Epidemilogy Research

Operative outcomes of patients with cervical spondylotic myelopathy at Cipto Mangunkusumo National Central Hospital 2014-2016

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ABSTRACT

Introduction: Cervical spondylotic myelopathy (CSM) is the most common type of myelopathy with cervical spondylosis as the underlying disorder. To this date, there has been ongoing debate regarding operative approach in CSM treatment that there is still no established treatment proven superior one over the other. This study aims to investigate the operative outcomes of CSM.

Methods: We retrospectively reviewed patients with CSM who had undergone anterior approach and posterior surgery at Cipto Mangunkusumo Hospital, Jakarta, Indonesia, between January 2014 and December 2016. The average follow-up time was 13-42 months, with an average of 27 months. The clinical data of patients were observed, including age, sex, operation records, pre- and post-operative Japanese Orthopaedic Association (JOA) scores, cervical spine canal stenosis, cervical curvature, and the presence of ossification of the posterior longitudinal ligament.

Results: Eight patients (6 male, 2 female) with CSM were enrolled in this study with mean age of 55.6 ± 9 years. Two patients experienced minor complication, and one patient had major complication of Frankel grade decrement and phrenic nerve paralysis that led to prolonged intensive care. The pre-operative cervical JOAs of the eight patients were 11.2 ± 2.81 and post-operative JOAs were 13.1 ± 3.44. ($p < 0.05$). Seven patients were satisfied with the outcomes of their surgery.

Conclusion: A definite conclusion could not be drawn regarding the most effective surgical approach for CSM. Further studies with larger number of samples and centres are required to investigate the comparison of best treatment choice for CSM.

ABSTRAK

Pendahuluan: Cervical spondylotic myelopathy (CSM) *adalah jenis mielopati yang paling umum dengan spondylosis serviks sebagai gangguan yang mendasarinya. Sampai saat ini, terdapat perdebatan yang terus berlangsung mengenai pendekatan operatif dalam pengobatan CSM bahwa tidak ada pendekatan operatif yang terbukti lebih unggul dari yang lainnya. Penelitian ini bertujuan untuk menyelidiki luaran operasi CSM.*

Metode: *Kami meninjau secara retrospektif pasien penyandang CSM yang telah menjalani pendekatan anterior dan bedah posterior di Rumah Sakit Cipto Mangunkusumo, Jakarta, Indonesia, antara Januari 2014 dan Desember 2016. Waktu* follow-up *rata-rata adalah 13-42 bulan, dengan rata-rata 27 bulan. Data klinis pasien diamati, termasuk usia, jenis kelamin, catatan operasi, skor Asosiasi Ortopedi Jepang (JOA) pra- dan pasca-operasi, stenosis kanal tulang belakang leher, kelengkungan serviks, dan adanya osifikasi ligamentum longitudinal posterior.*

Hasil: *Delapan pasien (6 laki-laki, 2 perempuan) penyandang CSM terdaftar dalam penelitian ini dengan usia purata 55,6 ± 9 tahun. Dua pasien mengalami komplikasi ringan, dan satu pasien mengalami komplikasi utama penurunan derajat Frankel dan kelumpuhan saraf frenikus yang menyebabkan perawatan intensif yang berkepanjangan. Skor JOA servikal pra-operasi dari delapan pasien adalah 11,2 ± 2,81 dan skor JOA pasca-operasi adalah 13,1 ± 3,44. ($p<0,05$). Tujuh pasien merasa puas dengan hasil operasi.*

Kesimpulan: *Kesimpulan definitif tidak dapat ditarik mengenai pendekatan bedah yang paling efektif untuk CSM. Penelitian lebih lanjut dengan jumlah sampel dan pusat yang lebih besar diperlukan untuk menentukan perbandingan pilihan pengobatan terbaik untuk CSM.*

Keywords: cervical spondylotic myelopathy, JOA scores, anterior and posterior approach

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INTRODUCTION

Cervical spondylosis or degenerative alteration of the cervical spine is the most frequent cause of neural dysfunction in the cervical spine. As the average life-expectancy increases, cervical spondylosis is becoming more prevalent these days. The degenerative changes associated with ageing comprise a mixed group of pathology involving intervertebral-disc, vertebral body, and/or facet joints. This condition is often asymptomatic, yet it may yield to canal or foraminal stenosis compromising the spinal cord or nerve roots to present symptomatically in 10-15% of cases.[1]

As a progressive degenerative process advances, spinal canal stenosis may develop. Such condition is termed as cervical spondylotic myelopathy (CSM) and encompasses a wide range of symptoms and examination findings, including motor and sensory abnormalities associated with dysfunction of the cervical spinal cord. The degree and combination of symptoms may vary extensively and not necessarily related to the extent of compression. A special form of CSM is caused by ossification of the posterior longitudinal ligament (OPLL).

CSM is the most common type of myelopathy in those over 55 years of age. In fact, its prevalence is estimated to be 10 to 15% of cervical spondylosis, and it is the most frequent cause of myelopathy in Caucasians.[2] In a national cohort of eastern Asia, the incidence of CSM-induced hospitalization was 4.04 per 100,000 persons each year. Moreover, it is reported that CSM was associated with higher incidences among older and male patients. CSM is the predominant reason for spinal cord injury and neurological dysfunction, particularly across industrialized countries, leading to disability as a life-long event, and posing great social and economic burden.[3]

There have been ongoing debates regarding operative measures in CSM treatment that no established treatment pathway was proven superior to another. The anterior approaches for treating CSM have been proven with good clinical outcomes and high fusion rate. It has been demonstrated that the clinical outcomes and the fusion rate were better in ACCF than those of multilevel ACDF in the treatment of multilevel ACDF in handling multilevel cervical spondylosis. However, ACCF is associated with early hardware failure. It is still uncertain whether single-level ACCF is better than two-level ACDF in treating two adjacent segments CSM with long-term follow-up.[4] Another anterior approach includes anterior discectomy without fusion and/or total disc arthroplasty. Posterior approaches comprise of laminectomy with or without instrumented fusion, laminotomy, and laminoplasty.

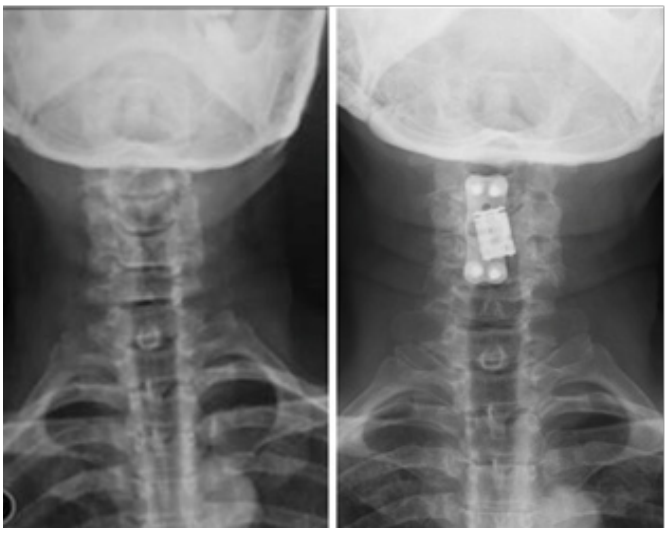
Different from the majority of other spinal problems, in which the clinical treatment is usually the first option, early surgery is believed to be a key point to interfere in the natural history of CSM and improve the neurological prognosis. In fact, there is strong evidence showing that surgery within one year from onset of symptoms strongly improves prognosis in CSM.[5] However, although surgical treatment has been advocated for CSM by numerous authors, the optimal surgical approach remains controversial. Anterior, posterior and combined anterior and posterior surgical approaches for patients with multilevel CSM all have been advocated.[6]

METHODS

Subjects were patients diagnosed with CSM with a combination of developmental cervical spine canal stenosis who underwent cervical spine surgery at Cipto Mangunkusumo National Central Hospital during the period of January 2014 to December 2016 and diagnosed with CSM combined with developmental cervical spine canal stenosis. All patients showed spinal cord compression symptoms, signs, and imaging findings, with two or more oppressed spinal cord segments, with either present or absent pre-existing cervical spinal canal stenosis (denoted by the ratio of Torg/Pavlov ratio of C4 level), without surgical contraindications, and without cervical tumor, trauma leading to cervical fracture, dislocation, or severe cervical kyphosis.

We gathered a total of nine patients that underwent operative treatment at our hospital with only eight patients completed the full follow-up course. The follow-up was achieved by examining the patients at the outpatient clinic and telephoning them. The inclusion criteria were as follows: (1) clearly diagnosed with CSM with developmental cervical spinal canal stenosis; (2) above 40 years of age; (3) had undergone operative treatment. The exclusion criteria were patients with 1) a previous history of cervical spine fracture, dislocation, or tumors; 2) comorbidity of neurological disorders leading to cervical spinal cord or pyramidal tract impairment; 3) incomplete imaging data; and 4) presence of severe pre-operative osteoporosis.

A B

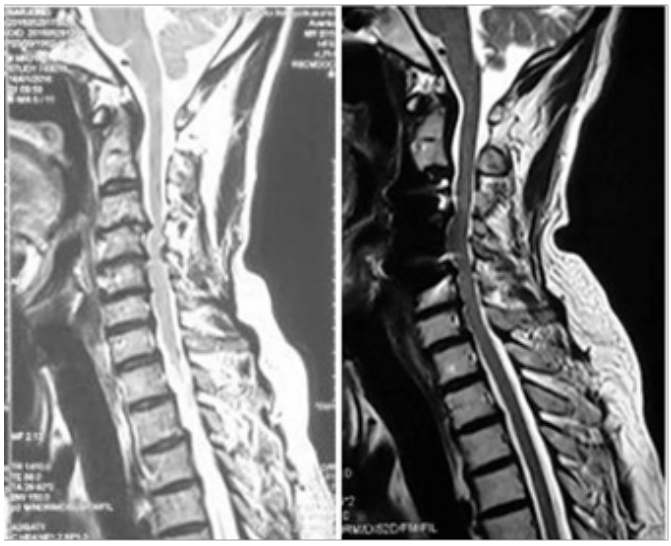


C D

Figure 1. Preoperative and postoperative cervical X-ray images.
Notes: (A) Preoperative lateral X-ray image, (B) postoperative right lateral X-ray image, (C) preoperative left A/P X-ray image, and (D) postoperative left A/P X-ray image. Abbreviation: A/P, anterior/posterior.

From all of the patients, we performed 5 (five) anterior decompression operation, and 3 (three) posterior decompression operation. The surgical choice among these approaches is based primarily on the location of the compressive pathology, the extent of the degenerative process, sagittal alignment of the cervical spine, the presence of pre-operative neck pain, previous surgeries, and the patient's age and overall medical conditions.

Anterior approach was chosen in 5 (five) patients



A B

Figure 2. Preoperative and postoperative cervical MRI images. Notes: (A) Preoperative MRI image showing the cord was compressed with "bead-like" shape. (B) Postoperative MRI image showing the compression of the cord was almost completely removed. Abbreviation: MRI, magnetic resonance imaging.

considering the pre-operative sagital alignment of the cervical spine that tends to be hypo-lordosis and needed to be corrected, localized location of compressive pathology (e.g. herniated disk), and the presence of neck pain/instability that required fusion. On the contrary, posterior approach was considered in patients with multiple level stenosis, diffuse pathology, with relatively good cervical sagittal alignment.

All patients underwent routine pre-operative preparation including imaging studies such as anteroposterior and lateral X-ray of the cervical spine and MRI examinations, as well as routine treatment of coexisting medical complications. All patients received cervical spine surgery and post-operative rehabilitation in the same hospital, and the same group of experienced doctors completed all the surgeries. Under general anaesthesia, the patient was either placed in a supine or prone position to the operating table, depending on the surgical procedure. A surgical procedure was performed after routine disinfection, operation sheet and towel placement, and skin preparation. The wound was thoroughly washed, the inventory of gauze and instruments were cleared, drainage tube was also placed, and finally, the wound was closed layer by layer. After the surgery, the patient would be given with a soft cervical collar and subsequently put a nasogastric tube for oral feeding.

The drainage tube was removed approximately 48 hours after surgery. Third generation cephalosporin antibiotics were used routinely for two days, as well as analgesics, and gastroprotectors. Potent steroid (we used methylprednisolone) was used to reduce nerve root oedema (125 mg intravenous t.i.d.). After removing the drainage tube, the patient was asked to ambulate and exercise under the protection with neck brace; A/P radiography was performed to check the recovery status of the cervical spine.

We collected data regarding the patients' profile and operation through medical records. Data regarding age, sex, course of hospitalization, operation time, blood loss, and perioperative complications for each patient were gathered. We assessed pre-operative and post-operative Japanese Orthopaedic Association (JOA) score (full score 17 points), and we also compared the pre- and post-operative Nurick score. We also analyze radiologic parameter, such as pre-operative cervical spinal stenosis (ratio of Torg/Pavlov ratio of C4 level), cervical spine sagittal curve (denoted by regional Cobb's angle of C2 upper end plate and C7 lower end plate, and local Cobb's angle of between superior and inferior adjacent spinal vertebra level). Internal fixation-related complications such as screw displacement, fracture, and loosening were also recorded through studying the cervical radiography at follow-up. The presence of ossification of the posterior longitudinal ligament (OPLL) were also observed by studying preoperative MRI and computed tomography images.

All statistical analysis were performed using SPSS 22.0 for Mac. Data were presented as mean ± standard deviation; qualitative data were expressed as a percentage. Paired t-test was used to analyze pre- and post-operative JOA scores and cervical curvature. For comparison between the two groups, t-test or Wilcoxon two-sample test was used for measurement data, and chi-square test or Fisher's exact test was used for qualitative data. Factors that affect post-operative improvement rate were analyzed with multivariate logistic regression.

RESULTS

General characteristics

As shown in Table 1, among total of eight patients, 6 were males and 2 were females (one male patient lost to follow up, so the final sample size is 8), aged 45-75 years with a mean age of 55.6 ± 9 years. The mean operation time was 212 minutes, the average amount of bleeding was 333 ml, average hospitalization day was 6.57 days (1 case excluded for complication management), and the follow-up time was 13-42 months, with an average of 27 months. There was no case of perioperative anaesthesia accident, cerebrovascular accident, wound infection, or non-healing wound. Five patients had no postoperative complication, while two patients experienced minor complication such as difficulty in swallowing and coarse voice and one patient had a major complication of Frankel grade decrement and phrenic nerve paralysis that led to prolonged intensive care.

Results of neurological recovery

The pre-operative cervical JOAs of the eight patients were 11.2 ± 2.81, post-operative JOAs were 13.1 ± 3.44. The average clinical improvement rate was 29% (cases that had post-operative worsening of function was excluded). Regarding residual symptoms, there were three cases of residual numbness and tingling over lower extremities, one case with unease right arm radiculopathy. At follow-up, two patients complained of neck and shoulder pain, one of them with moderate pain with visual analogue score of 5. There was one case with post-operative phrenic nerve paralysis C5 nerve palsy case. Seven patients were satisfied with the outcomes of their surgery.

Imaging analysis

Developmental cervical canal stenosis was present in all eight patients before surgery as shown in X-ray imaging, the ratio of lateral C4 canal sagittal diameter/vertebral body sagittal diameter was 0.63 ± 0.12. Analysis of pre-operative MRI showed that one case had lesions in six spine segments, two cases had lesions in three segments, and three cases had lesions in two segments. OPLL was found in one patient (incidence rate of 12.5%). The average pre-operation cervical curvature (C2-7 Cobb's angle) was 20.8 ± 16.3°, post-operation cervical curvature was 23.9 ± 11.7°. All patients achieved bony fusion without pseudarthrosis formation. There was no loose, shift, break, pull out, poor location, or other complications for all internal fixation screws. The cervical X-ray and MRI images of a 55-year-old male patient with a follow-up time of 24 months are shown in Figures 1 and 2. Figures 1 and 2 show that the spinal cord in the pre-operative image was compressed to "bead-like" shape, while post-operatively the compression was almost completely removed.

Table 1. General characteristic of the patients

Variants	Value, N=8
Sex, n (%)	
• Male	6 (75%)
• Female	2 (25%)
Age (years), mean ± SD	55.6 ± 9
• Maximum	45
• Maximum	75
Pre-op OPLL, n (%)	
• Yes	1 (12.5%)
• No	7 (87.5%)
Segment, n (%)	
• 1	2 (25%)
• 2	3 (37.5%)
• 3	2 (25%)
• 6	1 (12.5%)
Torg-Pavlov Ratio on C4, mean ± SD	0.63 ± 0.12
• Minimum	0.45
• Maximum	0.77
Pre-op JOA, mean ± SD	11.2 ± 2.81
• Minimum	7
• Maimum	15
Pre-op curvat, mean ± SD	20.8 ± 16.3
• Minimum	-14.1
• Maximum	42.2
Follow-up time (in months), mean ± SD	25.6 ± 10,1
• Mnimum	13
• Maximum	42

Abbreviations: OPLL, ossification of the posterior longitudinal ligament; JOA, Japanese Orthopaedic Association; SD, standard deviation.

Table 2. Post-operative findings

Variants	Value, N=8
Post-op JOA, mean ± SD	13.1 ± 3.44
• Minimum	6
• Maximum	17
Improvement rate, mean ± SD	0.29 ± 0.36
• Minimum	-0.5
• Maximum	0.7
Residual symptoms, n (%)	
• None	3 (37.5%)
• Upper extremity pain	1 (12.5%)
• Lower extremity tingling	1 (12.5%)
• Lower extremity numbness	2 (25%)
• Lower extremity weakness	1 (12.5%)
Post-op curvature, mean ± SD	23.9 ± 11.7
• Minimum	0
• Maximum	40
Post-op pain scale, VAS, n (%)	
• 0	2 (25%)
• 1	4 (50%)
• 2	1 (12.5%)
• 3	1 (12.5%)

Abbreviations: JOA, Japanese Orthopaedic Association; VAS, visual analogue scale; SD, standard deviation.

Table 3. Cervical curvature correction during follow-up examination

Pre-operative curvature	Follow-up curvature			Total
	Lordosis	Straight	Kyphosis	
Lordosis	7	0	0	7
Straight	0	0	0	0
Kyphosis	0	1	0	1
Total	7	1	0	8

Analysis of factors affecting post-operative JOA scores

Independent t-test was used to assess factors that may affect post-operative JOA scores, such as age, sex, torg-pavlov ratio, pre-operative and post-operative sagittal cervical curvature, pre-operative JOA score, onset of disease, and the presence of OPLL. However as shown in statistical study, not any single factors were regarded statistically significant as factors that may affect post-operative JOA scores ($p>0.05$). Although presumptively it was thought that the degree of myelopathy/spinal cord compression was directly related to the degree of anatomical damage of the neurological structure and thus affecting the healing reserves, pre-operative JOA score in this serial case was not an independent factor that affect post-operative JOA score ($p>0.05$). This finding was also concurrent with no significant relationship between the onset of disease and JOA score improvement ($p>0.05$).

DISCUSSION

Cervical spondylotic myelopathy (CSM) is a common disorder of progressive spinal cord characterized by compression of the spinal cord, and its prevalence accounted for 10-15% of cervical spondylosis. CSM is the predominant reason for spinal cord injury and neurological dysfunction, particularly among industrialized countries, which may lead to long-term disability event, thereby resulting in a great social and economic burden.[7]

Regarding the treatment of CSM, the majority of the guidelines have recommended operative treatment over conservative treatment for moderate to severe cases of CSM as well as for mild cases, if the patient presents with good clinical condition.

The primary aims of surgery for CSM are to relieve spinal cord compression and maintain cervical spine stability, whereas the secondary aims are to minimize complications, such as long-term pain and motion loss. The surgical techniques to treat CSM can be broadly divided into anterior, posterior or combined surgical approaches.[5] The surgical choice among these approaches is based primarily on the location of compressive pathology, the extent of the degenerative process, sagittal alignment of the cervical spine, the presence of pre-operative neck pain, previous surgeries, the patient's age and overall medical conditions.[6]

Since its development in the 1950s, the anterior approach has been applied to the treatment of cervical stenosis resulting from herniated disks, spondylosis or ossification of the PLL. ACDF is a surgical procedure focusing on the cervical spine through a small incision, and subsequently removing the intervertebral disc, and then replaced by a small plug of bone or other graft substitute, which usually applied for treating the compression of nerve root or spinal cord. Meanwhile, ACCF refers to a procedure that removes a part of the vertebra and adjacent intervertebral disks, thereby allowing the decompression of the cervical spinal cord and nerves. In the procedure, a bone graft, and sometimes a metal plate and screws, will be used to stabilize the spine. Regarding the clinical outcomes of ACDF and ACCF, it has been revealed that ACDF is more effective for those with CSM as ACDF was evidenced to significantly elevate the rates of fusion. Moreover, ACDF has been confirmed to be beneficial for the treatment of cervical degenerative diseases, contributing to a direct neural structures decompression, immediate stabilization of the operated segments, solid fusion or restoration of the cervical alignment; and consequently, a short-term follow-up of those patients.[3] It has been reported in multiple case series that ACDF of 1—3 levels is a safe and effective procedure for decompressing ventral pathology. However, when it is performed for more than three levels or in case of more than two corpectomies, the rate of further complications (such as fracture, graft extrusion, and pseudoarthrosis) increases exponentially. Thus, the majority of the authors have recommended adding further posterior instrumentation in such cases.[8–10]

Procedures via the posterior approach include laminectomy, laminoplasty, and laminectomy with fusion. Posterior laminectomy is a relatively simple procedure but has not been popular recently due to its association with post-operative instability or kyphotic deformity. In contrast, laminoplasty is recommended as it can prevent deformity while preserving motion to a certain extent.[11] Laminoplasty preserves most of the bony posterior vertebral elements and, therefore, may decrease the risk of post-laminectomy kyphotic deformity in comparison with laminectomy. In addition, laminoplasty seems to present a decreased incidence of adjacent-level degeneration by preserving normal cervical range of motion, as compared to laminectomy and fusion.[5]

The indications for laminoplasty include multilevel cervical stenosis and myelopathy, preferably with stenosis at 3 or more levels. If segmental instability exists, a concurrent lateral mass fusion of the involved levels may

be performed. The main contraindications of laminoplasty include the presence of kyphosis and preoperative neck pain. Individuals with significant neck pain should not be treated with a laminoplasty.[12] Although ACDF or ACCF and laminoplasty have been reported for the treatment of multilevel CSM, comprehensive studies comparing the clinical outcomes of these techniques are lacking. Thus, the ideal surgical strategy for multilevel CSM remains controversial.[13] Zhu, *et al*[14] found that the anterior approach was associated with better postoperative neural function compared to posterior approach. However, they found that the complication and reoperation rates were significantly higher in the anterior group compared to the posterior group.

In this study, we followed up serial of cases which surgery was conducted at our hospital for about 3 years, with an average follow-up of 2 years and 3 months. Five patients underwent anterior decompression operation, and three underwent posterior decompression operation. The surgical choice among these approaches is based primarily on the location of compressive pathology, the extent of the degenerative process, sagittal alignment of the cervical spine, the presence of preoperative neck pain, previous surgeries, and the patient's age and overall medical conditions.[6]
Anterior approach was chosen in 5 patients considering the pre-operative sagittal alignment of cervical spine that tends to be hypo-lordosis and needed to be corrected, localized location of compressive pathology (e.g. herniated disk), and the presence of neck pain/instability that required fusion. The advantage of anterior surgery is that it is more radical than posterior surgery in decompressing the nerve tissue by directly removing all of the anterior pathogenic structures, such as protruded discs, osteophyte or ossification lesion. In a meta-analysis of ten studies, Luo, *et al*[13] found that the anterior surgery was significantly better than the posterior one in the final follow-up post-operative JOA.

On the contrary, posterior approach was considered in patients with multiple level stenosis, diffuse pathology, with relatively good cervical sagittal alignment. However, there was an exception where we perform laminoplasty in 1 level stenosis case due to good cervical curvature and minimum change on the anterior structures or stability that does not require fusion.

Evaluating from all cases, we found that the clinical symptoms of most patients were improved, the JOA score at follow-up was better than the pre-operative score, and JOA score improvement rate was moderate (29%). Averagely, patients in the series showed certain level of neurological function improvement, although there was a patient that had a phrenic nerve palsy complication in this study. Post-operative cervical lordosis still could be well maintained, and there was no cervical kyphosis case. All of the patients, except one, were satisfied with the surgery outcomes, in general.

Factors that affect the clinical neurological improvement in CSM cases treated operatively have been investigated through the previous studies - although there were controversies in defining them. In this serial case, independent t-test was used to assess factors that may affect post-operative JOA scores, such as age, sex, torg-pavlov ratio, pre-operative and post-operative sagittal cervical curvature, pre-operative JOA score, onset of disease, and the presence of OPLL. Literatures had shown that age is a well-recognized influential factor, whereas older patients have a poorer prognosis. Sex was not an independent influential factor. However as shown in statistical study, not any single factors were regarded statistically significant as the factor that may affect post-operative JOA scores.

These results were thought to be caused by the few sample number used in the serial case, with bigger sample number would generate better and more reliable results. Although presumptively it was thought that the degree of myelopathy/spinal cord compression was directly related to the degree of anatomical damage of the neurological structure and thus affecting the healing reserves, pre-operative JOA score in this serial case was not an independent factor that affect post-operative JOA score ($p>0.05$). Roughly, we could see an almost homogenous rate of improvement (~29%) throughout all patients with various preoperative JOA score. This finding was also concurrent with no significant relationship between the onset of disease and JOA score improvement - though most scholars advocated early surgical intervention (the longer the duration of the disease, the more severe spinal cord damage, and the lower possibility of recovery even after surgical decompression).

Finally, it is related to the safety of the instrumentation used in each technique or approach. In this study, after follow-up, the location of all internal fixations was stable, there were no complications such as screw displacement, loose, pull-out, or broken, and no occurrence of screw

stimulating the nerve root. There was no wound infection, post-operative hematoma or anesthesia accidents reported in the patients. The operation time average could be controlled in ±3.5 hours (mean: 212 minutes), and the amount of bleeding was moderately limited (mean: 333 cc). In general, the safety in this serial case was well maintained.

However, there are several limitations of this study. 1) The sample size is small and there were no adequate number of samples in each of every procedure and also lost cases during the follow-up, which might adversely affect the result. 2) This serial case is limited to a single-center only, as more reliable results need to be further confirmed by conducting multicenter prospective studies.

CONCLUSION

Operative procedure for CSM cases conducted in our center showed an overall positive outcome, with average clinical improvement rate (JOA score) of 29%. Age, sex, torg-pavlov ratio, pre-operative and post-operative sagittal cervical curvature, and the presence of OPLL were found not to be the factors that may affect post-operative JOA scores. Further studies with larger samples and centers are required to evaluate factors that affect functional outcome of CSM operative treatment and also to compare which treatment approach is more superior between the anterior and the posterior one.

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