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Comparison of outcomes in open-door laminoplasty versus laminectomy and instrumented fusion in patients with ossification of the posterior longitudinal ligament involving multiple levels

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ABSTRACT

Background: This study aims to determine, in cases of multi-level ossification of the posterior longitudinal ligament (OPLL), expansive open-door laminoplasty (LP) is a better option than laminectomy and instrumented fusion (LMF).
Methods: A total of 44 cases were included and divided into group LP (n=22) and group LMF (n=22). Patients, who underwent surgical treatment for continuous and mixed type multi-level OPLL between January 2010- December 2021 were retrospectively reviewed. The cervical lordosis was evaluated by C2-7 Cobb angle and cervical sagittal balance by C2-C7 sagittal vertical axis (SVA). Range of motion (ROM), Japanese Orthopedic Association (JOA), visual analog scale (VAS) and neck disability index (NDI) were used to assess clinical outcomes.
Results: The LP group had significantly lower blood loss (280±50 ml vs. 450±70 ml) and shorter operative time (120±15 min vs. 160±20 min) compared to LMF. LP preserved cervical lordosis (4±1.5° vs. 7±2°, p=0.001) and ROM (8±2° vs. 14±3°, p=0.003) more effectively. NDI improvement was greater in the LP group (27±5 vs. 20±6, p=0.021). OPLL progression was higher in LP (1.2±0.3 mm vs. 0.5±0.2 mm, p=0.017). LP was associated with higher postoperative kyphosis (32% vs. 14%, p=0.038) and kyphotic change rate (28% vs. 10%, p=0.029), but lower incidence of axial pain (14% vs. 27%, p=0.043).
Conclusions: Compared with the LMF, the LP is recommended for cases with OPLL and straight cervical lordosis ensuring comparable neurological recovery, improved neck ROM, less axial pain and better neck function improvement. The stabilization obtained by adding instrumented fusion could suppress progression of OPLL thickness.

Keywords: Ossification of the posterior longitudinal ligament, Laminoplasty, Laminectomy, Continuous and mixed type of OPLL

INTRODUCTION

Ossification of the posterior longitudinal ligament (OPLL) is a progressive pathological condition characterized by ectopic bone formation within the spinal canal, predominantly affecting the cervical spine and leading to compressive myelopathy over time. Though its etiology remains multifactorial, encompassing genetic, metabolic, and mechanical influences, OPLL is increasingly recognized in aging populations, especially among East Asian males.[1] Surgical intervention becomes essential in cases of neurologically significant spinal cord

compression. The choice between anterior and posterior approaches remains contentious due to distinct advantages and risks associated with each technique.[2,3] Anterior decompressions and fusion (ADF) allow for direct resection of ossified masses and have shown efficacy in selected cases; however, they are technically demanding and carry higher risks of complications such as dural tears, spinal cord injury, and instrumentation failure, particularly when multilevel involvement is present.[4,5] Posterior approaches, including laminoplasty (LP) and laminectomy and instrumented fusion (LMF), are more commonly employed for multilevel OPLL, as they offer indirect decompression with fewer intraoperative risks and greater surgical exposure.[6] Expansive open-door LP has gained popularity due to its ability to preserve cervical motion and maintain neurological outcomes, especially in patients with maintained lordosis.[7] However, concerns persist regarding postoperative kyphosis and OPLL progression, particularly in younger or more mobile patients.[8]

Conversely, LMF offers better control of sagittal alignment and can stabilize the spine in cases with kyphosis or instability. Nevertheless, it is associated with greater soft tissue disruption, loss of cervical ROM, and a higher incidence of C5 palsy.[9] Comparative evaluations of LP and LMF in the management of multilevel OPLL remain limited, necessitating further clinical investigation to establish optimal surgical strategies based on individual patient profiles.

The purpose of this research is to ascertain whether expansive open-door LP is a superior treatment option to LMF in cases of multi-level OPLL.

METHODS

This study was conducted at both Bangladesh Medical University (BMU) and Popular Medical College Hospital, Dhaka, Bangladesh. We retrospectively reviewed data from 44 patients who underwent posterior cervical decompression (LP) or laminectomy with fusion (LMF) for cervical compressive myelopathy (CCM) due to OPLL between January 2010 and December 2021.

Inclusion criteria were OPLL spanning more than two cervical levels and concurrent cervical stenosis.

Exclusion criteria included ligamentum flavum ossification, thoracic or thoracolumbar OPLL/OLF, trauma, prior cervical surgery, and other neurological conditions (e.g., Parkinson's disease, multiple sclerosis). Patient demographics, clinical history, and radiologic findings were analyzed. OPLL was confirmed via X-ray and 3D CT, while CCM was diagnosed through neurological examination and MRI.

Surgery type (LP or LMF) was selected based on age, cervical curvature (lordosis, straight, or kyphosis), and spinal stability. The C2-C7 Cobb angle defined curvature type: lordotic (<-10°), straight (-10° to 0°), and kyphotic (>0°). LMF was preferred for patients with instability, straight/lordotic curves, or severe compression; LP was favored in younger patients (<55 years) to preserve motion.

Surgical technique and outcome assessment

All surgeries were performed under general anesthesia in prone position using a posterior midline approach. In LP, laminae were split and expanded unilaterally or bilaterally with titanium miniplates to maintain the open position. For LMF, bilateral lateral mass screws (C3-C7) and, if needed, pedicle screws at C2 were inserted using the Margerl technique. Decompression was followed by rod placement shaped to preserve cervical lordosis. Autologous bone grafts were used for fusion. Postoperatively, patients wore cervical braces for ~3 months and were followed radiologically at regular intervals. All patients underwent preoperative X-rays, CT, and MRI. OPLL types were categorized on sagittal CT as localized, segmental, continuous, or mixed. Radiographic measurements included C2-C7 SVA, lordotic angle, and total ROM. Changes in alignment were calculated as the difference between pre- and postoperative values. The spinal canal occupying ratio was measured on sagittal CT. Neurological status was assessed using the JOA score. Axial pain and neck function were evaluated using the VAS and NDI, respectively. Postoperative complications such as infection, CSF leakage, nerve palsy, pain, neurological decline, implant failure, and reoperations were documented.

Statistical analysis

Data were expressed as mean±SD or percentage. Student's t test or chi-square test was used for normally distributed data, while Mann-Whitney U test was applied for non-normal data. Pearson's correlation was used to assess relationships among cervical parameters, occupying ratio, and clinical scores (VAS, neck disability index (NDI) and JOA). Analyses were performed using SPSS v27, with significance set at $p<0.05$.

RESULTS

The study population consisted of more males than females, with males accounting for nearly two-thirds (63.6%) of the total cases. This aligns with existing epidemiological data suggesting a higher prevalence of OPLL in males, potentially linked to hormonal, genetic, and biomechanical factors.

The majority of patients (59.1%) were in the 50-69 age range, indicating that multilevel cervical OPLL requiring surgical intervention predominantly affects middle-aged to elderly individuals. The age distribution also supports the degenerative nature of the disease, which tends to progress with advancing age. Only a small proportion (13.6%) were under 40, reflecting the rarity of early-onset symptomatic OPLL.

LP demonstrates clear advantages with lower intraoperative blood loss and shorter operative time, indicating it is less invasive and associated with reduced surgical risks. Although both groups show a postoperative increase in cervical SVA, the difference is minimal and unlikely to be clinically significant. LP better preserves cervical lordosis and ROM, offering functional benefits where neck mobility is crucial, while LMF shows greater reductions due to rigid fusion. Neurological recovery and pain relief are comparable between groups, with no significant difference in JOA or VAS improvements. Importantly, LP provides superior improvement in neck-related daily function, reflecting its ability to preserve motion and reduce postoperative disability.

LP is associated with greater progression of OPLL. This may be due to continued motion in the decompressed segments that promotes ossification. In contrast, the fusion in LMF may stabilize spine and slow OPLL progression.

Kyphosis

LP is more likely to result in postoperative kyphosis (forward curvature of the neck), likely due to the removal of posterior stabilizing structures without instrumentation.

Axial pain

Despite more kyphosis, LP is associated with less axial neck pain. LMF patients may suffer more pain due to muscular dissection and hardware irritation.

Clinical implication

For patients at risk of kyphosis, LMF might be preferred. However, for those concerned about postoperative neck pain and function, LP may be more favorable.

Complications

Surgery-related complications occurred in 3 patients, two patients undergoing LMF and 1 patient undergoing LP developed dural tear. Post-operative paresthesia developed in 4 patients after 1 month of follow up, who recovered within 3 months. Superficial wound infections occurred in 3 patients, but no additional surgery was required to remove instrumentation.

Table 1: Gender distribution of study participants, (n=44).

Gender	N	Percentage
Male	28	63.6
Female	16	36.4

Table 2: Age distribution by category, (n=44).

Age group (in years)	N	Percentage
30-39	6	13.6
40-49	8	18.2
50-59	14	31.8
60-69	12	27.3
70-79	4	9.1

Table 3: Operative outcomes.

Parameters	Group A (LP) (mean±SD)	Group B (LMF) (mean±SD)	P value
Operation duration (minutes)	120±15	160±20	–
Total blood loss (mL)	280±50	450±70	–
Postoperative C2-7 SVA level (mm)	35±5 (Change +7 mm)	36±6 (Change +8 mm)	–
Loss of cervical lordosis (degrees)	4±1.5	7±2	0.001
Loss of ROM (degrees)	8±2	14±3	0.003
JOA score			
Pre-op	10.5	10.4	–
Post-op	14.8	14.6	–
Improvement	4.3±1.1	4.2±1.0	0.378
VAS score			
Pre-op	7.5	7.4	–
Post-op	2.1	2.3	–
Improvement	5.4±1.0	5.1±1.2	0.275
NDI			
Pre-op	45	44	–
Post-op	18	24	–
Improvement	27±5	20±6	0.021

Table 4: Progression of OPLL thickness (mm) in the procedures, (n=44).

Groups	Pre-op thickness	Post-op thickness	Progression (mean±SD)	P value
LP	5.0	6.2	1.2±0.3	0.017
LMF	5.1	5.6	0.5±0.2	

Table 5: Postoperative kyphosis and axial pain for both the procedures, (n=44).

Measure	LP group (%)	LMF group (%)	P value
Incidence of kyphosis (%)	32	14	0.038
Kyphotic change rate (%)	28	10	0.029
Incidence of axial pain (%)	14	27	0.043

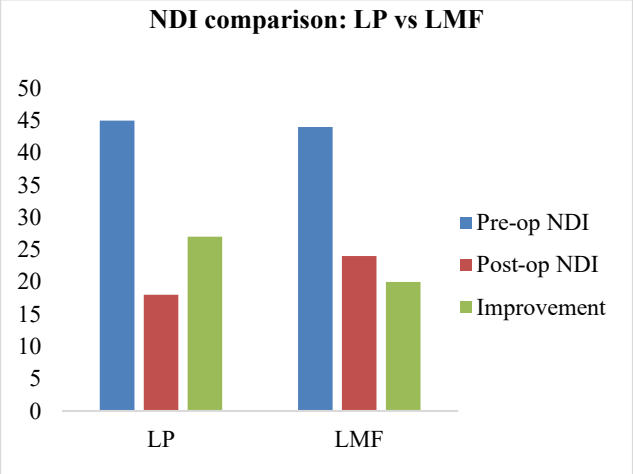

Figure 1: NDI improvement in both procedures, (n=44).

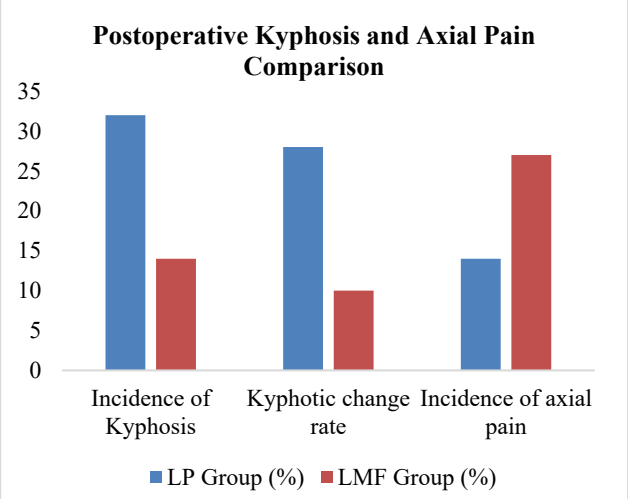

Figure 2: Postoperative kyphosis and axial pain for both the procedures, (n=44).

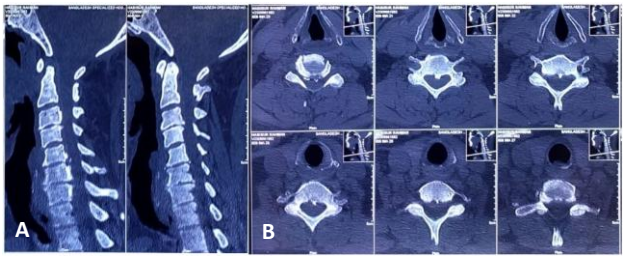

Figure 3 (A and B): Pre-operative CT scan of cervical spine (sagittal and axial section) showing segmental OPLL.

Figure 4: Pre-operative MRI of cervical spine (sagittal section) showing CCM.

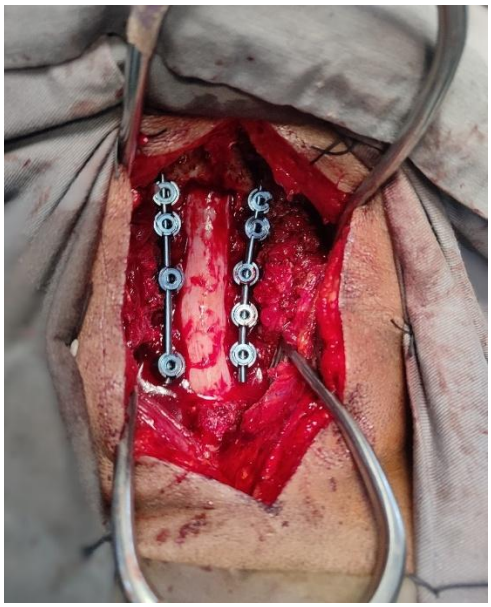

Figure 5: Per-operative picture showing laminectomy followed by instrumented fusion.

DISCUSSION

In this retrospective analysis of patients with multilevel cervical OPLL, both expansive open-door LP and LMF were found to be effective decompressive techniques. However, their respective strengths and limitations reveal distinct indications based on patient-specific anatomical and functional factors. LP demonstrated superior outcomes in preserving cervical lordosis and ROM, along with significantly less intraoperative blood loss and shorter operative times. These findings are consistent with several recent studies emphasizing the motion-preserving benefits of LP in cervical myelopathy patients without significant preoperative kyphosis or instability.[10] The reduced axial neck pain in LP patients further supports its application in relatively younger, active populations.[11] Nevertheless, the trade-off with LP includes a higher risk of postoperative kyphosis and progression of ossification. This is likely due to the continued motion and lack of stabilization post-decompression, as corroborated by prior biomechanical evaluations and longitudinal studies.[12] Notably, the progression of OPLL thickness was significantly more in the LP group, emphasizing the potential for disease recurrence or reoperation in the long term.

On the other hand, LMF provided better control over sagittal alignment and more effectively limited OPLL progression, likely attributable to segmental fixation and the elimination of micro-movements at decompressed levels.[13] However, this came at the cost of increased surgical morbidity, including more extensive blood loss, longer operation time, higher rates of axial pain, and reduced ROM—factors that can significantly impact postoperative recovery and patient quality of life.[14] Interestingly, both groups exhibited comparable improvement in JOA and VAS scores, suggesting that from a neurological decompression perspective, both techniques are efficacious.[15] This observation underscores the importance of tailoring surgical technique to the anatomical alignment and functional expectations of the patient rather than expecting substantial superiority in basic neurological outcomes.

The choice between LP and LMF should therefore be guided by cervical alignment, patient age, OPLL morphology, and the risk of kyphotic progression. Recent meta-analyses advocate for LP in patients with lordotic alignment and minimal instability, while LMF may be better suited for those with straight or kyphotic curvature or severe canal compromise.[16]

Limitations

As a retrospective analysis of consecutive cases, group differences and selection bias are unavoidable, particularly given the differing indications for LP and LMF. Additionally, neck muscle mass was not assessed, which may be relevant in understanding postoperative spinal alignment.

CONCLUSION

Expansive open-door LP is a less invasive and function-preserving surgical technique that provides satisfactory neurological recovery and improved quality of life in selected OPLL patients, particularly those with preserved cervical alignment and younger age. However, the risk of postoperative kyphosis and OPLL progression should not be overlooked. In contrast, LMF offers superior stability and suppresses OPLL progression, making it preferable in cases with cervical deformity or extensive ossification. A patient-centered approach, incorporating radiographic and clinical profiles, is essential to optimizing outcomes in cervical OPLL surgery.

Recommendations

Postoperative kyphosis appears linked to increased neck pain, especially after cervical LMF. For patients at risk of kyphotic changes, LP-due to its preservation of muscle-ligament structures-may be a better option in multilevel OPLL. However, in cases with extensive OPLL, LMF with screw fixation can help limit OPLL progression, despite its higher risk of C5 palsy. When using LMF, surgeons should be cautious about maintaining cervical alignment and consider extending fixation across the cervico-thoracic junction to minimize deformity risk.

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