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Prospective study of surgical outcomes of cervical myelopathy based on its etiology, duration of affection and radiological patterns of compression

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ABSTRACT

Background: Cervical spondylotic myelopathy (CSM) is considered the commonest cause of spinal cord dysfunction in individuals above 55 years of age and if left untreated, permanent cord damage may occur. This could contribute to increased dependence and reduced quality of life in older individuals. A prospective cohort study done in patients with cervical myelopathy who were admitted and operated after considering inclusion and exclusion criteria.

Methods: A prospective cohort study done in patients with cervical myelopathy who were admitted and operated after considering inclusion and exclusion criteria. Total 30 patients included in study. patients were operated according to patterns of compression. Anterior/posterior decompression SOS instrumentation was done according to POC. Pre-op and post-op Nurick's grading, pre-op and post-op modified Japanese orthopaedics association (mJOA) scores were used for comparison. Patients were followed up for period of 1 year from surgical intervention. Recovery rate calculated using preop and post op mJOA scores.

Results: Overall satisfactory surgical outcome found in patients of cervical myelopathy, out of 30 patients, 9 patients of pattern of compression I (POC I) had recovery rate (RR) of (91.6±7.8) , 8 patients of POC II had RR of (78.4±14.8), 6 patients of POC III had RR of (73.5±11.1), 4 patients of POC IV had RR of (74.9±29.2), 3 patients of POC IVv had RR of (80.4±4.1).the assessment of the final outcome was done using mJOA scoring system and Nurick's grading system.

Conclusions: Anterior cervical discectomy and fusion (ACDF) for POC I (one- or two-level anterior cord compression) and POC II (one or two levels of anterior and posterior cord compression) give good surgical outcome. Cervical laminectomy and SOS instrumentation is recommended for POC III (3 levels of anterior cord compression), IV (3 or more levels of anterior compression and development of narrow canal with multiple posterior compression) and IV variant (similar to POC IV with one or two levels, being more significant than the others).earlier diagnosis, prompt radiological investigations, individualizing surgical protocol, proper surgical techniques and proper follow-up evaluation are key in management of patients of cervical myelopathy.

Keywords: Cervical spine, ACDF, mJOA, Nurick, ACCF

INTRODUCTION

Cervical spondylosis (CS) refers to osteoarthritic changes in the cervical spine which occurs from vertebral wear and tear. Spondylosis generally tends to be ignored under the guise of normal aging process, which is destined to occur once the individual is old enough. Attention is even less serious in the cervical region where the outcome of myelopathy could be grievous. CSM is considered the commonest cause of spinal cord dysfunction in individuals above 55 years of age and if left untreated, permanent cord damage may occur.[1] This could contribute to increased dependence and reduced quality of life in older individuals. The risk factors for development of CS include repeated macro and micro trauma which could result from environmental and occupational conditions as well as genetic predisposition. Myelopathy develops when the degenerative process causes a reduction in both the spinal canal diameter and sagittal mobility of the spinal cord.[3,4] This results in ischaemic cord compression leading to cord atrophy, neuronal loss in the grey matter and white matter demyelination. CS is the most common nontraumatic cause of myelopathy in the cervical spine.[1] Different from the majority of the other spinal problems in which the clinical treatment is usually the first option, early surgery is a key point to interfere in the natural history of cervical myelopathy (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 CM.[2-4] Nevertheless, the diagnosis of CSM can be difficult because the signs and symptoms can vary widely among the population. Besides, onset of symptoms is usually insidious, with long periods of fixed disability and episodic worsening events. Some findings that can commonly appear are gait spasticity, followed by upper extremity numbness and loss of fine motor control in the hands. Although it is generally agreed that surgical intervention positively impacts the prognosis of CM, the decision algorithm for the selection of the most appropriate surgical technique is complex. In fact, the choice between anterior or a posterior approach depends on several factors such as the relative location of the primary compression (anterior×posterior) and the alignment of the cervical spine (lordosis×kyphosis), as well as patient-specific spinal biomechanics.[3-5]

METHODS

Study design

A total of 35 patients of CM were operated in a department in year 2018 and 2019 and followed up prospectively for an average period of one year. Patients were informed that they would be a part of the prospective study. Their consent was obtained along with the operative consent taken before surgery. Five patients were lost in follow-up.

Inclusion criteria

All patients diagnosed with cervical myelopathy were included in this study. Diagnosis of myelopathy was clinical with a corroborative MRI.

Exclusion criteria

Patients suffering from associated neurological disorders like: Parkinson's disease, hemiplegia and cerebral palsy, etc. as these conditions confounded with the neurological evaluation of the patient.

Radiological patterns of compression

Following POC were identified

POC I: Patients with significant one or two levels of anterior cord compression in a developmentally normal or narrow canal (Pavlov ratio <0.8).

POC II: both significant anterior and posterior cord compression at one or two levels irrespective of the canal size. We labeled such a compression as ''pincer cord''.

POC III: Three levels of anterior cord compression in a developmentally normal canal.

POC IV: Three or more levels of significant anterior and posterior cord compression (''beaded cord''), or three or more levels of only anterior cord compression in a developmentally narrow canal. The spinal alignment was lordotic or neutral on lateral radiographs.

POC IV variant (POC IV-v): Similar to POC IV but out of the multiple sites of anterior compression; one or two levels showed compression ratio significantly lower than the other levels. These levels frequently had localized focal signal intensity change.

POC V: Three or more levels of compression in a rigidly kyphotic cervical spine.

Evaluation of surgical outcome

Patients were examined monthly for first three months and then 3 monthly. A single surgeon, who was blinded to the purpose of the study, independently evaluated each patient and their radiographs. The average duration of follow-up was 1 year. Cervical spine radiographs were obtained at each follow-up. Patients who had doubtful fusion on plain radiographs underwent flexion–extension radiographs with or without supplemental CT scan evaluation. Recovery rate (RR) was calculated by the Hirabayashi's method.

$$\text{Recovery rate}=\frac{(Post\ op\ mJOA\ score-Pre\ op\ mJOA)}{(17-Pre\ op\ mJOA)}\times 100$$

Postoperative disability assessment was performed using a modification of the Nurick's DI. Outcome was graded as excellent, good, fair and poor on the basis of the DI. At each follow-up visit patients were specifically asked for any swallowing difficulties or change in voice. Swallowing difficulties were classified as painful swallowing (odynophagia) and difficulty in swallowing solid or liquid food or both.

Statistics

All the data was entered in M. S. excel and analysis was done in EPI.INFO 7.0 software. To find out difference between means, ANOVA test was used and for categorical data chi square test was used. Difference was considered statistically significant with $p<0.05$ with 95% confidence interval.

Nurick's grading

Excellent: Normal with no clinical signs of myelopathy sub clinical myelopathy but no difficulty in walking/no difficulty in working with hands

Good: Slight difficulty walking but that does not prevent full time employment and manages most activities/ adequate hand grip strength and coordination

Fair: Difficulty in walking that prevents full time employment or the ability to do all housework but is not so severe as to require someone else's help to walk/inadequate hand grip strength and coordination

Poor: Severely restricted activity, ability to walk only with someone else's help or with the aid of a frame. Unable to use hand for any activity

Chair bound or bedridden: Not able to walk even with the help of others. Always at bed or can move with the help of wheel chair.

Surgical protocol

Past experiences and few literatures have let us follow below described protocol.[34,35]

The surgical protocol was as follows. POC I and POC II patients underwent anterior decompression. POC II patients who had suboptimal neurological recovery (mJOA ≤13 or DI ≥ 3 at 3 months) underwent a second stage posterior decompression. POC III underwent cervical laminectomy. POC IV and POC IV-v patients underwent posterior decompression. POC IV-v patients who had suboptimal neurological recovery (mJOA<13 or DI >3 at 3 months) were considered for a targeted anterior decompression at one or two levels as demonstrated by MRI.

RESULTS

Mean age of our study was 48.7±12.3 years. Total mean duration of symptoms irrespective of POC was 11.8±6.4 months (Table 1).

Higher recovery rate was found in POC I as compared the others. Exception was POC IV variant with smaller sample size, which is statistically significant with ANOVA test with p=0.001 (Table 3).

Table 1: Preoperative clinical characteristics of the cohort classified according to the POC.

Variables	POC				
	I	II	III	IV	IVv
Number of patient	9	8	6	4	3
Mean age	39.5±6.61	44.6±5.74	50.1±13.3	44.1±15.2	56.3±10.2
Mean duration of symptoms (Months)	5.9±2.3	12.4 ±6.6	14.6±6.4	14.9±6.1	13.6±4.7
Mean pre-op MJAO	8.9±0.9	7.2±0.6	7.8±1.2	7.8±1.2	6.5±1.8

Table 2: Preoperative radiological characteristics of the cohort classified according to the POC.

Variables		POC (%)				
		I	II	III	IV	IVv
No. of levels involved	1	3 (33.3)	3 (37.5)	0 (0)	0 (0)	0 (0)
	2	6 (66.6)	5 (62.5)	0 (0)	0 (0)	0 (0)
	3	0 (0)	0 (0)	5 (83.3)	0 (0)	0 (0)
	4	0 (0)	0 (0)	1 (16.6)	3 (75)	2 (66.6)
	5	0 (0)	0 (0)	0 (0)	1 (25)	1 (33.3)

Table 3: Surgical outcome (means with standard deviation).

Variables		duration of symptoms (Months), mean	Post-op MJAO, mean	Recovery rate, mean
POC	I	5.9±.3	16.3±0.62	91.6±7.8
	II	12.4±6.6	14.8±1.45	78.4±14.8
	III	14.6±6.4	14.5±1.02	73.5±11.1
	IV	14.9±6.1	14.6±2.6	74.9±29.2
	IVv	13.6±4.7	15±0.00	80.4±4.1
P value		0.0001	0.0001	0.0001
ANOVA (F)		14.754	6.921	8.512

Table 4: Various parameters based on POC.

Variables	POC				
	I	II	III	IV	IVv
Mean no. of levels involved	1.6±0.5	1.9±0.3	3.1±0.2	4.3±0.5	4.1±0.4
Mean duration of symptoms (Months)	5.9±2.3	12.4±6.6	14.6±6.4	14.9±6.1	13.6±4.7
Mean pre-op mJAO	8.9±0.9	7.2±0.6	7.8±1.2	7.8±1.2	6.5±1.8
Mean age	39.5±6.6	44.6±5.74	50.1±13.3	44.1±15.2	56.3±10.2
Mean post-op mJAO	16.3±0.6	14.9±1.5	14.6±1.0	14.7±2.6	15.0±0.0
Recovery rate (%)	91.6±7.8	78.4±14.8	73.5±11.1	74.9±29.2	80.4±4.1

Table 5: Transition of Nurick's grading after surgery (in general for all POC's).

Post op Nurick's grade (range)	<3 levels (non- multilevel)	≥3 levels (multilevel)	Total
Excellent to good	13	4	17
Fair to poor	4	9	13
Total	17	13	30

Chi square: 14.916, p:0.0001, Dof: 1.

Table 6: Comparison of Nurick's grade for multilevel and non-multilevel groups.

Transition after surgery		
Category	%	N
Poor to fair	90.2	12
Poor to good	75.0	7
Fair to excellent	60.9	6
Poor to excellent	39.1	2
Fair to good	25	2
Fair to fair	9.8	1

Patient's functional outcome improved significantly among POC<3 level to POC greater than equal to 3. This was statistically proven by chi square test at p=0.0001. though it was lower satisfactory outcome was found in patients with multilevel group as the mean age was high and mostly were living sedentary lifestyle.

DISCUSSION

In this study, based on our inclusion and exclusion criteria 30 patients were selected and we operated as per our formulated surgical protocol. Patients were followed for average 1 year. For POC 1 and 2, we did anterior cervical discectomy and fusion (ACDF) addressing the pathology directly. For POC 3, 4, 4v we did indirect decompression approach by doing cervical laminectomy with sos instrumentation. We didn't come across a case having POC 5.

POC 1

There is little doubt that in cases of CM involving one or two levels, an anterior cervical approach is the preferred choice.[34-37] Most studies have demonstrated excellent to good results in this group of patients.[38] Our average modified MJAO score was 91.6±7.8.

In other study, "surgical approach to CSM on the basis of radiological patterns of compression: prospective analysis of 129 cases" by Bapat et al recovery rate for such pattern was 82.44±28.49.[33] Overall for such POC, anterior surgery is gold standard. We had done anterior cervical discectomy and fusion. Graft was taken from ASIS.

POC 2

Since the disc and ligamentum flavum are at the same level, if both protrude in the spinal canal, there is a likelihood of significant cord compression.[40] This situation also predisposes to the pincer phenomenon causing dynamic compression during extension of the spine. Our average mJAO was 78±14.8.

A few authors have suggested anterior decompressive surgery followed by a posterior decompression if necessary at a second stage for such patients.[40] Controlled distraction of disc space may reduce the invagination of ligamentum flavum into the canal, avoiding a second stage posterior decompressive procedure.[41,42] In other study, Surgical approach to CSM on the basis of radiological patterns of compression: prospective analysis of 129 cases" by Bapat et al recovery rate was 70.09±39.86.[33] Two-level anterior cervical discectomy versus one-level corpectomy in CSM,

Park et al concluded that surgical managements of 2-level CSM using ACDF or ACCF were found to be similar in terms of clinical outcomes.[60] However, 2-level ACDF was found to be superior to 1-level ACCF in terms of operation times, bleeding amounts, and radiologic results.

Our experience: we always preferred ACDF taking graft from ASIS.

Our experience for POC 2: following ACDF, sub-optimal recovery was found past 1 year and hence cervical laminectomy was done. One case of adjacent segmented disease had occurred for which he had to get operated. ACDF was done with later good functional outcome.

POC 3

Traditionally the number of levels of compression for patients undergoing multilevel anterior decompression has been limited to three levels.[43,42] Graft and instrumentation related complications have been shown to be unacceptably high for anterior decompressive surgery involving more than three levels.[44,45,49] Hilibrand et al reported a successful clinical outcome in more than 85% of patients undergoing instrumented ACCF for MCM with a low incidence of complications.[49] Papadopoulos et al reported a high rate of fusion and excellent to good outcome in 83% of patient treated with three-level instrumented ACDF.[43] The best argument against posterior surgery in this group of patients who are relatively younger and medically less morbid is the high incidence of post-surgery instability, recurrence of myelopathy and axial pain.[47,48] In our study, multilevel anterior compression were dealt with cervical laminectomy. Post- operative kyphosis is not seen in any patient in our1 year follow up. This could be due to proper dissection, repair of muscles (C2 muscle attachment) and ligaments and preserving lateral mass structures during surgery and isometric exercise of neck muscle post operatively. Adjacent segment disease was found in one during follow-up and was dealt with cervical laminectomy. We preferred cervical laminectomy, our result: recovery rate: 73.5±11.1.

In other study, "surgical approach to CSM on the basis of radiological patterns of compression: prospective analysis of 129 cases" by Bapat et al.[33] Where for such POC they opted for approach for surgery based on ASA grading. For anterior approach recover rate was 81.93±24.99 and for posterior approach recovery rate was 70.72±13.68. However, when the functional outcome was graded on based on Neurick's grading in the above study, outcome was found to be non-significant.

POC 4

This group underwent laminectomy considering the high rate of complications associated with three-level corpectomy. Moreover, some authors have suggested that in patients with multiple levels of anterior compression associated with a developmentally narrow canal or multiple posterior cord compressions, anterior surgery may increase the risk of injury to the spinal cord because the dura and the spinal cord are pressed against the posterior longitudinal ligament in a stenotic canal.[48] Also following anterior surgery if segments adjacent to the fusion develop degenerative changes it might compromise the cord if the canal is stenotic to start with.[51] These along with the problems associated with long segment anterior reconstruction were the rationale behind choosing posterior surgery for this group. Although laminectomy diminishes intrinsic spinal stability, the extent of their effect on stability is often exaggerated.[52] Studies have shown good results if strict criteria, such as avoiding significant facetectomy, are followed.[53,54] Moreover the patients in this group usually are older (approximately one decade older than those undergoing anterior surgery in our study), in whom due to the degenerative changes, the spinal column has significantly more intrinsic stability than the cervical spine in a younger patient.[40,55] None of the patients undergoing laminectomy in our study developed late neurological deterioration or post laminectomy kyphosis though the duration of follow-up for these cases is relatively short (1 year) result recovery rate: 74.9±29.2.

In similar study by Bapat et al recovery rate was 73.44±16.75. cervical laminectomy was the preferred treatment in both.[33] Laminoplasty versus laminectomy for multi-level CSM: a systematic review of the literature by lao.et al concluded that there was no significant difference between the two techniques in operative time, estimated blood loss, and surgical complications.[56] Compared to standard laminectomy and skip laminectomy, postoperative ROM (range of movement) was more limited in laminoplasty, yet laminectomy with fusion resulted in the greatest limitation of ROM. The clinical outcome evaluation results included in this review were not uniform. Skip laminectomy seemed to have better clinical outcome than laminoplasty, while the outcome was similar between laminoplasty and laminectomy with fusion. Based on these results, a claim of superiority for laminoplasty or laminectomy was not justified. No much difference in respective to surgical outcome was found when laminectomy was compared to laminoplasty in some studies.[56]

CONCLUSION

Hence, we conclude that overall satisfactory outcome has been found in patients of cervical myelopathy. Patients must be individualized. Our surgical protocol has led us to acceptable scores post-operatively. Our scores justify our surgical protocol.

Hence, we recommend Anterior cervical discectomy and fusion (ACDF) for POC I (one- or two-level anterior cord compression) and POC II (one or two levels of anterior and posterior cord compression). Cervical laminectomy and SOS instrumentation is recommended for POC III (3 levels of anterior cord compression), IV (3 or more levels of anterior compression and development of narrow canal with multiple posterior compression) and IV variant (similar to POC IV with one or two levels, being more significant than the others).

Earlier diagnosis, prompt radiological investigations, individualizing surgical protocol, proper surgical techniques and proper follow-up evaluation are key in management of patients of cervical myelopathy.

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