

Factors associated with surgical outcomes of cervical ossification of the posterior longitudinal ligament

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Abstract

To investigate factors associated with surgical outcomes of cervical ossification of the posterior longitudinal ligament (OPLL). This retrospective study included patients (662 males and 251 females; mean age 55.8 years) with symptomatic OPLL. All patients had been diagnosed with OPLL based on cervical magnetic resonance imaging and computed tomography scans. Demographic, surgical outcome was measured using visual analog scale (VAS) and Japanese Orthopedic Association (JOA) scale scores. The results of our study indicated radicular pain was more common in segmental and circumscribe OPLL subtypes ($P < 0.05$). An anterior approach was favored in patients with less than 3 involved vertebral levels ($P < 0.05$). All surgical methods showed good outcomes ($P < 0.05$). Continuous and mixed OPLL subtypes showed worse surgical outcome with higher VAS and JOA scores ($P < 0.05$). Laminoplasty and anterior cervical discectomy and fusion were significantly associated with a higher recovery rate ($P < 0.05$). Among these patients, there were more complications with the anterior approach ($P < 0.05$). Male gender, open door laminoplasty ipsilateral, and ipsilateral-to-symptom-side opening were associated with postoperative C5 palsy ($P < 0.05$). Cervical OPLL may cause myelopathy, surgery is a safe and effective treatment for OPLL. There were no differences in clinical outcome according to surgical type, but complication rates varied depending on sex and surgical approach to symptom.

Abbreviations: ACDF = anterior cervical discectomy and fusion, OPLL = ossification of the posterior longitudinal ligament.

Keywords: laminoplasty, myelopathy, ossification of posterior longitudinal ligament

1. Introduction

Ossification of the posterior longitudinal ligament (OPLL) is a multifactorial disease resulting from pathologic OPLL that can cause stenotic changes in the spinal canal. It is recognized as one of the most common causes of severe cervical myelopathy and surgery is often necessary. OPLL is a common disease in Asian countries, and its prevalence has been reported to be 1.9% to 4.3% in Japan,^[1–7] and 3.4% to 5.7% in Korea.^[5,8,9] A variety of surgical approaches have been used to treat cervical OPLL, depending on the degree of compression, sagittal alignment, number of compressed levels, and the patient's general status.^[2,10]

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In single-level or 2-level disease, anterior cervical discectomy and fusion (ACDF) allows for direct resection of ossified tissues and complete decompression of the spinal cord can be achieved. However, in patients with multilevel (more than 3 involved vertebrae) OPLL, specifically continuous or mixed subtypes, anterior decompression is riskier and more difficult. As a result, poorer clinical results are frequently reported in these patients, and the posterior approach is often considered. However, this technique is still associated with many complications.^[6,10–13]

In patients with cervical OPLL, clarifying the relevant factors associated with surgical outcomes will help to guide treatment.^[14] However, relatively few large scale OPLL studies have been conducted.^[5] The purpose of this study was to investigate relevant factors associated with surgical outcomes in cervical OPLL.

2. Methods

2.1. Patients and operations

This was a single-center retrospective study in Yonsei University Medical Center that evaluated 913 patients who underwent cervical surgery for OPLL (Anterior Cervical Discectomy Fusion, Laminoplasty, Posterior Cervical Fusion) (Figs. 1 and 2) from January 1998 to January 2012. All study methods were approved by the Ethics Committee of Severance Hospital of Yonsei University. Inclusion criteria were defined as follows: cervical OPLL involving level, surgical cases among all patients cases, minimum follow-up of 60 months. OPLL patients were excluded if their symptoms were associated with cervical spondylotic myelopathy from cervical stenosis or cervical deformity from

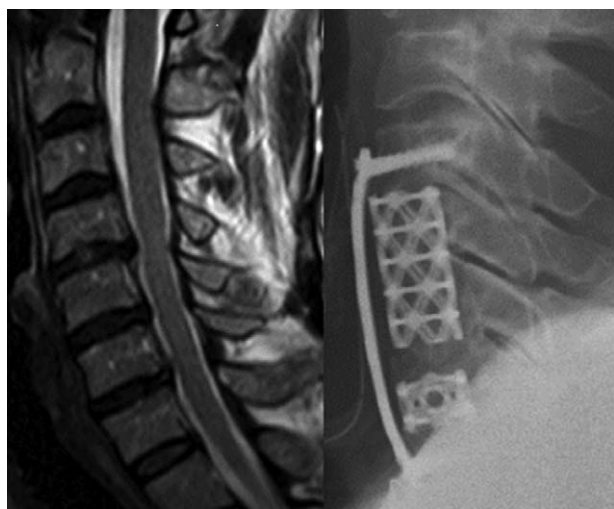


Figure 1. Anterior cervical corpectomy and discectomy fusion.

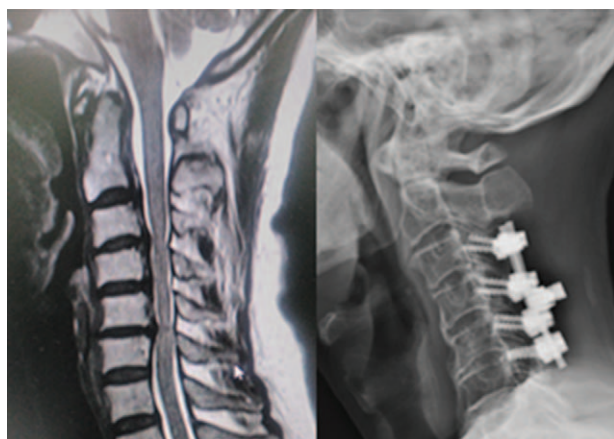


Figure 2. Posterior cervical laminectomy and fusion.

spinal injury, tumor, infection, congenital disorders, or inflammatory arthritis (including ankylosing spondylitis and rheumatoid arthritis). Patients with occipitocervical fusion and cervicothoracic fusion were also excluded. All patients were reviewed and followed up with for a minimum 60 months. Symptom duration was divided into acute (<1 month), subacute (1–3 months), and chronic (>3 months). This study was conducted to retrospectively analyze the demographics, clinical presentation, and radiographic findings in patients with OPLL of the cervical spine. This information could serve as a basis for further studies and potentially guide OPLL treatment in the future. There is no need to obtain informed consent from patients because this is a retrospective study and all data were collected and analyzed anonymously.

2.2. Radiological and clinical assessment

Computed tomography and magnetic resonance imaging scans of the cervical spine were obtained preoperatively in all cases. Plain X-rays were taken preoperatively and 1, 3, 6, 12, 24, 36, 48, and 60 months postoperatively. C2 to C7 Cobb angle was measured.

Table 1

Cervical OPLL patient demographic information.

Characteristic	Value \pm SD
No. of subjects	913
Gender	
Male:female	662:251
Age, y	
Mean \pm SD	55.8 \pm 9.8 (23–87)
Duration of symptoms, mo	
Mean \pm SD	21.5 \pm 36.5 (0.1–360)
Acute (<1 mo)	38 (4.2%)
Subacute (1–3 mo)	275 (31.1%)
Chronic (>3 mo)	600 (65.7%)
Follow-up period, mo	
Mean \pm SD	14.1 \pm 8.9 (1–60)
OPLL types	
Continuous	77 (8.5%)
Segmental	385 (42.7%)
Mixed	283 (31.4%)
Circumscribed	157 (17.4%)

OPLL = opacified posterior longitudinal ligament, SD = standard deviation.

We subdivided OPLL patients based on the classification system developed by the Japanese Investigation Committee on the Ossification of the Spinal Ligaments that includes localized, segmental, and mixed types. Following laminoplasty, we examined patients' kyphotic posture by measuring the cervical Cobb angle. By comparing results between pre- and postoperative cervical sagittal alignment, we classified the level of kyphotic changes into 3 subsets by evaluating the changes in C2 to C7 Cobb angle in patients with a laminoplasty: 0°, 0° to 10°, and >10° (lordotic). We also calculated differences in pre- and postoperative clinical outcomes using the visual analog scale (VAS) and Japanese Orthopedic Association (JOA) scores.

2.3. Statistical analysis

Data were presented as the number of subjects or mean \pm standard deviation. Comparison of each independent variable between the 2 groups was done by using the independent-sample Student *t* test for continuous variables and the Chi-squared test, linear-by-linear association, or Fisher exact test for categorical variables. Data analyses were performed using SPSS version 18 for Windows (SPSS, Inc., Chicago, IL).

3. Results

3.1. Patient demographics

Patient demographic data are summarized in Table 1. The mean preoperative symptom duration was 21.5 months (range 0.1–360 months). The mean follow-up period was 14 months (1–60 months). The majority of patients were male (662 males: 251 females) and segmental type OPLL was the most common (42.7%), and also the effects of preoperative variables (age, symptom duration, follow-up period, and OPLL types).

3.2. Clinical outcome

Clinical outcomes according to surgical approaches are visualized in Figures 3 and 4. The recovery pattern of clinical outcome was similar among the groups. Lower preoperative VAS scores

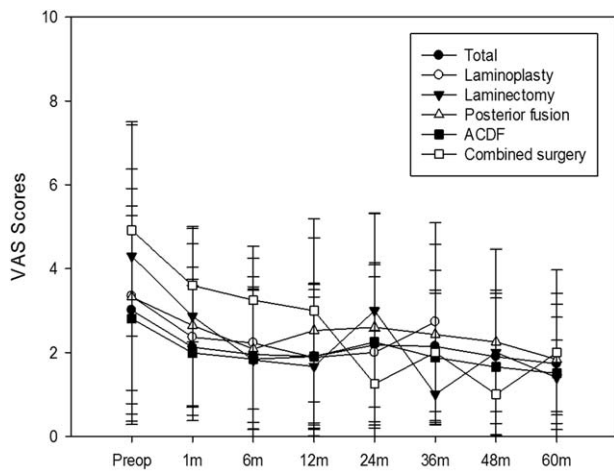


Figure 3. Comparison of baseline and postoperative visual analog scale scores according to surgical technique.

were seen in the laminectomy and combined groups. Until 60 months postoperative, the combined approach group showed lower VAS scores, but the differences were not significant. The posterior approach group showed worse preoperative JOA scores. Laminectomy, posterior fusion and combined surgery showed worse final JOA scores ($P < 0.05$).

3.3. Surgical procedures

We investigated the choice of surgical approaches in OPLL (Fig. 5). The anterior approach was the most common (55.78%), followed by posterior approach (43%) and combined approach (1.2%). In patients with less than 3 involved spinal levels, the anterior approach was the most common choice and in patients with 3 or more involved spinal levels, the posterior approach was typically used.

3.4. Radiologic progression

We investigated the relationship between C2 and C7 Cobb angle in the neutral position and various surgical techniques (Fig. 6).

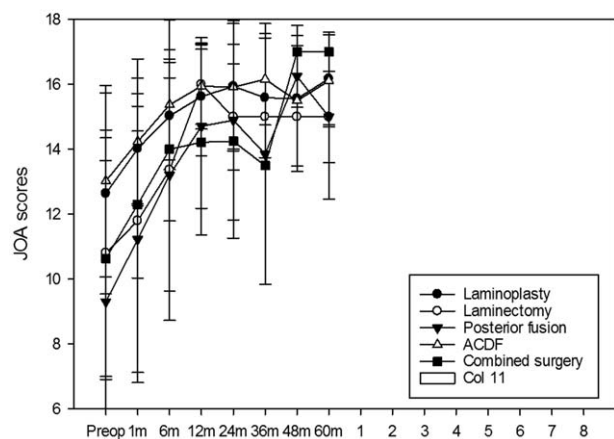


Figure 4. Comparison of baseline and postoperative Japanese Orthopedic Association scores according to surgical technique.

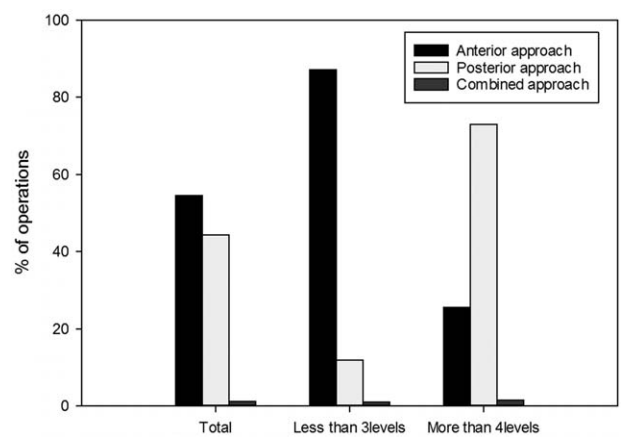


Figure 5. The choice of surgical techniques according to the involved level. Anterior versus posterior.

Posterior fusion and laminoplasty have higher progression C2 to C7 Cobb angle but slightly higher in patients who underwent laminoplasty surgery.

3.5. Complications

Postoperative complications were significantly more common in the anterior approach group than the posterior approach. Cerebrospinal fluid (CSF) leakage occurred in 21 patients (2.3%), C5 palsy occurred in 18 patients (2%), and neurological compromise occurred 9 patients (1%).

4. Discussion

Our study evaluated surgical approaches in the treatment of cervical OPLL. The majority of patients in this study were male. This result is consistent with a previous study.^[2] In our study, mean patient age was 55.8 years old and this was also consistent with previous OPLL research.^[2] Duration of symptoms mostly chronic state. According to OPLL types our study identified mostly segmental.

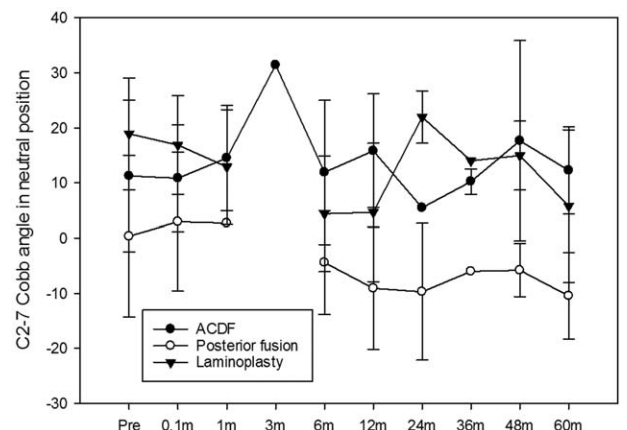


Figure 6. C2 to C7 Cobb angle neutral position according to surgical technique.

Surgical management of OPLL, specifically the choice of anterior or posterior approach, is a controversial issue. It is thought best for a neurosurgeon to perform surgery by the most familiar method also by comparison the advantages and disadvantages of each surgical method.^[12,15–19] A consensus has not been reached about the most effective surgical management of cervical OPLL. Some researchers have suggested that anterior decompression is associated with better outcome regardless of the canal-occupying ratio and neural function postoperatively, whereas other studies have demonstrated better success with posterior decompression.^[20] As relatively few studies have been published regarding the choice of surgical technique for cervical OPLL, our findings are helpful for selecting an appropriate surgical approach and identifying factors that could determine clinical improvement after cervical OPLL surgery.

Improvements in JOA and VAS scores were observed in all posterior neck surgery methods and showed substantial differences between groups (Figs. 3 and 4). Previous studies have demonstrated similar results.^[12,15] Although the choice of surgical approach is a critical factor with regard to postoperative complications, the location of spinal cord compression and sagittal alignment of cervical spine need to be considered when choosing operative technique.^[14,21]

This study identified that the anterior approach was more commonly performed in patients with cervical OPLL. A variety of complications were associated with the anterior approach, likely due to the soft tissue structure surrounding at the entry site of surgery, more than 3 involved level more frequent complication because technically demanding.^[4,10,22–27] ACDF and laminoplasty produces long-lasting improvement, confirmed at 5-year follow-up. Not only have favorable results been achieved higher recovery rate. Our study showed that the ossified cervical curve progression was increased regardless of the laminoplasty method. The cervical C2 to C7 Cobb angle at baseline varied somewhat by group because we usually performed posterior fusion in patients with neutral or correctable kyphosis.^[25,28]

Patients in this study had a wide range of follow-up times, ranging from 12 to 60 months. A previous study reported that ossification type was closely related to the outcome of laminoplasty. Our study showed that continuous and mixed subtypes showed worse surgical outcome with higher VAS and JOA scores.^[29] Previous researchers discussed the use of titanium miniplates that permitted adequate decompression of the cervical spinal cord and bilateral cervical nerve roots. They showed successful reconstruction of an enlarged rigid spinal canal this similar with our study that showed laminoplasty and ACDF have higher recovery rate among others.^[14,30–34] However, there were significant differences among the 3 groups in both C2 to C7 Cobb angle in neutral position during the study period (Fig. 5). Our study, all patients who underwent posterior neck surgery tended to lose greater cervical lordosis (Fig. 6).

The choice of surgical method for cervical OPLL was divided into 2 approaches: anterior or posterior. When planning the approach, the neurosurgeon should consider factors such as the location of spinal cord compression, number of levels involved, the sagittal alignment of the cervical spine, and general health status of the patient.^[2,10,35–37]

After posterior surgeries, our study showed a few complications. In patients who underwent anterior surgery, the incidence of CSF leakage and C5 palsy were significantly higher.^[38] The significance of demographic factors has been widely studied, but their role in guiding surgical approach has

not been demonstrated. In our study, male gender and open door laminoplasty ipsilateral, and ipsilateral-to-symptom-side opening were significantly associated with postoperative C5 palsy.

Our study had several limitations. First, this study was a retrospective clinical analysis at a single institution. Therefore, the possibility of selection bias exists. If patients with worse outcome could be followed, the results of this study would not be critical for selecting the appropriate surgical approach. Second, this study did not include preoperative measurement of dynamic factors, such as cervical range of motion, loss of cervical lordosis, and T1 sagittal slope. It is important to identify the relationships between cervical dynamic factors and surgical outcome in the treatment of OPLL. Our study could support the benefits of an anterior approach in the management of cervical OPLL, but we cannot definitively conclude whether it is superior to other treatment strategies. In conclusion the present study demonstrates that cervical OPLL compression may cause myelopathy, satisfied results can be achieved with surgery. There were no differences in clinical outcome according to surgical type, but complication rates varied depending on sex and surgical approach to symptom.

Author contributions

Conceptualization: Dong Ah Shin, Do Heum Yoon.

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Supervision: Dong Ah Shin, Keung Nyun Kim.

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Writing – review & editing: Farid Yudoyono, Dong Ah Shin.

References

- Maruo K, Moriyama T, Tachibana T, et al. The impact of dynamic factors on surgical outcomes after double-door laminoplasty for ossification of the posterior longitudinal ligament of the cervical spine. *J Neurosurg Spine* 2014;21:938–43.
- Lee CK, Shin DA, Yi S, et al. Correlation between cervical spine sagittal alignment and clinical outcome after cervical laminoplasty for ossification of the posterior longitudinal ligament. *J Neurosurg Spine* 2016; 24:100–7.
- Jeong SY, Eun JP, Oh YM. Magnetic resonance imaging analysis of deep cervical flexors in patients with ossification of the posterior longitudinal ligament and clinical implication. *Am J Phys Med Rehabil* 2015;94:967–74.
- Yang H, Lu XH, Wang X, et al. A new method to determine whether ossified posterior longitudinal ligament can be resected completely and safely: spinal canal “Rule of Nine” on axial computed tomography. *Eur Spine J* 2015;24:1673–80.
- Jeon TS, Chang H, Choi BW. Analysis of demographics, clinical, and radiographical findings of ossification of posterior longitudinal ligament of the cervical spine in 146 Korean patients. *Spine* 2012;37:E1498–503.
- Xing D, Wang J, Ma JX, et al. Qualitative evidence from a systematic review of prognostic predictors for surgical outcomes following cervical ossification of the posterior longitudinal ligament. *J Clin Neurosci* 2013;20:625–33.
- Yoshimura N, Nagata K, Muraki S, et al. Prevalence and progression of radiographic ossification of the posterior longitudinal ligament and associated factors in the Japanese population: a 3-year follow-up of the ROAD study. *Osteoporos Int* 2014;25:1089–98.
- Sohn S, Chung CK, Yun TJ, et al. Epidemiological survey of ossification of the posterior longitudinal ligament in an adult Korean population:

- three dimensional computed tomographic observation of 3,240 cases. *Calcif Tissue Int* 2014;94:613–20.
- [9] Kang MS, Lee JW, Zhang HY, et al. Diagnosis of cervical OPLL in lateral radiograph and MRI: is it reliable? *Korean J Spine* 2012;9:205–8.
- [10] Liu K, Shi J, Jia L, et al. Hemilaminectomy and unilateral lateral mass fixation for cervical ossification of the posterior longitudinal ligament. *Clin Orthop Relat Res* 2013;471:2219–24.
- [11] Lee SE, Chung CK, Jahng TA, et al. Long-term outcome of laminectomy for cervical ossification of the posterior longitudinal ligament. *J Neurosurg Spine* 2013;18:465–71.
- [12] Lee CH, Jang TA, Hyun SJ, et al. Expansive laminoplasty versus laminectomy alone versus laminectomy and fusion for cervical ossification of the posterior longitudinal ligament, is there a difference in the clinical outcome and sagittal alignment? *Clin Spine Surg* 2016;29:E9–15.
- [13] Nakashima H, Tetreault L, Nagoshi N, et al. Comparison of outcomes of surgical treatment for ossification of the posterior longitudinal ligament versus other forms of degenerative cervical myelopathy. *J Bone Joint Surg Am* 2016;98:370–8.
- [14] Gu Y, Shi J, Cao P, et al. Clinical and imaging predictors of surgical outcome in multilevel cervical ossification of posterior longitudinal ligament: an analysis of 184 patients. *PLoS One* 2015;10:e0136042.
- [15] Fujimori T, Iwasaki M, Okuda S, et al. Long-term results of cervical myelopathy due to ossification of the posterior longitudinal ligament with an occupying ratio of 60% or more. *Spine* 2013;39:58–67.
- [16] Hirabayashi S, Yamada H, Motosuneya T, et al. Comparison of enlargement of the spinal canal after cervical laminoplasty: open-door type and double-door type. *Eur Spine J* 2010;19:1690–4.
- [17] Kotani Y, Abumi K, Ito M, et al. Minimum 2-year outcome of cervical laminoplasty with deep extensor muscle-preserving approach: impact on cervical spine function and quality of life. *Eur Spine J* 2009;18:663–71.
- [18] Fujiyoshi T, Yamazaki M, Okawa A, et al. Static versus dynamic factors for the development of myelopathy in patients with cervical ossification of the posterior longitudinal ligament. *J Clin Neurosci* 2010;17:320–4.
- [19] Zhang P, Shen Y, Zhang YZ, et al. Preserving the C7 spinous process in laminectomy combined with lateral mass screw to prevent axial symptom. *J Orthop Sci* 2011;16:492–7.
- [20] Kim BW, Yoon DH, Shin HC, et al. Surgical outcome and prognostic factors of anterior decompression and fusion for cervical compressive myelopathy due to ossification of the posterior longitudinal ligament. *Spine J* 2015;15:875–84.
- [21] Choi JH, Shin JJ, Kim TH, et al. Does intramedullary signal intensity on MRI affect the surgical outcomes of patients with ossification of posterior longitudinal ligament? *J Korean Neurosurg Soc* 2014;56:121–9.
- [22] Chen Y, Chen D, Wang X, et al. Significance of segmental instability in cervical ossification of the posterior longitudinal ligament and treated by a posterior hybrid technique. *Arch Orthop Trauma Surg* 2013;133:171–7.
- [23] Feng F, Ruan W, Liu Z, et al. Anterior versus posterior approach for the treatment of cervical compressive myelopathy due to ossification of the posterior longitudinal ligament: a systematic review and meta-analysis. *Int J Surg* 2016;27:26–33.
- [24] Chen Y, Chen D, Wang X, et al. Anterior corpectomy and fusion for severe ossification of posterior longitudinal ligament in the cervical spine. *Int Orthop* 2009;33:477–82.
- [25] Hida K, Yano S, Iwasaki Y. Considerations in the treatment of cervical ossification of the posterior longitudinal ligament. *Clin Neurosurg* 2008;55:126–32.
- [26] Highsmith JM, Dhall SS, Haid RW Jr, et al. Treatment of cervical stenotic myelopathy: a cost and outcome comparison of laminoplasty versus laminectomy and lateral mass fusion. *J Neurosurg Spine* 2011;14:619–25.
- [27] Liu X, Min S, Zhang H, et al. Anterior corpectomy versus posterior laminoplasty for multilevel cervical myelopathy: a systematic review and meta-analysis. *Eur Spine J* 2014;23:362–72.
- [28] Yusof MI, Hassan E, Abdullah S. Predicted cervical canal enlargement and effective cord decompression following expansive laminoplasty using cervical magnetic resonance imaging. *Surg Radiol Anat* 2011;33:109–15.
- [29] Li H, Jiang LS, Dai LY. A review of prognostic factors for surgical outcome of ossification of the posterior longitudinal ligament of cervical spine. *Eur Spine J* 2008;17:1277–88.
- [30] Mori E, Ueta T, Maeda T, et al. Effect of preservation of the C-6 spinous process and its paraspinal muscular attachment on the prevention of postoperative axial neck pain in C3–6 laminoplasty. *J Neurosurg Spine* 2015;22:221–9.
- [31] Smith ZA, Buchanan CC, Raphael D, et al. Ossification of the posterior longitudinal ligament: pathogenesis, management, and current surgical approaches. A review. *Neurosurg Focus* 2011;30:E1–0.
- [32] Park HG, Zhang HY, Lee SH. Box-shape cervical expansive laminoplasty: clinical and radiological outcomes. *Korean J Spine* 2014;11:152–6.
- [33] Nishida N, Kanchiku T, Kato Y, et al. Biomechanical analysis of cervical myelopathy due to ossification of the posterior longitudinal ligament: effects of posterior decompression and kyphosis following decompression. *Exp Ther Med* 2014;7:1095–9.
- [34] Masaki U, Yamazaki M, Okawa A, et al. An analysis of factors causing poor surgical outcome in patients with cervical myelopathy due to ossification of the posterior longitudinal ligament anterior decompression with spinal fusion versus laminoplasty. *J Spinal Disord Tech* 2007;20:7–13.
- [35] Kwon SY, Shin JJ, Lee JH, et al. Prognostic factors for surgical outcome in spinal cord injury associated with ossification of the posterior longitudinal ligament (OPLL). *J Orthop Surg Res* 2015;10:2–9.
- [36] Heller JG, Raich AL, Dettori JR, et al. Comparative effectiveness of different types of cervical laminoplasty. *Evid Based Spine Care J* 2013;4:105–15.
- [37] Seng C, Tow BP, Siddiqui MA, et al. Surgically treated cervical myelopathy: a functional outcome comparison study between multilevel anterior cervical decompression fusion with instrumentation and posterior laminoplasty. *Spine J* 2013;13:723–31.
- [38] Imagama S, Matsuyama Y, Yukawa Y, et al. C5 palsy after cervical laminoplasty a multicentre study. *J Bone Joint Surg Br* 2010;92:393–400.