

ORIGINAL RESEARCH

A study of surgical strategies and their outcome in cervical ossification of posterior longitudinal ligament

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ABSTRACT

Aim: To evaluate the cases of cervical myeloradiculopathy due to ossified posterior longitudinal ligament (OPLL), different surgical approaches and their outcome. **Material and Methods:** The present prospective observational analytical study was conducted at Department of Neurosurgery, Bangur Institute of Neurosciences, Kolkata among 54 patients aged over 20 and up to 65 years including both male and female presenting for ossified posterior longitudinal ligament with cervical myeloradiculopathy and underwent surgery for the same from 1st March 2020 to 31st April 2022. Anterior cervical corpectomy and fusion was done in patients with cervical OPLL involving ≤ 3 levels, massive OPLL involving $> 50\%$ of spinal canal and with presence of cervical lordosis and subluxation. Posterior approach by laminectomy was done in patients with multilevel OPLL involving > 3 levels and with OPLL involving $< 50\%$ of spinal canal. Laminectomy & fusion was done in patients with multilevel OPLL involving > 3 levels, without pre-existing cervical lordosis and subluxation, to achieve effective decompression and for maintaining or restoring stability of the cervical spine. All the patients undergoing surgery were followed up at the end of 3 and 6 months to assess the various surgical outcome. **Results:** Out of these 54 patients 22 patients underwent posterior decompressive laminectomy (B1), 16 patients underwent posterior decompressive laminectomy and lateral mass fusion (B2) and 16 patients underwent anterior corpectomy and fusion (A). The differences of post-operative functional scores and neurological assessment did not reach statistical significance when comparing between the groups. **Conclusion:** We concluded that all the implemented surgical approaches for cervical OPLL i.e anterior cervical corpectomy and fusion (A), decompressive laminectomy (DL) and laminectomy with lateral mass fusion (LMF) are equally good in terms clinical outcome and effectiveness.

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INTRODUCTION

Ossification of the posterior longitudinal ligament (OPLL) is characterized by the heterotopic bone formation in the posterior longitudinal ligament (PLL) causing myeloradiculopathy as a result of chronic pressure on the spinal cord and nerve roots.¹ Cervical OPLL may compress the spinal cord and nerve roots, leading to sensory and motor dysfunction. Majority of patients with this condition are asymptomatic, can be managed with conservative methods. Once the symptoms of myelopathy, such as gait disturbance and disorders of fine motor movement in the hand develop, appropriate recovery is not expected with conservative treatments.^{2,3}

The two major surgical strategies used for the treatment of cervical OPLL are anterior decompression with fusion (A) and posterior decompression via techniques such as laminectomy (B1), laminectomy with fusion (B2) and laminoplasty (B3).⁴ The anterior approach can directly relieve compression, but the procedure is more complicated and prone to an increased risk of spinal cord injury. Anterior decompression and fusion is done in patients with OPLL involving more than 50% of canal occupancy and when less than three segments are involved.^{4,5}

Posterior approach can also provide canal decompression, the degree of decompression is sometimes insufficient, but it accomplished in a

shorter period of time with lesser blood loss. The posterior indirect decompression and fixation has now been adopted as the primary treatment for cervical OPLL involving multiple levels with the canal occupancy by OPLL less than 50%.^{4,5}

Laminectomy (B1) effectively decompress the spinal cord in patients with multi-level cervical OPLL, it may result in instability, progressive kyphosis and late neurological deterioration. Thus laminectomy with fixation (B2) and laminoplasty (B3) has been proposed and used. Choice of surgical technique is optional, depending on the surgeon's preference and the patient's status.⁶

Anterior approaches can be complicated by dysphagia, recurrent laryngeal nerve injury, CSF leaks & fistulas and increased risk of pseudarthrosis with multilevel fusion. Posterior approaches tend to have increased risk of infection, postoperative neck pain, C5 radiculopathy and post laminectomy kyphosis.⁷ In posterior approach, multi-level laminectomy (B1) is associated with increased risk of postoperative kyphosis. Laminectomy & fusion (B2) and laminoplasty (B3) are associated with increased risk of neurological deterioration immediately after surgery.⁷ This study will throw light on the outcome of various surgical approaches (A, B1, B2) in cervical OPLL and the factors influencing the outcome.

AIM

To study the cases of cervical myeloradiculopathy due to ossified posterior longitudinal ligament (OPLL), different surgical approaches and their outcome.

OBJECTIVES

1. To evaluate the patients of cervical OPLL by X-ray, magnetic resonance imaging (MRI) and Computed Tomography (CT) scan of cervical spine.
2. To assess the surgical outcome in patients with cervical OPLL by different functional & radiological parameters.

MATERIAL AND METHODS

The present prospective observational analytical study was conducted at Department of Neurosurgery, Bangur Institute of Neurosciences, Kolkata among 54 patients aged over 20 and up to 65 years including both male and female presenting for ossified posterior longitudinal ligament with cervical myeloradiculopathy and underwent surgery for the same from 1st March 2020 to 31st April 2022.

Sample size was calculated using the following formulae:

$$N = 2(Z_{\alpha/2})^2 s^2 / d^2$$

Where N denotes sample size, s is the standard deviation obtained from previous study, and d is the accuracy of estimate or how close to the true mean. $Z_{\alpha/2}$ is normal deviate for two-tailed alternative

hypothesis at a level of significance. Power design is assumed as 80%.

The sample size for the study was based on a study by Motoki Iwasaki et al, (2007)⁸, who reported the mean improvement of 69 ± 2.4 and 66 ± 2 in recovery rate at anterior and posterior site. Based on the formula given above, using the mentioned values, the sample size required is: $2 * (1.96 + 1.282) * 2.42 / 32 = 13.454$ (~14). Thus the proposed minimum sample size for each arm is 14. A total 54 patients with cervical ossification of PLL underwent various appropriate surgical procedures in our institute. All of them were included under this study. Hence the sample size taken for this study is 54 (16 in anterior group and 38 in posterior group) to get a better comparative analysis. The study has a follow up period of 6 months therefore we have 24 months for recruitment of sample subject for study.

INCLUSION CRITERIA

Patients with ossification of posterior longitudinal ligament in the cervical segment requiring surgery in the age group 20 to 65 years of age.

EXCLUSION CRITERIA

1. Patients with tandem ossification in another spinal region (thoracic ossification of the posterior longitudinal ligament and ossification of the ligamentum flavum).
2. Patient with cervical spinal cord injury with incidental finding of OPLL in cervical segment.
3. Patients with serious co-morbid conditions.
4. Patient unwilling for surgery.
5. Patient operated with both anterior and posterior approach.

METHODOLOGY

- a. Pre-operative clinical evaluation
- b. Radiological investigation
- c. Operative procedure
- d. Post op evaluation

Various radiological parameters taken into account are Mid Sagittal Diameter, Dynamic Stenosis, Pavlov's Ratio, Occupancy Ratio and Cobb's Angle. The midsagittal diameter of the spinal canal was measured as the distance from the middle of the dorsal surface of the vertebral body to the nearest point on the spino laminar line. Canal diameter measuring <13mm is considered to be stenotic. A distance of <12mm from the poster inferior corner of a vertebral body to the antero superior edge of the lamina of the immediately caudal vertebra with the neck in extension was suggestive of dynamic stenosis. Subluxation of >3.5mm was a measure of excessive translation between the vertebral bodies. High signal intensity of cervical spinal cord was identified and graded accordingly. Type of OPLL and radiological grading of OPLL.

MANAGEMENT

All the patients presenting with cervical myeloradiculopathy due to ossified posterior longitudinal ligament (OPLL), were assessed clinically and radiologically. Choice of surgical approach was selected based on number of levels of compression by OPLL, the occupancy ratio (i.e. the amount of the canal diameter occupied by the OPLL/total canal diameter at the particular levelx100), measurement of the cervical lordosis by Cobb’s angle and the determination of the subluxation by dynamic radiographs.

Anterior cervical corpectomy and fusion was done in patients with cervical OPLL involving ≤ 3 levels, massive OPLL involving > 50% of spinal canal and

with presence of cervical lordosis and subluxation. Posterior approach by laminectomy was done in patients with multilevel OPLL involving > 3 levels and with OPLL involving <50% of spinal canal. Laminectomy & fusion was done in patients with multilevel OPLL involving >3 levels, without pre-existing cervical lordosis and subluxation, to achieve effective decompression and for maintaining or restoring stability of the cervical spine.

NON-OPERATIVE MANAGEMENT

These include medications (non-steroidal anti-inflammatory drugs- NSAIDS, Opioid analgesics- Oxycodone, Muscle relaxants) and physiotherapy.

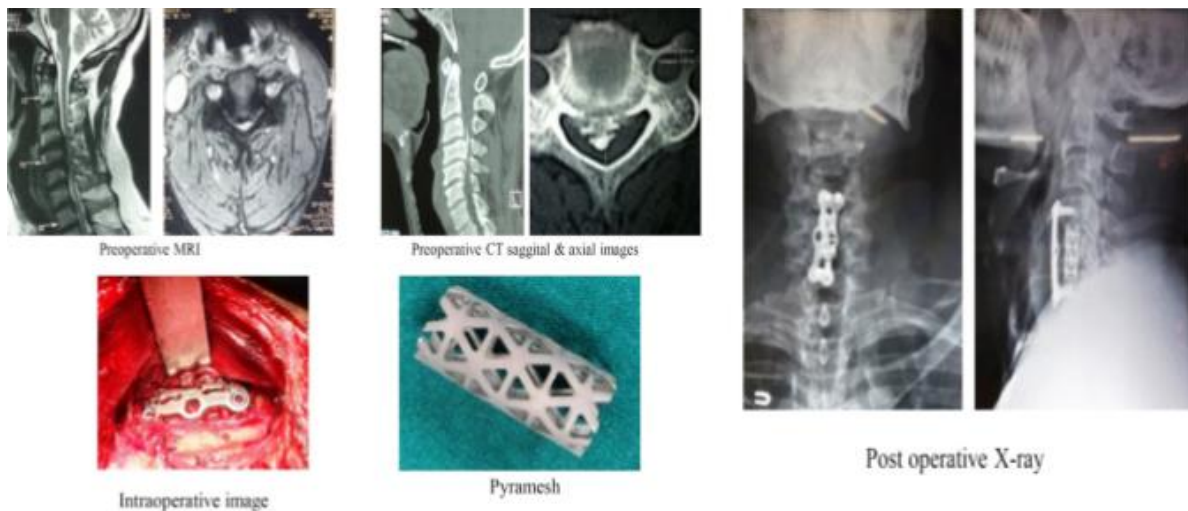


Figure 1: A case of C3-5 segmental OPLL underwent C4 corpectomy & fusion (Pyramesh+plate)

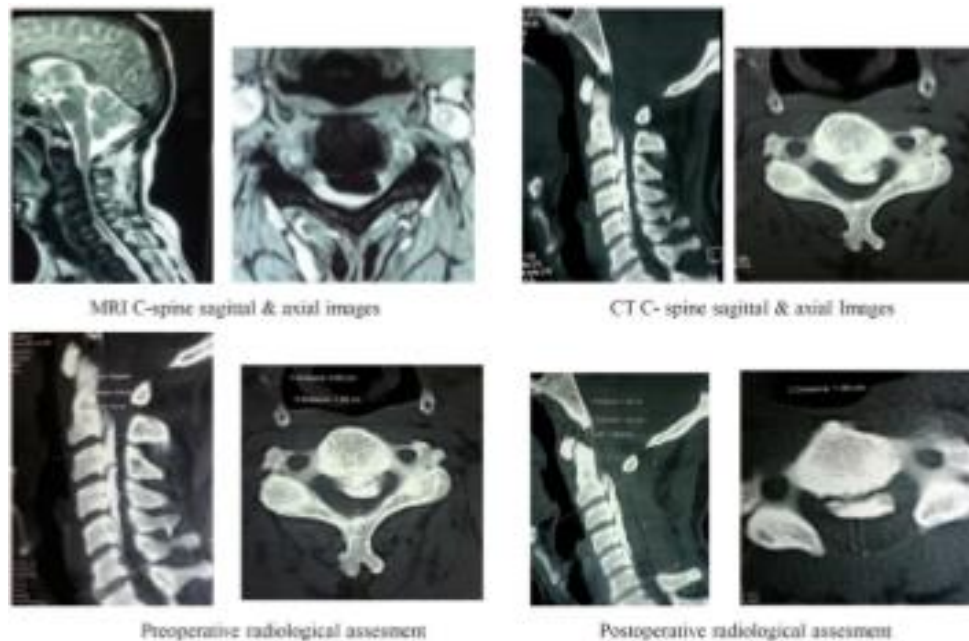


Figure 2: A case of C2-C5 continuous OPLL underwent laminectomy

All the patients undergoing surgery were followed up at the end of 3 and 6 months to assess the various surgical outcome. Recovery rate was assessed using

post-operative modified Japanese orthopedic association (mJOA) score at the end of 3 months and 6 months following the operative procedure.

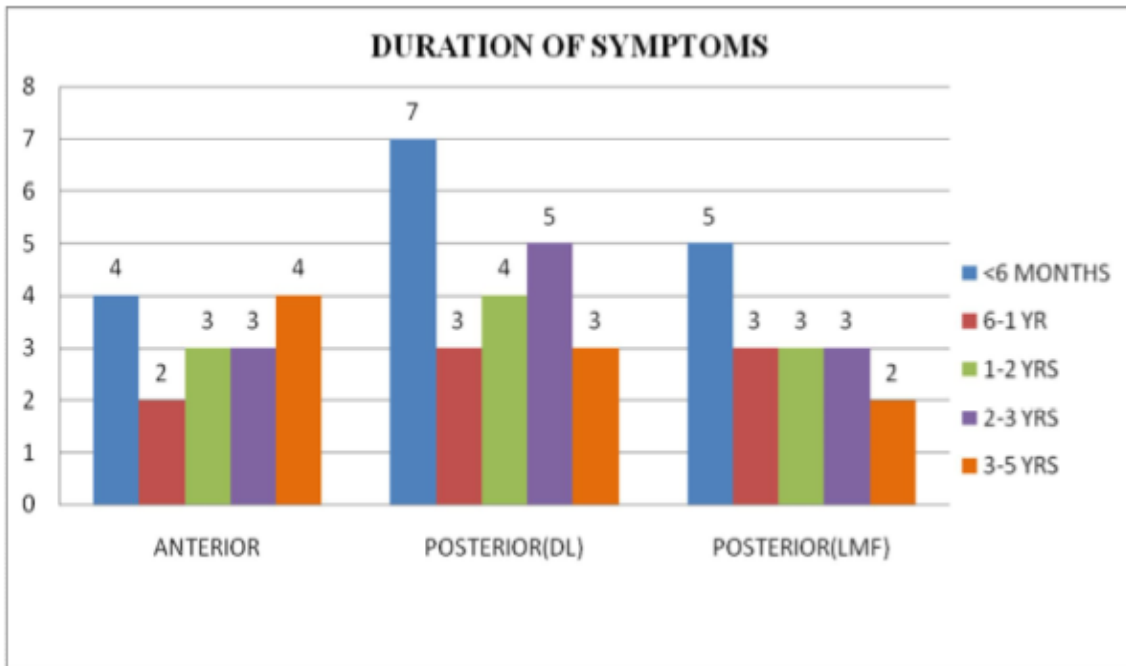
$RR = \frac{\text{postoperative JOA score} - \text{preoperative JOA score}}{(17 - \text{preoperative JOA score})} \times 100\%$

STATISTICAL ANALYSIS

Data was coded and recorded in MS Excel spreadsheet program. SPSS v23 (IBM Corp.) was used for data analysis. Group comparisons for continuously distributed data will be made using independent sample ‘t’ test when comparing two groups, and One-Way ANOVA when comparing more than two groups. Post-Hoc pairwise analysis was performed using Tukey’s HSD test in case of One-Way ANOVA to control for alpha inflation.

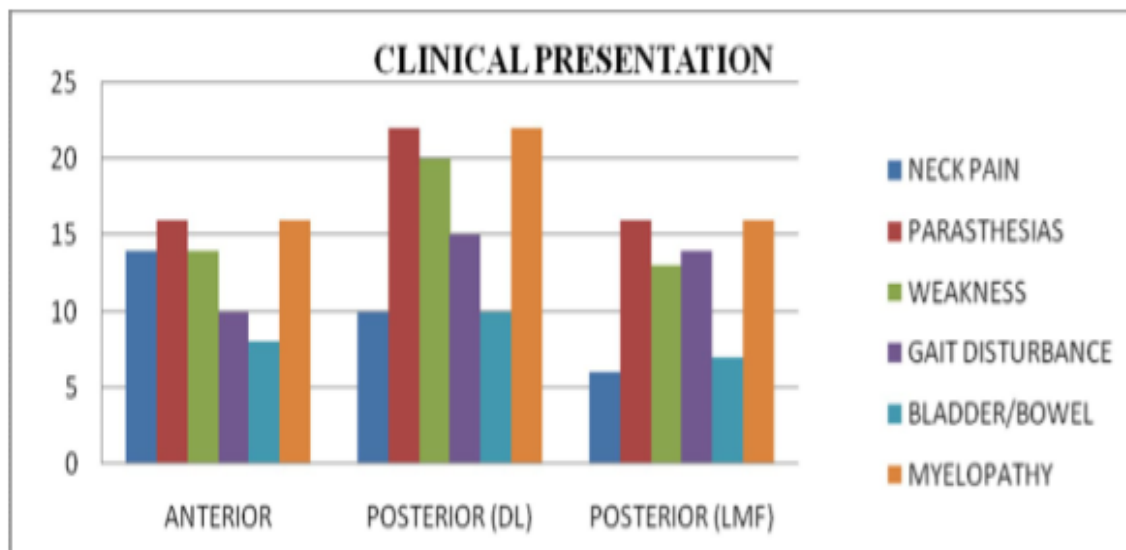
RESULTS

Among anterior group 9 were males and 7 females, posterior laminectomy group 13 were males and 9 female and 10 males and 6 female patients in posterior laminectomy & lateral mass fusion group. Male:female ratio was 1.4:1. Most of my patients were in the age group of 41-50 years i.e. 21 (38%) patients and mean age of presentation of OPLL was 47.22 years. Most of the patients had short duration of symptoms at presentation <6 months in 16 (29%) patients, 2-3 years in 11 (20%) patients and 1-2 years in 10(18%) patients as shown in graph 1.



Graph 1: Duration of Symptoms

Predominant symptom was parasthesias present in all group of patients (100%). Neck pain present predominantly in anterior group (87%). All the patients had myelopathic features as shown in graph 2.



Graph 2: Clinical Presentation

The number of levels of compression by cervical OPLL had significant difference in anterior and posterior groups with p value <0.0001. Preoperative occupancy ratio, Cobb's angle and subluxation were more in anterior group than in posterior group, but the differences did not reach statistical significance. Within the posterior group, choice of surgical

approach was selected based on cervical lordosis by Cobb's angle and subluxation by dynamic radiographs. Out of 38 posterior approach groups, 22 patients underwent posterior laminectomy and 16 patients underwent laminectomy followed by lateral mass fusion in view of greater Cobb's angle (table 1).

Table 1: Choice of surgical approach

Assessment done by	Comparison among groups	P value (significance)
Number of levels of compression	Anterior group	0.000
	Posterior group	
Occupancy ratio	Anterior group	0.788
	Posterior group	
Cobb's angle	Anterior group	0.469
	Posterior group	
Dynamic stenosis	Anterior group	0.547
	Posterior group	

The mean VAS in the anterior approach group decreased from preoperative 4.81±0.91 to postoperative 0.94±1.28. In the posterior laminectomy group, the preoperative value of 5.41±1.26 dropped to 0.59±0.66 and in lateral mass fusion group the mean VAS decreased from preoperative 5.25±1.18 to postoperative 1.25±1.29. There was significant improvement in VAS scores in all the groups postoperatively with p<0.0001. There was significant improvement in NDI scores within the groups in both

anterior and posterior groups postoperatively with p<0.005. Comparing between the groups there was no significant difference. There was significant improvement in Modified Ashworth Scale in all the groups with p<0.005. There was no significant difference between three groups. The average improvement rate according to JOA scale was 36.5% ±17.51% and 76.31% ±14.87% at first and second follow ups at the end of 3 months and 6 months respectively (table 2).

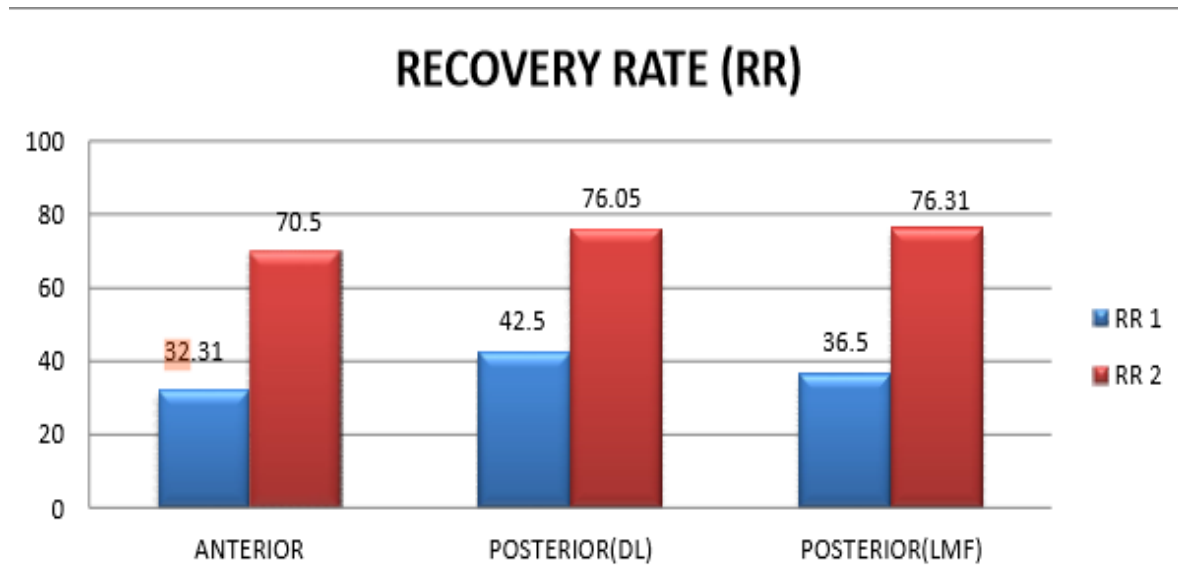
Table 2: Functional outcome

Variables	Anterior		Posterior (Laminectomy)		Posterior (LMF)		p value
	Mean	SD	Mean	SD	Mean	SD	
VAS							
Preop	4.81	0.91	5.41	1.26	5.25	1.18	0.28
Followup 1	2.75	1.34	2.55	1.34	3.25	1.73	0.34
Followup 2	0.94	1.29	0.59	0.67	1.25	1.129	0.18
Nurick's Grade							
Preop	3	1.32	2.95	1.49	3.19	1.05	0.86
Followup 1	2.06	1.34	2	1.27	2.06	1.12	0.98
Followup 2	1.06	1.23	0.82	1.01	1	0.89	0.76
Modified Ashworth Scale							
Preop	1.63	1.20	1.68	1.29	1.63	1.20	0.99
Followup 1	1.13	1.09	1.05	1.09	1.31	1.07	0.75
Followup 2	0.44	0.63	0.32	0.57	0.44	0.63	0.78
JOA Score							
Preop	9.50	3.67	9	3.51	8.81	2.267	0.82
Followup 1	11.31	3.22	12.14	2.817	11.31	2.60	0.590
Followup 2	14.81	1.83	15.32	1.249	14.94	1.81	0.599

The surgical outcome was defined by the RR as follows: Good (RR > 50%) and Poor (RR < 50%). There was significant improvement in recovery rate in both anterior and posterior groups postoperatively, but in between the groups there was no significance difference to compare (graph 3).

In anterior cervical group(A), there was CSF leak and dural tear in 2(12%), C5 radiculopathy in 1 (6%), axial neck pain in 5 (31%), dysphagia and hoarseness in 3 (19%) patients respectively. In Decompressive

laminectomy group (B1), CSF leak and dural tear was found in 3 (19%), C5 radiculopathy in 2 (12.5%), axial neck pain in 4 (25%) patients respectively. However no dysphagia and hoarseness was found in B1 (DL) group. In lateral mass fusion group (B2), CSF leak and dural tear was found in 1(4%), C5 radiculopathy in 4(18%), axial neck pain in 9 (40%) and dysphagia and hoarseness in 1(4%) patients respectively.



Graph 3: Recovery Rate

DISCUSSION

In our study most of the patients were in the age group of 41-50 yrs and the mean age of presentation of OPLL was 47.22 years, which was in accordance with Trojan et al⁹ and Rao Kommu et al¹⁰ study.

The present study showed a male predominance with the male to female ratio was 1.4:1, which was in accordance with study by Tsuyama et al¹¹ who also registered a sex ratio of 2:1. And another study by Rao Kommu et al¹⁰ noted a sex ratio was 3.5:1 (male:female) and Matsunaga et al¹² found it be 2.4:1. Many studies^{10,13,14,15,16} from the literature utilized various combination of outcome scores for the assessment of functional outcome in cervical OPLL patients. Hence the patient functional assessment in the present study was done preoperatively and postoperatively by using visual analogue scale, neck disability index, modified Ashworth scale, gait abnormality using Nurick's grading system and recovery rate (RR) using modified Japanese orthopedic association (JOA) score.

In the present sample of study there was significant improvement in postoperative VAS and NDI scores within the groups and the values were statistically significant with $p < 0.001$. The variation in VAS and NDI score when observed between the groups has not statistically different, similar to the result obtained by Qiushui Lin et al.¹⁷

In the present study there was significant improvement in Nurick's grade within the groups postoperatively with $p < 0.001$. But we observe no significant difference between the groups which is similar to study by Hai Li et al¹³ and Rao Kommu et al¹⁰.

Modified JOA score and recovery rate was suggested as standard and widely used method in evaluating functional disability among cervical OPLL surgery patients^{10,13,14,15,16}, hence it was used in the present study for the assessment of functional improvement of

patients. A significant improvement in mJOA score was noted within the groups with p value of < 0.001 and there was no significant difference noted between the groups, which was similar to above studies^{10,13,14,15,16}.

In the present study there was significant improvement in Modified Ashworth Scale in all the three groups postoperatively with $p < 0.001$. There was no significant difference between the groups which was similar to study by Rao Kommu et al¹⁰.

In the present study there was significant improvement in mid sagittal diameter within the groups postoperatively with p value of < 0.005 and there was no statistically significant difference between the group. The findings were similar to study done by Hai Li et al¹³, Yu Chen et al¹⁴ and Rao Kommu et al¹⁰.

There was significant improvement in Pavlov's ratio within the groups postoperatively with p value of < 0.005 and there was no statistically significant difference between the group. The findings were similar to study done by Jain SK et al¹⁸, Yu Chen et al¹⁴ and Rao Kommu et al¹⁰.

There was a significant decrease in the measured Cobb's angle values, both in the anterior corpectomy group and posterior laminectomy with fusion group (p value < 0.05) but the Cobb's angle measurement in the posterior laminectomy group increased from a mean preoperative value of 12.36 ± 9.49 to a mean postoperative value of 13.09 ± 11.21 (p value < 0.05). This finding showed a betterment of Cobb's angle in laminectomy with fusion group but there was no significant difference in Cobb's angle in between the groups pre-operatively and post-operatively. The similar findings were reported by Kato et al¹⁹ study which showed high rate of kyphosis in laminectomy group patients without any decline in patients clinical status.

The results from present study showed that anterior decompression and stabilization or posterior decompression and stabilization when compared, both anterior and posterior approaches are safe and effective means of decompression of cervical stenosis in the setting of OPLL.

Anterior cervical decompression and reconstruction is a safe and appropriate treatment for cervical spondylotic myelopathy in the setting of OPLL. For patients with increased cervical lordosis, posterior cervical decompression and stabilization is advocated. The use of laminectomy is indicated in patients with preserved cervical lordosis and less than 60% of the spinal canal occupied by calcified ligament, which is in accordance with the other studies in the literature^{10,13,15,16}.

CONCLUSION

We concluded that all the implemented surgical approaches for cervical OPLL i.e anterior cervical corpectomy and fusion (A), decompressive laminectomy (DL) and laminectomy with lateral mass fusion (LMF) are equally good in terms clinical outcome and effectiveness.

According to our study none of the surgical approaches i.e anterior cervical corpectomy and fusion, laminectomy and laminectomy with lateral mass fusion was found to be superior than other in terms of outcome. The parities in each group were entirely different and mutually exclusive. Hence the above mentioned three procedures cannot be compared with each other. For that the patients should have been similar in all respects before surgery.

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