade at follow-up					Grade at follow-up			
	A	B	C	D		A	B	C	D
Grade at admission					Grade at admission				
A		1	1		A	1			
B			4	3	B			1	
C			4	9	C			4	3

Frankel grade was used as outcome measure.

**Patients who had completed at least 6 mo of follow-up were included.*

We also sought to clarify the clinical characteristics of SCI patients with OPLL. The majority of such patients were elderly with the peak incidence in those occurring between 70 and 75 years of age. Most of these patients were without bone injury and presented with incomplete SCI. Concomitant injuries were relatively rare, and the primary cause of SCI was minor trauma, such as a fall (74%). Patients suffered severe neurologic deficit after experiencing even subtle trauma such as falling from a standing height or falling onto one's rear, underscoring the fact that individuals with OPLL are extremely vulnerable to trauma.

Despite its potential role in preventing SCI, patient awareness of OPLL has not been fully investigated. We found that the vast majority of SCI patients with OPLL were unaware of OPLL before injury. An earlier study has suggested that once patients are made aware of OPLL and its potential risk, they are expected to more carefully avoid high-risk behaviors such as walking on a slippery slope or drinking too much alcohol.[7] Indeed, in this study, SCI associated with alcohol ingestion was significantly decreased when patients had been made aware of OPLL. This finding underscores the importance of patient awareness and indicates the effectiveness of patient education in reducing cervical SCI in those with OPLL.

The efficacy of decompressive surgery in treating cervical SCI remains controversial,[11,12] particularly in patients without bone injury. Some authors recommend surgery for patients with preexisting canal stenosis, as persistent cord compression may hinder neurologic improvement.[13–15] In contrast, other researchers have reported no additional benefit with surgery in comparison to conservative treatment.[16,17]

In this study, we evaluated the safety and efficacy of surgical treatment in patients with OPLL. Most of the surgeries we conducted here were classified as "late surgery," with a median interval of 2 weeks from injury to surgery. The surgery and conservative groups were comparable with regard to age, maximum canal compromise, and initial severity of neurologic injury (Table 3), and both groups had similar rates of complications. Overall, no significant difference was noted between the groups in neurologic recovery as defined by improvement in Frankel grade (surgery group: 71%, conservative group: 52%). However, further stratification showed that surgery was associated with better neurologic recovery in those who had gait disturbance before injury (surgery group: 82%, conservative group: 44%).

The reason why surgery benefitted patients with preexisting gait disturbance is not clear. In most patients, presence of gait disturbance indicated that the patient had already developed myelopathy. Contrary to our initial hypothesis, however, our results indicated that this subgroup of patients experienced improved neurologic recovery after decompressive surgery.

Two distinct factors must be considered in understanding the pathomechanism of SCI in patients with OPLL: direct injury by traumatic force, which is believed to be irreversible; and preexisting cord compromise because of long-standing compression. The relative contribution of these two factors may vary among patients. Decompressive surgery may have little or no benefit on primary cord injury caused by traumatic force, but may in turn benefit cord compromise brought on by persistent compression. Presumably, the contribution of traumatic force, an irreversible factor, may be smaller in patients with gait disturbance before injury than in those without gait disturbance. Patients with preexisting cord compromise may be particularly vulnerable and may easily become paraplegic on suffering minor trauma. In this study, we assumed that the variable contribution of these two factors accounts for the seemingly perplexing results obtained here. Further research in this field may provide valuable information for predicting neurologic recovery after decompressive surgery in SCI patients with preexisting canal stenosis.

Several limitations to our study warrant mention. First, the follow-up period was relatively short. Although significant improvement in motor function is known to be achieved within 6 months after injury, longer term follow-up studies may yield additional information.[14] Our follow-up rate was 68% at 6 months postinjury. This could have influenced the validity of our conclusion, although we found no apparent bias in the patients who were lost to follow-up within 6 months. Reasons for the dropout are not specified and can vary. This study was carried out at academic tertiary referral centers serving a relatively large area. SCI patients admitted to these medical centers are subsequently transferred to local hospitals near their residence after the acute phase. Presumably, some patients, especially who remained nonambulatory, required a great deal of assistance for transport. These patients might have found it difficult to travel a long distance from their residence to the hospital. We can also speculate that some patients, especially elderly patients, might have been suffering from complications after injury or comorbidities. These medically fragile patients might have been in poor or deteriorated health status and unable to show up at prescheduled checkup. The conclusions of this study need to be verified by future prospective studies. Second, Frankel grade was used as an outcome measure. Frankel grade has been widely used to rank severity of SCI in the literature despite its low discriminative ability. We therefore may have underestimated the neurologic recovery of the patients. Other validated outcome measures with high-discriminative ability may provide more detailed information. In addition, the indications and timing of surgery were not standardized between institutions, and thus selection bias cannot be entirely discounted. Despite these limitations, however, we feel that our study contains valuable information of clinical importance, providing a basis for future research.

CONCLUSION

In conclusion, our results underscore the importance of OPLL in the occurrence of acute traumatic cervical SCI in Japan, particularly in patients without bone injury. Our data indicate that patient awareness of OPLL may aid in preventing cervical SCI. Furthermore, our results suggest the efficacy of surgical decompression in patients with preexisting gait disturbance. These findings may aid in implementing an action plan aimed at prevention and better treatment of cervical SCI complicated by OPLL.

➢ Key Points

- ❑ OPLL was highly prevalent in patients with acute SCI, particularly in those without bone injury.
- ❑ Most of cervical SCI associated with OPLL were incomplete, without bone injury, and caused primarily by low-energy trauma. Majority of these patients was elderly and unaware of OPLL before injury.
- ❑ Decompression surgery was associated with better neurologic recovery compared with conservative treatment in patients who had gait disturbance before injury.

References

1. Iwasaki M, Yonenobu K. Ossification of the posterior longitudinal ligament. In: Herkowitz H, Garfin S, Eismont F, et al. eds. *Rothman-Simeone The Spine*. 5th ed. Philadelphia, PA: Saunders; 2006: 896–912.
2. Matsunaga S, Sakou T. OPLL: disease entity, incidence, literature search, and prognosis. In: Yonenobu K, Nakamura K, Toyama Y, eds. *OPLL Ossification of the Posterior Longitudinal Ligament*. 2nd ed. Tokyo, Japan: Springer, 2006:11–17.
3. Endo S, Shimamura T, Nakae H, et al. Cervical spinal cord injury associated with ossification of the posterior longitudinal ligament. *Arch Orthop Trauma Surg* 1994;113:218–21.
4. Koyanagi I, Iwasaki Y, Hida K, et al. Acute cervical cord injury associated with ossification of the posterior longitudinal ligament. *Neurosurgery* 2003;53:887–91; discussion 91–2.
5. Frankel HL, Hancock DO, Hyslop G, et al. The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. I. *Paraplegia* 1969;7:179–92.
6. Tsuyama N. Ossification of the posterior longitudinal ligament of the spine. *Clin Orthop Relat Res* 1984:71–84.
7. Matsunaga S, Sakou T, Hayashi K, et al. Trauma-induced myelopathy in patients with ossification of the posterior longitudinal ligament. *J Neurosurg* 2002;97:172–5.
8. Bracken MB, Shepard MJ, Collins WF, et al. A randomized, controlled trial of methylprednisolone or naloxone in the treatment of acute spinal-cord injury. Results of the Second National Acute Spinal Cord Injury Study. *N Engl J Med* 1990;322:1405–11.
9. Koyanagi I, Iwasaki Y, Hida K, et al. Acute cervical cord injury without fracture or dislocation of the spinal column. *J Neurosurg* 2000;93:15–20.
10. Mihara K, Torigoe Y, Konishi H. Cervical spinal cord injury associated with ossification of the posterior longitudinal ligament [in Japanese]. *Orthop Traumatol* 1991;40:763–5.
11. Fehlings MG, Sekhon LH, Tator C. The role and timing of decompression in acute spinal cord injury: what do we know? What should we do? *Spine (Phila Pa 1976)* 2001;26:S101–10.
12. Fehlings MG, Skaf G. A review of the pathophysiology of cervical spondylotic myelopathy with insights for potential novel mechanisms drawn from traumatic spinal cord injury. *Spine (Phila Pa 1976)* 1998;23:2730–7.
13. Bose B, Northrup BE, Osterholm JL, et al. Reanalysis of central cervical cord injury management. *Neurosurgery* 1984;15:367–72.
14. Chen L, Yang H, Yang T, et al. Effectiveness of surgical treatment for traumatic central cord syndrome. *J Neurosurg Spine* 2009;10:3–8.
15. Guest J, Eleraky MA, Apostolides PJ, et al. Traumatic central cord syndrome: results of surgical management. *J Neurosurg* 2002;97:25–32.
16. McKinley W, Meade MA, Kirshblum S, et al. Outcomes of early surgical management versus late or no surgical intervention after acute spinal cord injury. *Arch Phys Med Rehabil* 2004;85:1818–25.
17. Pollard ME, Apple DF. Factors associated with improved neurologic outcomes in patients with incomplete tetraplegia. *Spine (Phila Pa 1976)* 2003;28:33–9.

Surgical Outcomes and Complications of Massive OPLLs with Occupying Ratios of Greater than 60%

Motoki Iwasaki[*1], Takahito Fujimori[*1], Masafumi Kashii[*1], Hideki Yoshikawa[*1], Shinya Okuda[*2], Takenori Oda[*2]

Key words : ossification of the posterior longitudinal ligament (OPLL), anterior decompression and fusion, laminoplasty

Introduction

There is some controversy over the appropriate method of surgery for myelopathy caused by ossification of the posterior longitudinal ligament of the cervical spine (OPLL)[6]. We have reported that extensive laminoplasty (LAP) is effective and safer for most patients with OPLL with an occupying ratio of less than 60%[3,4,6]. However, some studies reported that neurological outcome of anterior decompression and fusion (ADF) would be better than that of laminoplasty for OPLL patients with hill-shaped and/or massive ossified lesions[5,7~9]. This retrospective study focused on OPLL with an occupying ratio of greater than 60% and we compared surgical outcomes and patient-based evaluations between ADF and LAP.

Materials and Methods

We performed either LAP or ADF for cervical myelopathy due to OPLL on 25 patients with an OPLL occupying ratio of greater than 60% who could be followed for more than 2 years. Since we have treated 130 patients with cervical myelopathy due to OPLL so far, the proportion of patients with an occupying ratio of greater than 60% to total operated patients with OPLL was 19% (25/130). Mean age at surgery was 56.4 years (range, 41-74 years). LAP data was available for 13 patients (11 men and 2 women) in which the mean duration of follow-up was 9.1 years (range, 2-18 years), whereas ADF data was available for 12 patients (7 men and 5 women) in which the mean duration of follow-up was 8.9 years (range, 2-14 years). During the period from 1986 to 1996, LAP was the only procedure selected for compression myelopathy[3,4]. Although no definitive selection criteria have been applied since 1996 in the selection of either LAP or ADF, ADF was chosen on the basis of the following characteristics : hill-shaped ossification, massive ossified lesions, and sharp angulation of the spinal cord[4~6]. Surgical outcomes were assessed using an original satisfaction questionnaire, 100-mm visual analogue scales (VAS), and the Japanese Orthopedic Association scoring system (JOA score). Neurological outcome was evaluated from recovery rate : excellent, >75% ; good, 50-74% ; fair, 25-50% ; poor, <25%.

Mean preoperative OPLL occupying ratio was 65.8% (range, 60-85%) in LAP and 67.5% (range, 60-80%) in ADF, respectively. Plateau-shaped ossified lesions were observed in 6 LAP patients and 5 ADF patients, whereas hill-shaped ossified lesions were observed in 7 LAP patients as well as 7 ADF patients. The ADF and LAP procedures have been described in detail elsewhere[1~3,5~7,9,10]. Autografts were used in all patients who underwent ADF ; a tricortical iliac crest graft was used in 2 patients and a fibular strut graft was used in 10 patients. The mean number of intervertebral levels fused was 3.3 (range, 2-5). Immobilization with

*1 Department of Orthopaedic Surgery, Osaka University, Graduate School of Medicine [2-2 Yamadaoka, Suita 565-0871, Japan]
*2 Department of Orthopaedic Surgery, Osaka Rosai Hospital

Table 1 Neurological outcomes of ADF and LAP (Mean±SD)

		ADF ($n=12$)	LAP ($n=13$)	p
JOA score	Preop	9.5±2.2 (4.5-12)	9.3±2.7 (5-12)	NS
	Final F/U	13.3±1.9 (10-16.5)	12.1±2.5 (8.5-15)	NS
Recovery rate	Max	65±19% (33-92%)	49±23% (0-80%)	0.08
	Final F/U	52±18% (30-92%)	36±26% (−21-69%)	0.08
Neurological deterioration		null	2 cases	

ADF : anterior decompression and fusion, LAP : laminoplasty, F/U : follow-up, NS : not statistically significant, Max : at time of maximum recovery

a halo-vest was maintained after surgery for a mean of 8.2 weeks (range, 6-14 weeks). Mean operation time was 139 minutes (range, 100-185 minutes) for LAP and 314 minutes (range, 190-470 minutes) for ADF, and the mean estimated blood loss was 284g (range, 120-600g) for LAP and 600g (range 150-1,730g) for ADF. Statistical analysis was performed using the Student t test.

Results

1. Surgical Outcomes

Among the 12 patients who underwent ADF, mean JOA score improved from 9.5 (range, 4.5-12) before surgery to 13.3 (range, 10-16.5) at final follow-up ; mean recovery rate was 65% (range, 33-92%) at time of maximum recovery and 52% (range, 30-92%) at final follow-up. On the other hand, among the 13 patients who underwent LAP, the mean JOA score improved from 9.3 (range, 5-12) before surgery to 12.1 (range, 8.5-15) at final follow-up ; mean recovery rate was 49% (range, 0-80%) at time of maximum recovery and 36% (range, −21-69%) at final follow-up. The ADF surgical outcome tended to be superior to that of LAP although the difference was not statistically significant ($p=0.08$) (Table 1). The ADF neurologic outcome was excellent in 2, good in 4, and fair in 6 of 12 patients, whereas the LAP neurologic outcome was good in 3, fair in 8, and poor in 2 of 13 patients. The proportion of excellent or good results (recovery rate of more than 50%) was 50% in ADF patients and 23% in LAP patients, whereas fair and poor outcomes (recovery rate of less than 50%) were more frequent in LAP (77%) than in ADF patients (50%).

2. Surgical Complications

With regard to intra-operative complications, cerebrospinal fluid leakage due to dural tearing was observed in one ADF case and 2 LAP cases. Among the 12 patients who underwent ADF, neurologic deterioration was observed in one case who demonstrated C5 segment palsy immediately after surgery and additional anterior decompression was required because of inadequate decompression of the ossification ; pseudarthrosis in one case who required additional posterior stabilization with instrumentation ; and laminoplasty was added thereafter in one case who exhibited late neurologic deterioration 35 months after surgery. Among the 13 patients who underwent LAP, on the other hand, neurologic deterioration was observed in one patient who developed epidural hematoma and recovered completely after emergent surgical reexploration ; transient palsy in the upper extremity was observed in 2 cases ; and laminectomy of the axis was added in one case who exhibited late

Table 2 VAS after ADF and LAP (Mean±SD)

	ADF ($n=10$)	LAP ($n=10$)	p
Pain/stiffness of neck or shoulder	60.0±33.3	29.4±26.7	0.09
Chest pain	26.0±27.6	6.7±11.2	0.08
Pain/numbness of arm or hand	49.0±30.0	31.1±23.7	NS
Pain/numbness from chest to foot	43.6±30.4	42.2±31.1	NS

VAS : visual analogue scale (0-100mm), ADF : anterior decompression and fusion, LAP : laminoplasty, NS : not statistically significant

neurologic deterioration 2 months after surgery. Ultimately, additional cervical spine surgeries were required in 3 (25%) of 12 patients who underwent ADF, whereas they were required in 2 (15%) of 13 patients who underwent LAP. With regard to postoperative neuropathic pain, one patient (8%), who experienced late neurologic deterioration due to a traffic accident 99 months after ADF, developed severe postoperative pain in the left arm, whereas 4 (31%) of 13 patients who underwent LAP developed severe postoperative pain in the upper and/or lower extremities.

3. Patient Satisfaction and Postoperative Pain

Eight patients (73%) of the 11 responders among the 12 patients who underwent ADF reported being satisfied with the results of their surgery, one (9%) was neither satisfied nor dissatisfied, and 2 patients (18%) were dissatisfied. Ten patients (91%) reported that surgery improved their condition and one (9%) reported no change. Ten patients (91%) reported that they would recommend surgery if family or friends suffered from the same disease. On the other hand, 8 patients (80%) of the 10 responders among the 13 patients who underwent LAP reported being satisfied with the results of their surgery, while 2 (20%) were dissatisfied. Eight patients (80%) reported that surgery improved their condition one (10%) reported no change and one (10%) reported a worsening of his condition. Seven patients (70%) reported that they would recommend surgery if family or friends suffered from the same disease.

Regarding patient-based evaluation, VAS of pain or stiffness of the neck and shoulder as well as chest pain tended to be higher in ADF and than LAP patients although the difference was not statistically significant ($p=0.09$ and 0.08) (Table 2).

Discussion and Conclusions

In patients with an occupying ratio ≥60%, the neurological outcome of ADF tended to be better than that of LAP although the difference was not statistically significant. We consider that there might be multiple predictive factors for OPLL ; not only occupying ratio but also a hill-shaped ossification or angulation of the spinal cord would have influence on OPLL surgical outcomes[4~6]. Moreover, the operation took a longer time in ADF and additional cervical spine surgeries were more frequent in ADF than in LAP. Since we have never performed a simultaneous anterior and posterior approach, it is difficult for us to discuss its indication. In patients with an occupying ratio ≥60%, however, we consider that it would be better to add LAP for patients who have little improvement or deterioration after ADF.

Although pain or stiffness of the neck and shoulders as well as chest pain tended to be higher in ADF than in LAP patients, neuropathic pain which was different from radicular pain or axial pain and difficult to treat was observed more frequently in LAP patients. Although palsy in the upper extremities has a benign course after LAP, an unsolved problem is this neuropathic pain : 31% patients who underwent LAP developed severe postoperative neuropathic pain. Since ossification remains ventral to the spinal cord and can progress after LAP[5], we consider that it might be influenced by remnant or progression of ossified lesions.

References

1) Hirabayashi K, Watanabe K, Wakano K et al : Expansive open-door laminoplasty for cervical spinal stenotic myelopathy. Spine. 1983 ; 8 : 693-699
2) Ito T, Tsuji H : Technical improvements and results of laminoplasty for compressive myelopathy in the cervical spine. Spine. 1985 ; 10 : 729-736
3) Iwasaki M, Kawaguchi Y, Kimura T et al : Long-term results of expansive laminoplasty for ossification of the posterior longitudinal ligament of the cervical spine : more than 10 years follow up. J Neurosurg. 2002 ; 96 : 180-189
4) Iwasaki M, Okuda S, Miyauchi A et al : Surgical strategy for cervical myelopathy due to ossification of the posterior longitudinal ligament. Part 1 : Clinical results and limitations of laminoplasty. Spine. 2007 ; 32 : 647-653
5) Iwasaki M, Okuda S, Miyauchi A et al : Surgical strategy for cervical myelopathy due to ossification of the posterior longitudinal ligament. Part 2 : Advantages of anterior decompression and fusion over laminoplasty. Spine. 2007 ; 32 : 654-660
6) Iwasaki M, Yonenobu K : Ossification of the posterior longitudinal ligament. Rothman-Simeone The Spine, 5th ed. Herkowitz HN, ed. Elsevier, Philadelphia, pp896-912, 2006
7) Matsuoka T, Yamaura I, Kurosa Y et al : Long-term results of the anterior floating method for cervical myelopathy caused by ossification of the posterior longitudinal ligament. Spine. 2001 ; 26 : 241-248
8) Tani T, Ushida T, Ishida K et al : Relative safety of anterior microsurgical decompression versus laminoplasty for cervical myelopathy with a massive ossified posterior longitudinal ligament. Spine. 2002 ; 27 : 2491-2498
9) Yamaura I, Kurosa Y, Matuoka T et al : Anterior floating method for cervical myelopathy caused by ossification of the posterior longitudinal ligament. Clin Orthop. 1999 ; 359 : 27-34
10) Yonenobu K, Wada E, Ono K : Part B : Laminoplasty. The Cervical Spine, 4th ed. Cervical Spine Research Society Editorial Committee. Lippincott Williams & Wilkins, Philadelphia, pp1057-1071, 2005

J Neurosurg Spine 14:726–733, 2011

Patient satisfaction with surgery for cervical myelopathy due to ossification of the posterior longitudinal ligament

Clinical article

Takahito Fujimori, M.D.,[1] Motoki Iwasaki, M.D., Ph.D.,[1] Shinya Okuda, M.D., Ph.D.,[2] Yukitaka Nagamoto, M.D.,[1] Hironobu Sakaura, M.D., Ph.D.,[1] Takenori Oda, M.D., Ph.D.,[2] and Hideki Yoshikawa, M.D., Ph.D.[1]

[1]Department of Orthopaedic Surgery, Osaka University Graduate School of Medicine; and [2]Department of Orthopaedic Surgery, Osaka Rosai Hospital, Osaka, Japan

Object. Surgical results in cervical myelopathy caused by ossification of the posterior longitudinal ligament (OPLL) evaluated with a patient-based method have not yet been reported. The purpose of this study was to examine patient satisfaction with surgery for cervical myelopathy due to OPLL and to clarify factors related to satisfaction.

Methods. Clinical data in 103 patients (74 male and 29 female) who underwent surgery for cervical OPLL were retrospectively reviewed. The average age at surgery was 57 years, and the average follow-up period was 9.3 years. Outcomes were assessed using an original satisfaction questionnaire, the conventional Japanese Orthopaedic Association (JOA) scoring system, the JOA Cervical Myelopathy Evaluation Questionnaire, the 36-Item Short Form Health Survey, and the hospital anxiety and depression scale. Spearman rank correlation coefficients for 5-scale patient satisfaction against outcome measures were calculated to test relationships between variables. All variables were compared between the satisfied (responses of very satisfied or satisfied) and dissatisfied (responses of dissatisfied or very dissatisfied) groups. Parameters exhibiting a significant Spearman rank correlation or difference between the groups were entered in a stepwise logistic regression analysis model, with satisfaction as the dependent variable.

Results. Sixty-nine patients were included in the analysis. There was not a significant difference in clinical data between these 69 study patients and the other 34 patients. Fifty-five patients (80%) were satisfied with the results of the surgery, and 58 patients (84%) reported that their condition was improved by the surgery. All patients who reported being very improved were either very satisfied or satisfied with the results of surgery. Quality of life (QOL), physical function (PF), and role physical (RP) were significantly correlated with patient satisfaction. The dissatisfied group had significantly more severe pain; lower maximum conventional JOA scores; lower maximum recovery rates; worse lower-extremity function (LEF); reduced QOL; and lower PF, RP, and vitality scores. Stepwise logistic regression analysis showed that PF, QOL, LEF, and maximum recovery rate based on JOA score were correlated with satisfaction.

Conclusions. Eighty percent of patients were satisfied with the surgical results after treatment of cervical myelopathy due to OPLL. Surgery for cervical OPLL was effective, as evaluated by both doctor- and patient-based methods. Patient satisfaction was related to QOL, PF (especially LEF), and improvement. *(DOI: 10.3171/2011.1.SPINE10649)*

Key Words • **ossification of the posterior longitudinal ligament** • **patient satisfaction** • **myelopathy** • **surgical outcome** • **cervical spine** • **Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire**

Ossification of the posterior longitudinal ligament of the cervical spine (termed cervical OPLL) is one of the major disorders that causes myelopathy. It has previously been reported that surgical treatments are effective for cervical OPLL with appropriate indications.[8–10,23] Other studies have reported 50% to 70% recovery rates according to the conventional JOA scoring system.[17,18,25] However, all of these previous reports included only evaluations by doctor-based methods. Recently, patient-based evaluation methods have drawn much attention for investigations of effectiveness of treatments in many medical fields. Because the concept of patient-based evaluation did not exist when the conventional JOA scoring system was developed, patient satisfaction, QOL, and psychological components are not evaluated in the conventional JOA scoring system. Given this background, the JOA produced a new evalu-

Abbreviations used in this paper: HAD = hospital anxiety and depression; JOA = Japanese Orthopaedic Association; JOACMEQ = JOA Cervical Myelopathy Evaluation Questionnaire; LEF = lower-extremity function; NRS = numerical rating scale; OPLL = ossification of the posterior longitudinal ligament; PF = physical function; QOL = quality of life; RP = role physical; SF-36 = 36-Item Short Form Health Survey; UEF = upper-extremity function; VAS = visual analog scale.

ation method for cervical myelopathy: the JOACMEQ, a patient-based, multidimensional and statistically validated scoring system.[3–6]

Evaluation from the patient's viewpoint has become essential for discussion of the effects of treatment. Although there have been many reports of high patient satisfaction with total hip or knee arthroplasty,[11,16] lumbar disc herniation,[21,26] lumbar canal stenosis,[27] and scoliosis,[1] no study has reported the surgical results of cervical OPLL evaluated with a patient-based method. In the present study, surgical treatments for cervical OPLL were evaluated using a patient-based method, focusing on patient satisfaction. The purpose of this study was first to investigate patient satisfaction with cervical OPLL surgery, and second to identify factors related to satisfaction.

Methods

Patient Population

A questionnaire was mailed to 103 consecutive patients with cervical OPLL (74 male and 29 female) who had undergone surgery between 1981 and 2007. The average age at surgery was 57 years, and the average follow-up period was 9.3 years. No patients were treated by the first author. All patients presented with signs of cervical myelopathy, such as spastic gait disturbance and/or clumsiness of the hands. The surgical procedure was selected appropriately, depending on the occupying ratio and range of compression. Anterior decompression and fusion was performed in 30 cases and laminoplasty in 73 cases.

The first author, as an independent observer, mailed a set of survey sheets to all 103 patients and collected the 72 completed sheets. Informed consent was obtained from the patients, and the study was approved by the internal review board of our institution.

Outcome Measures and Questionnaires

The conventional JOA scoring system and recovery rate were used to evaluate pre- and postoperative outcomes of cervical myelopathy as a doctor-based evaluation method.[28] The occupying ratio of OPLL was used as a radiographic assessment. Complications were defined as neurological deterioration, CSF leakage, epidural hematoma, and dislocation of grafted bone.

A set of 4 survey sheets included the following: 1) an original satisfaction questionnaire; 2) a JOACMEQ scoring sheet; 3) an SF-36 scoring sheet; and 4) an HAD scale. In the original patient satisfaction questionnaire, patients were asked to select from among the following 5 options for closed-type questions: 1) very good; 2) good; 3) fair; 4) bad; and 5) very bad *(Appendix)*. For open-type questions, patients were asked whether they were satisfied or dissatisfied, and they wrote their responses freely. Pain was evaluated on an NRS of 0–5 in the neck, arms, and legs; a score of 0 indicated no pain, whereas a score of 5 indicated intolerable pain.

The JOACMEQ has 5 functional scores (cervical spine function, UEF, LEF, bladder function, and QOL), which are obtained for corresponding domains according to previously reported formulas.[3–6] Each functional score ranges from 0 to 100, with higher scores indicating better conditions. The JOACMEQ also includes 100-mm VASs for pain or numbness in the neck, chest, arms, or hands, and from the chest to the toes. A score of 0 indicates no symptoms, and a score of 100 indicates the worst conceivable symptoms.

The SF-36 is a widely used measure for health-related QOL consisting of 8 scales, with higher scores indicating a better condition:[12–14,24] PF, RP, bodily pain, social functioning, general health perceptions, vitality, role emotional, and mental health. The HAD scale is a measure for anxiety and depression.[7,29]

Statistical Analysis

To confirm that the 69 patients included in the study were an appropriate sample, demographic data were compared with those of the 34 patients not included in the analysis (Mann-Whitney U-test, and Fisher exact probability test). Spearman rank correlation coefficients for 5-scale patient satisfaction against all outcome measures were calculated to test relationships between variables. Patients were divided into 2 groups: satisfied (responses of very satisfied or satisfied) and dissatisfied (responses of dissatisfied or very dissatisfied). The 2 groups were compared over all variables of the conventional JOA scoring system, the JOACMEQ, pain scale, SF-36, and HAD scale (Mann-Whitney U-test, Fisher exact probability test, and Pearson chi-square test). Parameters that exhibited a significant correlation or difference were entered in a stepwise logistic regression analysis model, with satisfaction as the dependent variable. The predefined significance for inclusion in the next step of the regression model was 0.2. Statistical analyses were conducted with JMP version 8.0.1 software (SAS Institute, Inc.), and a p value less than 0.05 was considered significant.

Results

Response Rate and Patient Demographic Data

Of the 103 patients who underwent surgery and to whom questionnaires were mailed, 75 received the survey sheets. From these 75 patients, 72 sets of survey sheets were collected. Of the remaining 31 patients, 13 had died, 15 were lost to follow-up, and 3 did not return the survey sheets, for a response rate of 96% (72 of 75). No patient died because of surgical complications. Of the 72 responders, 69 patients fully completed the survey; the remaining 3 patients could not complete the survey sheets due to neurovascular disease or dementia, although their family members partly filled in the questionnaire on the patients' behalf. According to the returned questionnaires, all of these 3 patients were satisfied with the surgery. These incompletely answered survey sheets were not included in further statistical analysis (Fig. 1). To verify these 69 patients as an appropriate sample, the demographic data and conventional JOA scores at the last follow-up were compared between the 69 study participants and the other 34 patients (Table 1). Although the 34 patients who were not included tended to have lower scores, this difference was not statistically significant.