




Prognostic Indices of Surgical Outcome in Cervical Spondylotic Myelopathy: A Clinical Prospective Study

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Abstract

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BACKGROUND: One of the most common causes of spinal cord dysfunction is cervical spondylotic myelopathy (CSM) especially in the elderly. Prognostic indices can aid the surgeon preoperatively to detect the patients' prognosis.

AIM: The aim of the work is to better assess patients and to find possible indicators for post-operative improvement or deterioration in CSM patients.

METHODS: Forty patients with multiple levels CSM, admitted and operated on in the Neurosurgery Department of Cairo University Hospitals, have been enrolled randomly in this study after fulfilling the criteria for CSM surgical intervention. The patient age, complaint duration, number of levels affected, signal intensity on T1-weighted and T2-weighted magnetic resonance (MR) images, Japan Orthopedic Association (JOA) scoring system, and Nurick's score were evaluated before surgery and correlated with outcome after 1 year follow-up.

RESULTS: About 80% of patients improved after operation with average pre- and post-operative JOA and Nurick scores about 11.23 and 3.12; 14.1 and 1.6, respectively. Patient age, sex, number of levels affected, and signal intensity on T1-weighted and T2-weighted MR images were not significantly associated with post-operative improvement, $p > 0.05$. However, the only significant prognostic factor was the duration of symptoms if less than 1 year with $p < 0.05$.

CONCLUSION: Short complaint duration coupled with close intra-operative monitoring was directly correlated with good CMS operation outcome while age, sex, number of levels affected, presence of cord signal on MR imaging, and surgical approach appear to have no significant effect on outcome.

Introduction

Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord dysfunction [1]. It is also the leading cause of spinal cord related disability in the elderly [2]. It results from degenerative narrowing of the spinal canal, causing spinal cord compression in a slow, progressive manner [3]. The degree and location of spinal cord compression are heterogeneous and can result from ventral pathologies such as herniated discs and disc osteophyte complexes or from dorsal compression from the facet joints and ligamentum flavum hypertrophy [3]. The diagnosis requires a careful correlation between findings in patient history, physical examination, and imaging studies as magnetic resonance imaging (MRI), computed tomography (CT) and X-rays, which provide a quantitative assessment of central canal narrowing [4]. Treatment options for CSM include conservative non-surgical measures and surgical measures. Conservative measures comprise some form of cervical immobilization (soft collar or brace), restriction of high-risk activities and environments (e.g. slippery surfaces, vigorous neck

movement, heavy lifting, and action sports), pain management, and physiotherapy [5].

Surgical management

At present, there is consensus that a modified Japanese Orthopedic Association score (mJOA) of ≤ 12 is a definite indication for surgery in patients with CSM. For patients who have a mJOA score of > 12 on presentation, the decision to proceed with surgery should be based on an individualized basis. The timing of surgery depends on the patient's clinical presentation. A rapid neurological decline will require a more urgent intervention whereas a stable deficit can be approached in an elective manner. When indicated, surgery should be performed within 6 months to 1 year of symptom onset to achieve good results [6].

The choice of operative procedure should take into consideration the individual patient's clinical and radiological characteristics, age, comorbidities, lifestyle (smoking, etc.), procedure-specific risks and finally, the experience and comfort level of the surgeon with various surgical procedures [7].

A variety of surgical approaches are available and they are either anterior or posterior approaches. Anterior approaches include: Anterior cervical discectomy without or with fusion; supplemental instrumentation may be required as an additional support to the cervical column in select cases or anterior cervical corpectomy and fusion with instrumentation. Posterior approaches include laminectomy, laminectomy with lateral mass fusion, and laminoplasty [8]. The anterior approach offers the following advantages: Direct decompression of pathologies in the anterior cervical spine (i.e. osteophytes, ossification of the posterior longitudinal ligament, and disc herniations), muscle sparing dissection to minimize post-operative pain, lower infection rates, the ability to decompress, and correct cervical kyphosis. The posterior approach allows for a wider decompression and is dependent on the ability of the cord to drift away from anterior lesions. It is, therefore, important to take cervical sagittal alignment into consideration, as the cord may not drift posteriorly in cases with significant cervical kyphosis [9].

Methods

Study design and target population

This is a prospective study conducted on 40 patients with CSM as verified clinically and radiologically, operated on in the Neurosurgery Department, Cairo University Hospitals. Anterior or posterior approaches were performed in the period from January 2019 to July 2019. Patients were assessed as regards age, sex, onset, course, duration, and severity of symptoms, number of levels affected and intrinsic cord changes.

Inclusion criteria

Inclusion criteria included patients with clinical signs and symptoms of CSM supported by radiologic findings with no history of previous cervical operations whom were medically fit for surgery.

Exclusion criteria

The following criteria were excluded from the study:

1. Patients with cervical compression on imaging not related to clinical signs and symptoms
2. Radiculopathy without CSM
3. Traumatic myelopathy
4. Medically unfit patients
5. Active infection, neoplastic disease, rheumatoid arthritis, and ankylosing spondylitis
6. Presence of concomitant neurological conditions such as amyotrophic lateral sclerosis or multiple sclerosis.

Pre-operative clinical and radiological evaluation

All patients were subjected to complete history taking, general, and neurological examination including assessment by modified Ashworth scale [10], Nurick's Classification of Disability [11] and mJOA [12]; and radiological assessment by both plain X-rays and MRI.

Post-operative evaluation and follow-up

The follow-up program continued for 1 year after surgery, the initial 2 weeks focused on evaluating pain and patient progress as regard ambulation and physical activity. Radiological assessment was performed by plain X-ray and CT scan, and final outcome assessment using Odom's criteria for satisfaction [13].

Statistical analysis

Continuous variables were presented in the form of mean value and standard deviation; the categorical variables were presented in the form of numbers and percentages. Comparison between two datasets was performed using independent t-test, while the categorical data by Chi-square test.

Results

Patient's characteristics and clinical evaluation

The mean age of patients was 61 years; 57.5% of cases were males. The duration of symptoms ranged from 1 to 48 months, with mean duration 11.6 months. About 72.5% of the cases presented with cord signal and most cases had three level affection 45%. The JOA score of cases ranged from 7 to 14 with mean about 11; moreover, the range of Nurick's score was about 1–5 with a mean of 3 (Table 1).

Intra-operative findings

The duration of surgery ranged from 90 to 210 min, with mean about 142 min. About 65% were operated on by the posterior approach: Laminectomy (eight cases), laminectomy with fusion (11 cases), laminoplasty (six cases), and foraminotomy (one case). About 35% were operated on by the anterior approach: ACDF (13 cases) and corpectomy (one case), (Table 2).

Taking into account the intra-operative neurophysiological monitoring (IONM) assessment during operation, about 13 cases had the chance to be assessed according to the criteria indicated. Of the 13 patients assessed with IONM, eight patients showed

Table 1: Patient characteristics and pre-operative evaluation

Factors	Total (n = 40)	
	Mean	SD
Age (years)	51.8	7.66
	Min	Max
	36	74
Sex	n	%
	Female	42.5
Male	23	57.5
Duration of symptoms (Month)	Mean	SD
	11.32	10.93
	Min	Max
JOA score	1	48
	Mean	SD
	11.225	1.687
Nurick's score	Min	Max
	7	14
	Mean	SD
Cord signal	3.125	0.911
	Min	Max
	1	5
Level affected	n	%
	No	27.5
Yes	29	72.5
Level affected	n	%
	One segment	15
	Two segment	12.5
	Three segment	45
Four segment	11	27.5

N: Number, SD: Standard deviation, JOA: Japanese Orthopedic Association.

improvement, five patients showed no improvement, four patients had a drop in the somatosensory evoked potentials, and motor evoked potentials. The other nine patients had no significant alerts; none of our cases had permanent neurological deficit.

Post-operative outcomes

The length of stay in the hospital ranged from 2 to 5 days with mean about 3 days. The success rate of operation was satisfactory, hence 80% of cases improved as regards clinical and physiological evaluation. In addition, during follow-up assessment the mJOA score ranged from 11 to 17, with mean about 14; also, the Nurick's score ranged from 0 to 4 with mean about 1. Odom's criteria grades ranged from 1 to 3 with mean about 2 (Table 3).

Table 2: Operative findings

Factors	Total (n = 40)	
	Mean	SD
Length of surgery In minutes	142.88	33.93
	Min	Max
	90	210
IONM	n	%
	No	72.5
Yes	13	27.5
Type of surgery	n	%
	Anterior	35
	Posterior	65

N: Number, SD: Standard deviation, IONM: Intra-operative neurophysiological monitoring.

Factors influencing post-operative improvement

Considering patient related factors, only duration of illness significantly influenced the outcome, hence a complaint of <1 year preoperatively was significantly correlated with success rate, $p = 0.006$, with insignificant impact of age, sex, cord signal affection or specific level of affected segment on final outcome. Moreover, all factors related to surgery regarding approach or duration did not affect outcome.

Table 3: Post-operative assessment and outcome

Factors	Total (n = 40)	
	Mean	SD
JOA score	14.075	1.7
	Min	Max
	11	17
Nurick's scale	Mean	SD
	1.6	0.81
	Min	Max
Length of hospital stay (day)	0	4
	Mean	SD
	3.12	0.85
Odom's criteria	Min	Max
	2	5
	Mean	SD
Outcome	1.95	0.677
	Min	Max
	1	3
Not improved	n	%
	8	20
	Improved	32

N: Number, SD: Standard deviation, JOA: Japanese Orthopedic Association.

In addition, both groups of patients; improved and unimproved showed almost equal duration of hospital stay, $p = 0.6$, while the improved group showed significantly higher degrees of satisfaction, $p = 0.002$ (Table 4).

Table 4: Score difference after operation

Factors	Failed (n = 8)		Improved (n = 32)		p-value
	Mean	SD	Mean	SD	
Age (years)	54	7.09	51.25	7.8	0.35 [§]
Sex					
	Female	25	15	46.88	0.26 [#]
Male	6	75	17	53.13	
Duration of symptoms	<1 year	37.5	27	84.38	0.006 [#]
	>1 year	62.5	5	15.63	
Cord signal	No	37.5	8	25	
	Yes	62.5	24	75	0.4 [#]
	Level affected (segment)				
1	0	0	6	18.75	0.28 [#]
2	0	0	5	15.63	
3	5	62.5	13	40.63	
4	3	37.5	8	25	
Length of surgery	152.5	32.1	140.5	34.4	0.37 [§]
Type of surgery	Anterior	12.5	13	40.6	0.08 [#]
	Posterior	87.5	19	59.4	
Length of hospital stay	3.25	0.707	3.094	0.893	0.6 [§]
Odom's criteria	2.625	0.518	1.781	0.608	0.002 [§]

[§]Independent t-test, [#]Chi-square test, p considered significant if < 0.05.

Discussion

The current study was designed to detect factors that influence the post-operative outcome of CSM. Many prognostic factors have been discussed by the previous authors [14], [15] with emphasis on age, sex, duration of symptoms, and pre-operative neurological status, radiological findings including number of levels of compression and intrinsic cord signal changes.

Age

In our study, the mean age was 51.8 years, (range 36–74), with no impact of age on prognosis, ($p = 0.35$), similar to findings by Shin *et al.* [16], hence he found that the mean age of patients was 51.1 years

(range 26–69 years), which showed no correlation with final prognosis. Yamazaki *et al.* [17] also discussed the fate of sixty-four patients with CSM who underwent canal expansive cervical laminoplasty, with mean age 65 years; older patients had significantly lower post-operative JOA scores than younger ones but with insignificant correlation of age with recovery rates. The correlation between age and preoperative clinical state may be due to anatomopathological injury, which causes greater functional impairment in older patients than in younger patients. Old age and a low pre-operative JOA score have been associated with unsatisfactory surgical outcome. However, there were no correlations between the two factors and final outcome.

Sex

In our study, we had 17 females (42.5%) and 23 males (57.5%), with insignificant association with final prognosis, $p = 0.26$. Sex as a factor did not affect overall recovery rate [14]. This is in contrast with a recent study where Yagi *et al.* [15] observed the effects of sex difference on intra-medullary signal strength changes and found higher signal strength in men with no statistically significant difference.

Duration of symptoms

In the present work; the mean duration of symptoms was 11.32 months, with range about (1–48) month. Thirty patients had duration of symptoms <1-year; 27 of them improved versus ten patients had duration more than 1 year, and, only five improved with better outcome association with those had shorter duration of symptoms, $p = 0.006$. That came in harmony with other studies [14], [17]; hence, the improvement in symptoms was significantly correlated with a shorter time of complaint. In contrary to Shin *et al.* [16] and Naderi *et al.* [18], who report insignificant correlation between symptom duration and surgical outcome.

Number of levels affected

In our study, none of the patients with less than three levels affected show failed surgery, while from the failed cases five patients had three levels affected and three had four levels (62.5% and 37.5% of the failed patients, respectively). Although both improved and unimproved groups showed a significant increase in post-operative JOA scores, there was an insignificant association with number of levels affected, $p = 0.28$. In the study conducted by Ahn *et al.* [19] which included 39 patients operated on with laminoplasty for cervical myelopathy, with 3–5 segment affection range, and patients with <3 levels of compression showed a significantly better outcome. In concordance with our results, Göçmez *et al.* [20] found that the pre-operative average JOA score of patients with two or

less compressed disks was 10.8 ± 3.4 , whereas the post-operative average score was 15.2 ± 2.4 . The pre-operative average score of patients with three or more compressed disks was 11.3 ± 3.5 , whereas the post-operative average score was 14.4 ± 2.6 . However, both groups showed a statistically significant increase in the post-operative JOA scores ($p < 0.05$), the post-operative JOA scores of patients with three or more segments showed less improvement. This difference was not statistically significant ($p > 0.05$).

Signal intensity changes in MRI

MRI is the optimal modality to show the spinal cord condition in patients with CSM. High signal intensity on T2-weighted MRI images and low signal intensity on T1-weighted MRI images indicate spinal cord affection [19]. Authors are divided on the relationship between high signal intensity on T2-weighted MRI images and post-operative outcome. In our study, there were 29 patients with cord signal on T2 MRI and 11 patients with no cord signal. About 75% of patients who showed postoperative improvement had a cord signal, as opposed to 62.5% in the unimproved group. There was insignificant difference between the two groups ($p = 0.4$).

Kohno *et al.* [21] also stated that the reversibility of a condition cannot be foreseen utilizing MRI signal changes alone and that intervertebral disc herniation and a short illness duration are associated with reversible changes.

Morio *et al.* [22] and Yone *et al.* [23] also found the correlation between the signal changes on the preoperative T2-weighted images and the clinical outcome was uncertain.

However, Okada *et al.* [24] and Matsuda *et al.* [25] observed that pre-operative T2-weighted images are significantly related to the prognosis.

Surgical approach

The present work showed that the mean pre-operative Nurick's score was 2.7 in the anterior group and 3.3 in the posterior group with an overall improvement in the post-operative Nurick's score (mean = 1.1) for the anterior group and (mean = 1.7) for the posterior group with $p < 0.05$. Post-operative improvement utilizing the anterior and/or posterior approaches has also been identified in the previous studies [26], [27], [28]. Moreover, a meta-analysis [29] including 379 patients from six studies utilizing the recovery rate of JOA score to assess clinical outcome; found that the results were irrelevant in the final follow-up JOA scores between the two groups.

Odom's criteria

In our study, Odom's criteria grades ranged from 1 to 3 with mean 1.95 with a significant difference

between improved and unimproved cases. Furthermore, Odoms score for the patients operated by the anterior approach was good or excellent in 78% opposite to 77% of the patients operated by the posterior approach. That came in consistence with recent studies [30], [31] in which, Odom's criteria were good or excellent in 81% in the patients operated by the anterior approach. In addition to Cabraja *et al.* [32], where Odom's criteria were good or excellent in 79% of the patients operated by the anterior approach while the score was good or excellent in 83% of the patients operated by the posterior approach.

Conclusion

In our study, where the duration of symptoms was <1 year, this affected surgical outcome positively, whatever the choice of approach was. Therefore, we conclude that surgery should be performed promptly so that it is more effective and would significantly carry a better prognosis.

Based on our study, we also conclude that age, sex, number of levels affected, and signal changes on MRI had no effect on prognosis and should not be taken into account when making a surgical decision, as the percentages of recovery are not correlated with them as prognostic factors. The choice of surgery whether anterior or posterior solely depends on spinal column affection and does not affect outcome. Finally, awareness regarding the diagnosis and prognosis of CSM should be established for proper management and best patient outcome.

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