ORIGINAL ARTICLE

Clinical features and surgical outcomes of cervical spondylotic myelopathy in patients of different ages: a retrospective study

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Study design: Retrospective chart audit.

Objectives: This study aims to compare the clinical features and surgical outcomes in patients with cervical spondylotic myelopathy (CSM) among different age groups.

Setting: The first Affiliated Hospital of Anhui Medical University, China.

Methods: A total of 460 patients with CSM who were surgically treated over the period of 1995–2009 were investigated. Considering the peak age (40–60 years old) for the onset of symptoms, we divided the patients into three groups by age: young (<40), middle-aged (40–60), and old (>60). The differences in symptoms, symptom durations, involved levels, surgical approaches and outcomes were evaluated.

Results: The number of symptoms and involved levels, symptom duration and posterior approach significantly increased with increasing age, whereas preoperative Japanese Orthopedic Association score decreased among the three groups. Spinal cord function improved after surgery in all groups. The highest degree of recovery occurred during the first 6 months after surgery, especially within the first week, and then reached a plateau. After 6 months, however, recovery continuously improved, stabilized and declined in the young, middle-aged, old groups, respectively. The recovery rate was not significantly different at an immediate period (1 week) after operation among the three groups, but was significantly different at later periods (3 or more months postoperatively). Three groups showed no difference in postoperative complication rates.

Conclusion: The severity of CSM increased with increasing age. Age was inversely correlated with recovery, and recovery decreased as age increased. Six months post operation was the prime time for the recovery of spinal cord function.

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INTRODUCTION

Cervical spondylotic myelopathy (CSM) is a highly common spinal cord disorder that is caused by the degeneration of spinal structures. CSM causes neurological impairment and functional decline, thus reducing the independence and the quality of life of affected individuals. According to a previous study on the natural history of cervical diseases, CSM has continuing and developing characteristics; surgery can prevent the deterioration of neurological function^{1–5} and may even improve neurological function in several cases.^{4–6} A recent study estimated the prevalence of surgically treated CSM as 1.6 per 100 000 inhabitants; the actual incidence and prevalence of this disease, however, remains unclear.⁷

The elderly are the largest population group affected by CSM.¹ However, because of sociocultural and lifestyle changes, the incidence of CSM increases annually, and the young are increasingly becoming affected. Patients with CSM in different age groups could present different clinical features and experience different surgical outcomes. Thus, we counted patients with CSM who had undergone surgical treatment in our department over the period of 1 January 1995 to 31

December 2009. We then divided these patients into three groups on the basis of the peak age for the onset of symptoms in patients aged 40–60 years.³ Then, we described and analyzed the clinical features and surgical outcomes of CSM in the three groups to obtain data for CSM treatment.

MATERIALS AND METHODS

Patient population

We retrospectively reviewed patients with CSM who underwent decompression surgery over the period of 1 January 1995 to 31 December 2009 at the First Affiliated Hospital of Anhui Medical University. CSM was diagnosed based on history and examination. Diagnosis was performed by a consultant spinal surgeon and was then confirmed through radiological imaging. Patients with the following conditions were excluded from this study: (1) traumatic cervical myelopathy or aggravated symptoms after trauma; (2) ossified posterior longitudinal ligament, herniated cervical disc, rheumatoid arthritis, spine or spinal cord tumor; (3) previous cervical surgery; (4) palsy attributed to other neurological disorders, such as cerebral palsy, cervical myeloradiculopathy, cervical spondylotic amyotrophy, diabetic neuropathy or psychiatric diseases; and (5) required additional treatment such as hemodialysis.

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Follow-up duration was 25–264 months (average of 36.5 months). Patients were observed at 1 week, 3 months, 6 months and 12 months after surgery. A total of 27 patients were lost to follow-up because they changed their addresses or phone numbers, and 21 patients refused to return because they were far from the hospital or they felt that they did not have any serious problems that required consultation. Moreover, two patients died of unrelated causes. A total of 460 patients responded to our invitation and made return visits.

Based on the peak age for the onset of symptoms in patients aged 40–60 years,³ we divided the patients into three groups as follows: young group (22–39 years old, 61 patients, 13%), middle-aged group (40–60 years old, 313 patients, 68%), and old group (61–78 years old, 86 patients, 19%).

Data collection and outcome assessment

All surgeries were performed by fellowship-trained spine surgeons. The medical records, office notes and operative reports of the patients were reviewed to collect pre-, peri- and postoperative data. The differences in the preoperative symptom duration, clinical data, involved levels, type of surgery, surgical outcome and postoperative complications among the three age groups were evaluated. Spinal cord status was determined through magnetic resonance imaging (MRI). The MRI scans were acquired prior to surgery with a 0.5–1.5T general electric instrument using conventional sequences, including T1, T2 and STIR (short-tau inversion recovery) images in the sagittal plane and axial T2-weighted gradient-echo scans that coherently covered five segments of the cervical spine from levels C2/C3 to C6/C7. The imaging criterion for cervical cord compression was defined as a change in spinal cord contour at the level of an intervertebral disc on axial or sagittal MRI scan compared with that at the midpoint level of the neighboring vertebrae.

Clinical data were evaluated using the scoring system for CSM of the Japanese Orthopedic Association (JOA score).⁸ The pre- and postoperative JOA scores were recorded for each patient. The postoperative JOA score was

clinically recorded at each follow-up. All pre- and postoperative JOA scores were determined by both the treating spinal surgeon and the attending neurologist. Surgical outcomes were evaluated using the recovery ratio, which was calculated on the basis of the preoperative and postoperative JOA scores.⁹ Recovery rate (%) = (Postop JOA score—Preop JOA score)/(17—Preop JOA score) × 100. During each follow-up visit, a senior author (SA) clinically assessed the clinical indications of hyperreflexia, provocative signs and overall recovery.

Surgical protocol

Surgical treatment for CSM included anterior and posterior approaches, depending on the cervical alignment and the compression levels and sources. Anterior decompression including anterior cervical discectomy and fusion and anterior cervical corpectomy and fusion or both combined were adopted for patients with 1–3 level compressions, particularly those with greater compression on the anterior side. Laminoplasty was performed on patients who exhibited preserved cervical lordosis and >3-level canal stenosis, C3–C6 (or C7). Laminoplasty was also selected for patients with significant compression on the posterior side, even if the patients exhibited <3-level compression. We arbitrarily selected the combined approach for multilevel cervical spondylosis associated with severe ventral compression, especially when the occupancy ratio of the spinal canal exceeded 50%. Patients who have CSM with severe kyphotic deformity, osteoporosis or instability were also considered for the combined approach.

Statistical analysis

We constructed the quantitative database using EpiData 3.1 (EpiData Forenigen, Odense, Denmark) after checking and coding the questionnaires. Data were separately entered by two doctors and then cross-checked again to ensure the data accuracy. The finalized database was analyzed using SPSS 10.01 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were calculated, including the

Table 1 Patients' characteristics and clinical features of the three groups

Parameter	All	Young	Middle-aged	Old	P-value
Age (years)	51.4 ± 10.5	34.9 ± 4.1	50.5 ± 6.1	66.2 ± 4.6	
Gender (men/women)	345/115	48/13	238/75	59/27	0.287 ^a
Symptom duration (months)	15.7 ± 24.1	10.9 ± 18.3	15.3 ± 23.8	20.8 ± 28.2	
Symptoms	4.0 ± 1.6	3.6 ± 1.5	3.9 ± 1.6	4.4 ± 1.7	0.006 ^b
Upper limb numbness	340 (73.9)	51 (83.6)	225 (71.9)	64 (74.4)	
Gait disturbance	331 (72.0)	42 (68.9)	225 (71.9)	64 (74.4)	
Lower limb numbness	264 (57.4)	34 (55.7)	179 (57.2)	51 (59.3)	
Lower limb weakness	200 (43.5)	20 (32.8)	136 (43.5)	44 (51.2)	
Upper limb weakness	176 (38.3)	13 (21.3)	113 (36.1)	50 (58.1)	
Gait imbalance	113 (24.6)	16 (26.2)	74 (23.6)	23 (26.7)	
Loss of hand dexterity	100 (21.7)	12 (19.7)	65 (20.8)	23 (26.7)	
Neck pain	97 (21.1)	13 (21.3)	65 (20.8)	19 (22.1)	
Urination and defecation functional disturbance	95 (20.7)	9 (14.8)	68 (21.7)	18 (20.9)	
Thoracic waist zonesthesia	93 (20.2)	7 (11.5)	66 (21.1)	20 (23.3)	
Trunk numbness	21 (4.6)	2 (3.3)	15 (4.8)	4 (4.7)	
Involved levels	2.0 ± 0.9	1.7 ± 0.7	2.0 ± 0.9	2.5 ± 1.0	0.000 ^b
C2/3	4 (0.9)	0 (0)	3 (1.0)	1 (1.2)	
C3/4	128 (27.8)	14 (23.0)	75 (24.0)	39 (45.3)	
C4/5	255 (55.4)	27 (44.3)	166 (53.0)	52 (72.1)	
C5/6	388 (84.3)	48 (78.7)	270 (86.3)	70 (81.4)	
C6/7	153 (33.3)	12 (19.7)	101 (32.3)	40 (46.5)	
Surgical approach					0.000 ^a
Anterior	371 (80.7%)	58 (95.1%)	257 (82.1%)	56 (65.1%)	
Posterior	84 (18.3%)	3 (4.9%)	52 (16.6%)	29 (33.7%)	
Combined	5 (1.1%)	0 (0%)	4 (1.3%)	1 (1.2%)	

^aχ²-test.

^bOne-way test.

Several patients had two or more involved levels and symptoms. Values for age, symptom duration, symptoms and involved levels are given as the mean ± s.d. Other values are given as number (%).

frequency, the mean $\pm$ s.d. and 95% confidence interval (CI). Chi-square and one-way tests were used for the analysis. In all the statistical tests, the level of significance was set to $P < 0.05$.

RESULTS

Patient characteristics and clinical features

A total of 460 patients with CSM were included in the analysis. Among these patients, 345 were men (75%) and 115 were women (25%). The average age was 51.3 ± 10.5 years (range of 22–78 years).

Our study sample was dominated by patients aged 50–59 years the most (149, 32%), followed by those who were 40–49 years old (138, 30%), 60–69 years old (92, 20%) and 30–39 years old (57, 12%). Patients under 30 (4, 1%) or above 69 years old (20, 4%) showed a low incidence.

Symptoms among the patients included gait disturbances and imbalance, upper and/or lower limb weakness, upper and/or lower limb numbness, loss of hand dexterity, urination and defecation functional disturbance, neck pain, thoracic waist zonesthesia and/or trunk numbness. Upper limb numbness (340, 74%) was the most common symptom among the three groups, followed by gait disturbance (331, 72%) and lower limb numbness (264, 57%) (Table 1 and Figure 1). The average number of symptoms was 4.0 ± 1.6 among the three groups, 3.6, 3.9 and 4.4 in the young, middle-aged and old groups, respectively. A total of 14 (3%) patients had one symptom, 73 (16%) patients had two symptoms, 107 (23%) patients had three symptoms, 114 (25%) patients had four symptoms and 152 (33%) patients had five or more symptoms. The average symptom duration was 15.7 ± 24.1 months in these patients, 10.9 months, 15.3 months and 20.8 months in the young, middle-aged and old groups, respectively (Table 1). The number of symptoms

($P = 0.006$, $F = 5.102$) and symptom duration ($P = 0.042$, $F = 3.194$) increased with age and had significant difference among three groups.

Cervical level was affected from C2/3 to C6/7 among the three groups. Of all the involved levels regardless of severity, C5/6 (388, 84%) was the most common, followed by C4/5 (255, 55%) (Table 1 and Figure 2). No difference was observed among the three groups. The average number of involved levels was 2.0 ± 0.9 among the three groups, and 1.7, 2.0 and 2.5 in the young, middle-aged and old groups, respectively. A total of 147 patients (32%) exhibited only one affected level, 188 (32%) were affected in two levels, 91 (20%) were affected in three levels, 33 (7%) were affected in four levels and 1 was affected in five levels. The number of involved levels ($P = 0.000$, $F = 17.518$) increased with increasing age and had significant difference among three groups.

Mean preoperative JOA score was 10.4 ± 2.8 among the three groups, 11.2, 10.3 and 9.9 in the young, middle-aged and old groups, respectively (Table 2). The preoperative JOA score ($P = 0.001$, $F = 6.686$) decreased with age and had significant difference among the three groups.

Among the three groups, 371 (81%), 84 (18%) and 5 (1%) patients underwent anterior, posterior and combined approaches, respectively. In the young group, 58 (95%), 3 (5%) and 0 patients underwent anterior, posterior and combined approaches, respectively. In the middle-aged group, 257 (82%), 352 (17%) and 4 (1%) patients underwent anterior, posterior and combined approaches, respectively. In the old group, 56 (65%), 29 (34%) and 1 (1%) patients underwent anterior, posterior and combined approaches, respectively (Table 1). Surgical approach was significantly different among three groups ($P = 0.000$, $\chi^2 = 22.672$). The posterior approach was more likely to be selected as a treatment option with increasing age.

Surgical outcomes

After surgery, all three groups exhibited significant neurological improvement. The mean postoperative JOA scores increased from 10.4 to 13.1, 13.9, 14.5, 14.6 and 14.6, at 1 week, 1 month, 6 months, 1 year and final follow-up, respectively. In the young group, the mean postoperative JOA scores increased from 11.2 to 13.7, 14.6, 15.3, 15.7 and 16.0 at 1 week, 1 month, 6 months, 1 year and final follow-up, respectively. In the middle-age group, the mean postoperative JOA scores increased from 10.3 to 13.0, 13.8, 14.5, 14.5 and 14.6 at 1 week, 1 month, 6 months, 1 year and final follow-up, respectively. In the old group, the mean postoperative JOA scores increased from 9.9 to 12.8, 13.4, 13.9, 13.9 and 13.8 at 1 week, 1 month, 6 months, 1 year and final follow-up, respectively (Table 2).

Furthermore, in all the three groups, the JOA recovery rates were 41, 53, 63, 64 and 64% at 1 week, 1 month, 6 months, 1 year and final follow-up, respectively. In the young group, the JOA recovery rates were 45, 61, 72, 78 and 83% at 1 week, 1 month, 6 months, 1 year and final follow-up, respectively. In the middle-aged group, the JOA recovery rates were 41, 53, 63, 64 and 64% at 1 week, 1 month, 6 months, 1 year and final follow-up, respectively. In the old group, the JOA recovery rates were 40, 49, 56, 54 and 52% at 1 week, 1 month, 6 months, 1 year and final follow-up, respectively (Table 2).

In general, the highest degree of recovery (postoperative JOA score and the JOA recovery rates) was observed during the first 6 months' post operation, especially during the first week. Recovery then stabilized after this period. However, after 6 months' post operation, recovery continuously improved in the young group, stabilized or marginally improved in the middle-aged group and declined in the old group (Figures 3 and 4). Age was inversely correlated with the recovery, which significantly decreased with increasing age. The immediate recovery rate (1 week) after operation had no significant difference among the three groups ($P = 0.323$), but was significantly

Figure 1 Symptoms associated with cervical myelopathy occurred in the three groups. Numbness of the upper limbs was the most common symptom in the three groups, followed by gait disturbance and lower limb numbness. A full colour version of this figure is available at the *Spinal Cord* journal online.

different at later periods (3 or more months postoperatively) ($P < 0.001$).

Complications

The incidences of postoperative complications were 10, 11 and 16% in the young, middle-aged and old groups, respectively (Table 3). No group had any major complications, such as pulmonary thrombosis,

Figure 2 Cervical disc level was affected from C2/3 to C6/7 in three groups, C5/6 was the most commonly affected level, followed by C4/5. No significant difference was observed among the three groups. A full colour version of this figure is available at the *Spinal Cord* journal online.

myocardial infarction or even death. However, eight patients (one in young; six in middle-aged and one in old) experienced the transient aggravation of the injury of spinal cord. The young, middle-aged and old groups showed cerebrospinal fluid leakage in one, five and three patients, respectively, and C5 palsy in one, six and five patients, respectively. Two patients in the middle-aged group and two in the old group had superficial wound complications. Postoperative epidural hematoma was present in three patients from the middle-aged group and in one from the old group. One patient in the young group, three in the middle-aged group and one in the old group suffered from temporary dysphonia after surgery. Similarly, dysphagia was reported in three groups (one in young, four in middle-aged and one in old). One patient in the young group and two patients in the middle-aged group experienced displacement of the bone graft or loosening of plate and screw at 1 month after operation; these patients were then required to wear cervical collars for 3 months. Only three incidences of bone graft complications were reported in the middle-aged group. Except for two patients who suffered from postoperative epidural hematoma (one in the middle-aged and one in the old group) who received a reoperation for hematoma clearing, the remaining patients were treated conservatively with rest and rehabilitation. No significant difference was observed in the postoperative complication rate among the three groups ($P = 0.340$, $\chi^2 = 2.156$).

DISCUSSION

To partially reflect the characteristics of the natural course of CSM and to minimize other external factors, such as the impact of trauma on the recovery of spinal cord function, the present study excluded patients with CSM with a history of trauma, cervical spine fracture or dislocation.

CSM is a highly common spinal cord disorder among the elderly. People aged 40–60 years are widely assumed to easily acquire the disease.³ Moreover, the disease is more common in males than in females. This study confirmed that more men than women are affected by CSM with a ratio of 3:1, which is similar to the ratio of 2.7:1 that was by Northover and Kalsi-Ryan.^{1,10} The reasons for these similar results may be as follows: (1) In the young and middle-aged groups, CSM results from active lifestyles, work intensity and pressures

Table 2 Surgical outcomes (pre- and postoperative JOA scores, JOA score recovery rate) of the three groups

JOA score	All		Young		Middle-aged		Old	
	Mean $\pm$ s.d.	95% CI	Mean $\pm$ s.d.	95% CI	Mean $\pm$ s.d.	95% CI	Mean $\pm$ s.d.	95% CI
Preoperatively	10.4 $\pm$ 2.2	10.2–10.6	11.2 $\pm$ 2.6 ^{a,b}	10.6–11.9	10.3 $\pm$ 2.1	10.1–10.6	9.9 $\pm$ 2.3	9.4–10.4
One week postoperatively	13.1 $\pm$ 2.0	12.9–13.3	13.7 $\pm$ 1.9 ^{a,b}	13.2–14.2	13.0 $\pm$ 2.0	12.8–13.2	12.8 $\pm$ 1.8	12.4–13.2
Three months postoperatively	13.9 $\pm$ 1.8	13.7–14.0	14.6 $\pm$ 1.6 ^{a,b}	14.2–15.0	13.8 $\pm$ 1.8 ^c	13.6–14.0	13.4 $\pm$ 1.7	13.0–13.8
Six months postoperatively	14.5 $\pm$ 1.5	14.4–14.6	15.3 $\pm$ 1.3 ^{a,b}	14.9–15.6	14.5 $\pm$ 1.5 ^c	14.3–14.7	13.9 $\pm$ 1.4	13.6–14.2
One year postoperatively	14.6 $\pm$ 1.5	14.4–14.7	15.7 $\pm$ 1.1 ^{a,b}	15.4–16.0	14.5 $\pm$ 1.5 ^c	14.4–14.7	13.9 $\pm$ 1.4	13.6–14.2
Final follow-up	14.6 $\pm$ 1.6	14.5–14.8	16.0 $\pm$ 1.0 ^{a,b}	15.7–16.2	14.6 $\pm$ 1.6 ^c	14.4–14.8	13.8 $\pm$ 1.5	13.5–14.1
Recovery rate for JOA score (%)	Mean $\pm$ s.d.	95% CI	Mean $\pm$ s.d.	95% CI	Mean $\pm$ s.d.	95% CI	Mean $\pm$ s.d.	95% CI
One week postoperatively	41 $\pm$ 20	39–43	45 $\pm$ 18	40–49	40 $\pm$ 21	38–42	40 $\pm$ 19	36–44
Three months postoperatively	53 $\pm$ 19	52–55	61 $\pm$ 18 ^{a,b}	57–66	53 $\pm$ 20	51–55	49 $\pm$ 18	45–53
Six months postoperatively	63 $\pm$ 16	62–65	72 $\pm$ 15 ^{a,b}	68–76	63 $\pm$ 16 ^c	62–65	56 $\pm$ 15	53–59
One year postoperatively	64 $\pm$ 18	62–66	78 $\pm$ 16 ^{a,b}	74–83	64 $\pm$ 17 ^c	62–66	54 $\pm$ 19	50–58
Final follow-up	64 $\pm$ 24	62–67	83 $\pm$ 15 ^{a,b}	79–86	64 $\pm$ 18 ^c	62–66	52 $\pm$ 35	45–60

^aSignificant difference between the young group and middle-aged groups.

^bSignificant difference between the young group and old groups.

^cSignificant difference between middle-aged group and old groups.

The values are given as the mean $\pm$ s.d., with the 95% CI.

Figure 3 Trend of pre- and postoperative JOA scores (+s.d.) of the three groups. The average preoperative JOA score (+s.d.) was different among the three groups and decreased with increasing age. JOA scores can be improved after surgery in the three groups. The major improvement of JOA scores was during the first 6 months, especially in the first week. After 6 months, JOA scores continuously improved in the young group, stabilized or a marginally improved in the middle-aged group and declined in the old group. A full colour version of this figure is available at the *Spinal Cord* journal online.

Figure 4 Trend of recovery rate for JOA scores (+s.d.) of the three groups. In the three groups, spinal cord function can be improved after surgery. The highest degree of recovery was observed during the first 6 months, especially within the first week. After 6 months, recovery had a continuous improvement in the young group, stabilized or marginally improved in the middle-aged group and declined in the old group. A full colour version of this figure is available at the *Spinal Cord* journal online.

of working prolonged hours. Therefore, the two groups do not pay attention to exercise and the maintenance of the neck. This inattention leads to a high incidence of the disease in these two groups. By contrast, most elderly beyond the age of 60 are in their retirement

stage. Therefore, desk work is no longer required. Nevertheless, elderly patients can still perform neck exercises and maintenance to reduce the occurrence of CSM in this age group. (2) Studies have shown that the cervical disc degenerates earlier in men than in women.^{11,12} As

Table 3 Postoperative complications in three groups

Complication	All patients n(%)	Young n(%)	Middle-aged n(%)	Old n(%)
Aggravation of injury of spinal cord	8 (2)	1 (2)	6 (2)	1 (1)
Paraparesis (C5)	12 (3)	1 (2)	6 (2)	5 (6)
Wound problems	4 (1)	0 (0)	2 (2)	2 (2)
Cerebrospinal fluid leakage	9 (2)	1 (2)	5 (2)	3 (4)
Injury of superior laryngeal nerve	6 (1)	1 (2)	4 (1)	1 (1)
Injury of laryngeal recurrent nerve	5 (1)	1 (2)	3 (1)	1 (1)
Epidural hematoma	4 (1)	0 (0)	3 (1)	1 (1)
Displacement of bone graft or loosening of plate and screw	3 (1)	1 (2)	2 (1)	0 (0)
Complications of bone graft	3 (1)	0 (0)	3 (1)	0 (0)
Total	54 (12)	6 (10)	34 (11)	14 (16)

Statistical result $\chi^2=2.156$; $P=0.340$. Several patients had two or more complications.

men are traditionally considered as the breadwinners of the family, they experience more work pressure and intensity than women do.¹² Men also are also inattentive to the health of their necks. This inattention leads to high incidences of CSM.

The most commonly affected cervical levels were C5/6, followed by C4/5 and C6/7; these results are consistent with those reported by Northover and Kalsi-Ryan.^{1,7,10} No significant differences were observed in the levels in different age groups. A cadaveric study of Lee *et al.*¹³ on bony cervical spine anatomy showed the increasing trend in stenosis at all levels with increasing age. However, they found that C4 is the most affected level in 10.5% of CSM cases, although the common at C5 and C6 are affected at similar rates (10.0% and 10.2%, respectively). A large number of studies on human cervical spine biomechanics have shown that when people flex their neck, neck stress frequently occurs on C4, C5 and C6. The analyses of several clinical cases have confirmed that C5 and C6 are the most prone to bone hyperplasia.^{1,2} The results also showed that cervical lesion segment is common in parts that undergo severe activities and weight-bearing.

Our study also found that the numbness of the upper and lower limbs and gait disturbance are the main symptoms of CSM. These corresponding clinical symptoms may be due to herniated cervical discs, vertebral posterior osteophyte and hypertrophy of the ligamentum flavum, which directly compresses the spinal cord or spinal artery because of an abnormality in the blood supply of the spinal cord.^{3,14,15} The clinical symptoms and cervical spine degeneration levels are well matched and both are beneficial in CSM diagnosis.

However, cervical spine degeneration and its symptoms varied among different ages. Cervical disc degeneration is a crucial factor in the pathological process of CSM. Routine autopsies and imaging research have shown that disc degeneration typically begins before the age of 20. Disc degeneration is highly serious in elderly patients in most cases.¹² In addition, CSM starts slowly without any apparent symptoms and tends to be neglected. Patients, especially the elderly, only accept conservative treatment, and the majority are unwilling to consider surgery until symptoms significantly affect their quality of life.¹⁶ Consequently, compared with young patients, the elderly are more likely to have more prolonged symptom durations, more levels involved and more severe symptoms.^{7,17–20} Thus, the surgical approach and type may be different in the treatment of different age patients. Similarly, we found that the number of symptoms and involved levels, symptom duration and posterior approach increased with increasing age.

Furthermore, patients frequently experience other comorbid chronic diseases with age. These chronic diseases, such as cardiovascular disease and thoracic lumbar vertebral degeneration, severely

degrade neurological function.¹⁶ This conclusion can be corroborated by the preoperative JOA scores, which were significantly lower in the old group than those in the young and middle-aged groups.

Surgery can immediately eliminate spinal cord compression. Therefore, the spinal cord function can rapidly improve during the first week after surgery, as demonstrated by the absence of significant difference in the recovery rates among the three groups. A high rate of recovery was observed within 6 months after surgery. After 6 months, recovery continuously improved in the young group, stabilized or marginally improved in the middle-aged group and declined in the old group. Similar to the findings of other studies,^{16,21} the recovery rate declined with age, which caused a significant difference in later periods (3 months or more) after surgery among the three groups. This pattern may occur because of the following reasons: (1) The risk factors for poor prognosis include age, involved cervical levels and prolonged spinal cord compression,^{17–20,22} which also resulted in diversity and increased complexity of the clinical manifestations. These factors disrupt diagnosis and hinder the recovery of the spinal cord function.^{23–25} (2) Elderly patients have low physical function even prior to surgery, thus decreasing their ability to recover. In addition, postoperative elderly stay in bed for a long time and have severe osteoporosis.¹⁶ Some patients have other diseases, such as cerebral infarction. These factors inevitably influence the recovery of the elderly patients. (3) Finally, postoperative rehabilitation exercises have an important function in improving recovery after surgery.²⁶ The potential of elderly patients for postoperative functional exercise is lower than that of younger patients. The former group also has low expectations to improve their health. Thus, they may not be able to translate neurological recovery to functional improvements as young patients do.²⁷

Postoperative complications were not significantly different and were not severe in all groups. This result is similar to that observed in Nagashima H's and Machino M's study^{17,28} but is different from previous reports.^{21,29} Our results could be attributed to the conscientious pre- and postoperative care, experience and operative skills of the medical officers who provided additional care to the elderly patients. Besides, we did not perform surgery on patients with serious comorbid conditions.

Surgical treatment has become the main method of treatment for CSM. Although elderly patients with CSM have more prolonged symptoms, greater number of involved levels and more severe damage in the spinal cord function than the young patients, they can still attain the similar surgical effects as those young patients when the surgical approach is appropriate and the decompression is complete. Surgery was effective for the treatment of CSM among patients of different

ages in the current study, which is consistent with the findings of the other authors.^{17,18,21,30,31} However, on the basis of the observation of the changes in the trends in the curative effects of surgery on patients with CSM, the treatment of cervical myelopathy in its early stages is still considered essential, and age could be an important factor that affects the outcomes of surgery.

This study has several limitations. First, we only reviewed patients who had undergone surgery. Therefore, an adequate number of controls who had undergone nonsurgical therapy were not obtained (~92% patients with CSM referred to our hospitals were considered candidates for surgery). In addition, surgery could not have been offered to all elderly patients, especially those (5% in the old group) with serious comorbid conditions or those who were refused anesthesia by an anesthesiologist. A total of 36 patients who did not return to our clinics 6 months after their surgery were excluded. Therefore, this study may contain bias. Second, clinical data were evaluated using only the JOA scores. Notably, the Nurick classification is another feasible evaluation method. The JOA score is a simple scoring system that accurately reflects neurological and functional status. Compared with the Nurick disability score, the JOA score more specifically assesses motor function, sensation and urinary symptoms. Third, MRI was used for the radiological evaluation of the cervical spine. However, as the MRI machine has been upgraded and modernized, the compression and signal of the spinal cord on the MRI cannot be evaluated with the same standard.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

RJZ participated in the study design and data analysis, and drafted the manuscript. FLD, PWS, PG, PX and HQZ reviewed the medical records of the patients, as well as the office notes and operative reports to collect the pre-, peri- and postoperative data. JXZ participated in data analysis. CLS and JXZ should be XJZ participated in data analysis. CLS and JXZ participated in the study design and performed the surgery. All authors read and approved the final manuscript.

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