Ossification of Cervical Posterior Longitudinal Ligament: Clinico-Radiological Correlation and Surgical Outcome.

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Abstract:
Background*: The precise contribution of static and dynamic factors to the disease progression of the cervical OPLL (Ossification of posterior longitudinal ligament) remains controversial. So an attempt has been made to correlate the clinical features with preoperative radiological findings and postoperative outcome.*
Methods: *After Institutional ethical clearance, written informed consent were taken from 26 patients (31 to 70 years of age) to enroll in this prospective longitudinal study over 3 years period. OPLL was proven radiologically and the degree of preoperative myelopathy was assessed by modified Japanese Orthopaedic Association(mJOA) score. Decompressive laminectomy was performed in all the patients and Hirabayashi's recovery rate was assessed at 3 and 6 months postoperatively.*
Results: *It was found that poor surgical outcome was correlated with age > 60 years, duration of myelopathy>2 years, preoperative bladder dysfunction (p< 0.001), MRI cord signal changes (p=0.041) and lower cross sectional area of the cervical spinal cord (p = 0.035).*
Conclusion*: Preoperative poor functional status of the patient as well as radiological findings of lower cross sectional area of cervical spinal cord and signal changes in MRI are predictive of poor outcome.*
Keywords*: Laminectomy ,myelopathy, neurological, ossification, radiological.*

I.   Introduction

Ossification of the posterior longitudinal ligament (OPLL) was first described by Aston C. Key [1] of Guys Hospitaln, London in 1838. It then remained unnoticed for a long time until Tsukimoto[2] in 1960 reported an autopsy case presenting the syndrome of compression of the spinal canal. Ossification of the posterior longitudinal ligament has been recognized as a common clinical entity that causes compressive myelopathy of the cervical spine. Gradually OPLL became established as a disease entity that is distinguishable from ankylosingspinal hyperostosis, ankylosing spondylitis and diffuse idiopathic skeletal hyperostosis.

Now a days OPLL which is most commonly found in the cervical region is a well known cause of cervical myelopathy and / or radiculopathy [3]. OPLL has been found to be strongly associated with regions demarcated as fluoretic belts across the world including those in the Indian subcontinent. Surgical management of cervical OPLL has been characteristically marred by unpredictable outcome. The precise contributionof the static and dynamic forces to the disease progression remains controversial. No long lasting improvement has been obtained by any of the non-operative methods. Conservative treatment has a limited role in the management of cervical OPLL. Surgical treatment should be so delayed that irreversible cord damage occurs.The aims and objectives of the present study are 1) to correlate the radiological findings with clinical features in patients with cervical OPLL and 2) to evaluate the outcome of surgical management.

II.   Methods

Following ethical committee approval , this prospective longitudinal study was carried out at the department of Neurosurgery , NarayanaHrudayalaya Institute of Medical Sciences, Bangalore, India. Written informed consent was obtained from the patients. A total of 26 patients could be recruited during the three years study period. Patiens with proven OPLL (on CT and or MRI) having cervical radiculopathy, myelopathy or both were included in the study. Patients having the same neurological findings but due to degenerative diseases, previous surgery, fluorosis of the spine, trauma or neoplasm were excluded from the study. Preoperative clinical evaluation was done using modified Japanese Orthopaedic Association Score (mJOA)[5].

Modified Japanese Orthopaedic Association Score (mJOA):
I.   **Motor dysfunction of upper limb   Score**
- inability to move hands   -----   0
- inability to eat with spoon but able to move hands   -----1

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* inability to button shirt but able to eat with spoon -----2
* able to button shirt with great difficulty   -----   3
* able to button shirt with slight difficulty   ----- 4
* no dysfunction   -----   5

II. Moetor Dysfunction Of Lower Limb   Score

* complete loss of motor and sensory function   -----   0
* sensory preservation without ability to move leg   -----   1
* able to move legs but unable to walk   -----   2
* able to walk on flat floor with aid   -----   3
* able to walk up/down stairs with hand rail   -----   4
* moderate to significant lack of stability but
  able to walk up/down stair without hand rail   -----   5
* mild lack of stability but able to walk unaided
  with smooth reciprocation   ----- 6
* no dysfunction   ----- 7

III. Sensation Score

* complete loss of sensation   -----   0
* severe sensory loss or pain   -----   1
* mild sensory loss   -----   2
* no sensory loss   -----   3

IV. Sphincter dysfunction Score

* inability to micturate voluntarily   -----   0
* marked difficulty in micturation   -----   1
* mild to moderate difficulty in micturation   -----   2
* Normal micturation   --   3

Pre-operatively the stability (maintaining the alignment) is assessed by dynamic cervical spine x-ray in lateral view. The decision whether the patient should undergo cervical laminectomy alone or with posterior fusion is based on assessment of cervical lordosis or kyphosis.[5,6]. In cervical lordosis the posterior border of all cervical vertebrae lie anterior to more than 2mm away from the imaginary line drawn from the dorso-caudal border of C_2 to C_7.

Decompressive cervical laminectomy usually includes a segment above and below the radiological abnormal segments. Laminectomy is initiated using a high speed air drill to shave down the lamina in the lateral gutters. Once the ventral bony cortex or ligamentumflavum is exposed, micro kerrison punches and micro curettes are used to complete the laminectomies from inferior to superior.

Immediate post-operative status was evaluated clinically in terms of motor, sensory and sphineter functions. Postoperative complications and their management were documented. Detailed clinical evaluations were done at discharge and follow up at 3 and 6 months postoperatively.

Recovery rate was calculated in percentage by the method described by Hirabayashi[7] at discharge and during follow up.

Recovery rate =
$$\frac{\text{Post op mJOA Score} - \text{pre op mJOA Score}}{17 - \text{Pre op mJOA Score}} \times 100$$

Radiological evaluation when performed post-operatively and at follow-up were done to include certain parameters like changes in canal diameter, kyphosis, alignment of the vertebral bodies etc. stability of the spine was assessed using dynamic x-rays.

Statistical analysis was performed using SPSS15 and strata 8.Q. Descriptive statistics and ANOVA were used where appropriate. A p value of <0.05 was considered significant.

III. Results

Demographic profile is shown in Table I.Male : Female ratio is 11.2 (84.6% : 15.4%). Highest incidence (30.8%) is found in the 4th decade (41-51 years of age). However most of the patients who remained clinically static or worsened postoperatively were ≤ 60 years of age. Although the Indian sub-continent is included in the fluorotic zone, myelopathy due to fluorosis was excluded from the study.

Table-I: Demographic profile values are expressed as numbers with their percentage in the brackets.
No.of patients : 26
Sex (male:female): 22:4 (84.6% : 15.4%)

Incidence with age range:

31 – 40 years	15.4%
41 – 50 years	30.8%
51 – 60 years	26.9%
61 – 70 years	26.9%

Geographical distribution:

Karnataka	–	21	(80.7%)
Tamil Nadu	–	3	(11.5%)
Andhra Pradesh	–	2	(7.6%)

Most patients (42.3%) had duration of myelopathy less than 1 year. However 2 patients each in the poor outcome groups (clinically static and clinically worsened) had duration of myelopathy more than 2 years.

Table- II:
Clinical profile of the patients.

- Duration of myelopathy

	No. of patients (%)
< 1 year	11 (42.3%)
1– 2 years	4 (15.4%)
3 – 4 years	9 (34.6%)
< 4 years	2 (7.7%)

- Distribution of signs and symptoms

Both upper and lower limb weakness	26 (100%)
Sensory symptoms	23 (88.4%)
Gait disturbances	14 (53.8%)
Neck pain	12 (46.15%)
Sphincter dysfunction	7 (26.9%)

- Co-morbid conditions

Hypertension	3 (11.5%)
Coronary artery disease	1 (3.8%)
Both hypertension and diabetes	1 (3.8%)

Table -III
OPLL Characteristics

Number of patients (percentage)		90% confidence Interval
Type . continuous 17 (65.4%)		49.3 – 78.6
• Mixed 9 (34.6%)		21.4 – 50.7
• Focal	Nil	
• Segmental		

OPLL

Thickness	upto 2mm	3(11.5%)	4.71 – 25.60
	2 – 3 mm	10(38.5%)	24.57 – 54.52
	3 – 4 mm	12 (46.2%)	31.21 – 61.83
	> 4mm	1(3.8)	0.8 – 15.53
Level	$C_3 - C_5$	9(34.6%)	
	$C_3 - C_6$	12 (46.2%)	

$C_4 - C_6$ 5(19.2%)

Cross-sectional area of cord at maximum compression

Level (square mm)		
< 41	1	(3.8%)
41 – 50	8	(30.8%)
51 – 60	12	(46.2%)
61 – 70	3	(11.5%)
> 71	2	(7.7%)

MRI cord signal changes		
T_1 Hypo	1	(3.8%)
T_2 Hyper	10	(38.5%)
No change	15	(57.7%)

The OPLL type in this study are continuous (65.4%) or mixed (34.6%). Maximum number (46.2%) of patients had cross sectional (at the level of maximum compression) area of 51 – 60 square mm though 2 patients in the poor outcome group had cross-sectional areas of 40.8 and 42 sq. mm.

Table –IVgives an idea of the operative outcome. Nine out of 26 patients (34.6%) underwent decompressive laminectomy at C_{3-6} level followed by lesser number of patients at other overlapping levels. Nineteen patients (73.1%) improved at 3 and 6 months follow up. Of the patients in the poor outcome group, 3 patients (11.5%) clinically worsened and 4 patients (15.4%) remained clinically static.

Table - IV
Operative Outcome of OPLL

Parameters		No. of patients %	90% confidence Interval
Level of decompressive Laminectomy	C_{2-5}	4 (15.4%)	7.10 – 30.2
	C_{2-6}	4 (15.4%)	
	C_{2-7}	4 (15.4%)	7.10 – 30.2
	C_{3-5}	1 (3.8%)	0.8 – 15.5
	C_{3-6}	9 (34.6%)	21.4 – 50.4
	C_{3-7}	5(19.2%)	6.7 – 34.6%

Post Operative complications :

- Chest infection
- Wound discharge   1 each (3.8%)
- Lower limb motor
  Weakness mJOA score 1
- Urinary retention
- Upper limb motor   3 each (11.5%)
  Weakness mJOA score 0
- Persistent neck pain 3 (11.5%)

Length of stay in hospital (days) :

- ≤ 5 days
- >10 days
- 6 – 1- days 18(69.2%)

Overall outcome :

- Improvement 19 (73.1%)   57.1 – 84.7
- Status quo 4 (15.4%)   7.1 – 30.2
- Worsened   3 (11.5%)   4.7 – 25.6

Table 5 highlights the poor prognostic factors. Statistical significance could not be demonstrated for some parameters whenwe take the average value. But considering the small number of patients who had poor outcome – clinically static (n=4) and clinically worsened (n=3) and the actual number of patients with the particular parameter, we can get some insight about the correlation of the outcome. Three patients in the clinically static group and 2 patients in the clinically worsened group actually had age ≥ 60 years. Similarly preoperative mJOA score < 11 had a tendency towards poor outcome. Preoperative bladder dysfunction (P<0.001), cross sectional area of the cervical spinal cord at the level of maximum compression (p=0.035) and MRI cervical cord signal changes (p=0.041) were clearly predictive of poor outcome.

Table – V Poor prognostic factors, values are expressed in mean ± SD (standard deviation).P < 0.05 is significant

Parameter	Clinically improved (n=19)	Clinically static (n=4)	Clinically worsened (n=3)	P - value
• Age(years)	51.11 ± 10.43	61.25± 4.78	58.00± 9.17	0.140
• Duration of symptoms (years)	2.34 ± 1.52	1.75 ± 2.16	1.63 ±2.06	0.690
• Preoperative mJOA	12.26 ± 1.69	11.00 ± 1.15	10.33 ± 3.21	0.163
• Postoperative mJOA	14.42 ± 1.02	11.00 ± 1.16	6.67 ± 1.16	<0.001
• Bladder dysfunction number of patients (%)	1(5.3%)	3 (75%)	3(100%)	<0.001
• Cross-sectional area of cord (square mm)	57.81 ± 7.65	48.67 ± 5.73	48.60 ± 7.60	0.035
• MRI Cord signal changes	5 (26.3%)	3(75%)	3(100%)	0.041
• Cord diameter sagittal(mm)	14 ± 2.0	11 ± 1.21	9 ± 1.0	0.034
• Length of stay in hospital (days)	7.53 ± 1.98	7.00 ± 1.83	10.67 ± 1.53	0.036

IV.   Discussion

Ossification of the posterior longitudinal ligament is a common cause of cervical myelopathy. Inspite of these, there are definite uncertainties as regards its etiology and treatment options. For those patients above 65 years of age with rapidly progressive myelopathy and several co-morbid conditions are managed conservatively because of the increased risk of morbidity and mortality[8.] Despite the widely held view that surgical treatment is indicated for patients who have neurologic deficits hindering activity of daily life, the new trend is prophylactic surgery when there is radiological evidence of cord compression to avoid further quadriparesis or quadriplegia[9]. Absolute (canal diameter < 10 mm) and relative (canal diameter 10-13 mm) have been shown to predispose patients with OPLL in developing more severe deficits earlier in the clinical course. Symptomatic myelopathy typically occurs when the canal diameter is less than 9.4 mm (<8 mm for lower limb weakness) [10,11.]Similarly cervical spinal cord cross sectional area[12] ≤ 42 square mm or occupancy ratio[13] > 40% to 60% increases the risk of symptomatic myelopathy. However other dynamic factors like mobility of the cervical spine needs to be considered[14].

The operative procedure remains controversial .Some study[15] found no significant difference between the anterior and posterior approaches while others[16] found the anterior approach to have better postoperative outcome . However, the anterior approach is relatively more difficult and carries potential risk of graft extrusion, CSF (cerebrospinal fluid) leak, excessive venous bleeding, dysphagia and implant failure[17]. High risk patients older than 65 years of age with OPLL but with adequate cervical lordosis may undergo posterior decompressive procedures including laminectomy, laminectomy with posterior fusion or laminoplasty with a modicum of success[18]. Generally, the primary target of the anterior approach is OPLL of the segmental or localized type not extending above C_3, and the target of the posterior approach, OPLL of the continuous or mixed type[4]. In our study, all the patients underwent posterior decompressive laminectomy as all of them fit criteria for cervical lordosis[5,6] and instability was excluded by dynamic cervical x-rays. All of them were of continuous and mixed types (Table III). In other study[7], segmental form is the commonest type. Whether this finding is indicative of ethnic difference or late presentation of the patients to the clinician needs further evaluation.

In this study, the male: female ratio is 11:2. Similar[19] and dissimilar[20] findings have been quoted by others. Hightest incidence (30.8%) is found in the fourth decade(Table II), which is a decade younger than that reported by Naoichi et al[20]. It may reflect ethnic variation from the Japanese study. In our study, myelopathy with gait disturbance is found in 53.84% of cases which is in accordance (~ 56%) with literature[21]. Although symptoms are gradual in onset, 10% patients may precipitously develop myelopathy after mild trauma. Such event was not encountered in our study.

As in other areas of clinical medicine clear delineation of natural history is the basis against which all forms of intervention must be judged. However little is understood about the natural history of OPLL. Contribution of various clinical and radiological parameters remain controversial thus confounding attempt to define a natural history and prognostical surgical outcome There is a distinct paucity of literature in this regard with no prospective study exclusively addressing this problem till date.

Although 73.1% had improved clinical outcome postoperatively in keeping with the literature (~72%)[5], we have re-affirmed certain traits to be predictive of poor outcome. Age at presentation is an important factor. In this study 2 out of 3 patients who worsened clinically and 3 out of 4 patients who did not improve after surgery were≥60 year of age corroborating with other studies[7,22]. Symptom duration of less than 6 months to one year is considered critical for good outcome, Hirabayashiet al[7] reported that myelopathy of more than 2 years duration was associated with poor outcome. In our study, 2 patients each out of those who remained clinically static (n=4) or clinically worsened (n=3) presented with myelopathy for more than 2 years, though statistical significance could not be shown in the results (Table-V). Similarly there is a trend towards poor

postoperative outcome with pre-operative mJOA score < 11 despite statistical insignificance (P=0.163). Hirabayashi at al[7] considered preoperative JOA score<7 to be associated with poor outcome. We have used the modified scoring system. Motor deficit of the lower extremities is significantly increased when the sagittal cervical canal diameter is less than 8 mm[11]. In this study, 2 patients who worsened clinically in the postoperative period had sagittal cervical canal diameters of 9 mm and 8 mm, thus predicting poor surgical outcome (P=0.034). Cross sectional area[12] of the cervical spinal cord at the level of maximum compression less than 42 square mm is also associated with greater severity of myelopathy postoperatively. In our study, 2 patients from the poor outcome group (status quo and worsened) had cross-sectional area of cord 40.8 square mm and 42 square mm. MRI cord signal changes preoperatively were also predictive of poor outcome (P=0.041). Most of the patients who had pre-operative bladder dysfunction had poor postoperative outcome (P< 0.001). The impact of co-morbid conditions could not be ascertained as few patients had comorbid conditions, a finding which had been noted earlier[21].

V. Conclusion

Our study has attempted to look into putative prognostic factors determining the surgical outcome in symptomatic cervical OPLL patients. We have found that pre-operative functional status of the patient in terms of modified Japanese Orthopedic association scoring, bladder symptoms. MRI cord signal changes and lower cross-sectional area of spinal cord at the level of maximum compression to be predictive of poor postoperative outcome.

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