Cervical surgery for ossification of the posterior longitudinal ligament: One spine surgeon’s perspective

Nancy E. Epstein

Chief of Neurosurgical Spine and Education, Winthrop University Hospital, Mineola, NY 11051, USA

E-mail: Nancy E. Epstein - nancy.epsteinmd@gmail.com

*Corresponding author

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Abstract

Background: The selection, neurodiagnostic evaluation, and surgical management of patients with cervical ossification of the posterior longitudinal ligament (OPLL) remain controversial. Whether for prophylaxis or treatment, the decision to perform anterior vs. posterior vs. circumferential cervical OPLL surgery is complex.

MR and CT Documentation of OPLL: Together, MR and CT cervical studies best document the full extent of OPLL. While MR provides the optimal soft-tissue overview (e.g. hyperintense signals reflecting edema/myelomalacia in the cord), CT’s directly demonstrate the ossification of OPLL often “missed” by MR (e.g. documents the single or double layer signs of dural penetration.

Patient Selection: Patients with mild myelopathy/cord compression rarely require surgery, while those with moderate/severe myelopathy/cord compression often warrant anterior, posterior, or circumferential approaches.

Operative Approaches: Anterior corpectomies/fusions, warranted in patients with OPLL and kyphosis/loss of lordosis, also increase the risks of cerebrospinal fluid (CSF) leaks (e.g. single/double layer sign), and vascular injuries (e.g. carotid, vertebral). Alternatively, with an adequate lordosis, posterior procedures (e.g. often with fusions), may provide adequate multilevel decompression while minimizing risk of anterior surgery. Occasionally, combined pathologies may warrant circumferential approaches.

Anesthetic and Intraoperative Monitoring Protocols: The utility of awake nasotracheal fiberoptic intubation/awake positioning, intraoperative somatosensory/motor evoked potential, and electromyographic monitoring, and the requirement for total intravenous anesthesia (TIVA) for OPLL surgery is also discussed.

Conclusion: Anterior, posterior, or circumferential surgery may be warranted to treat patients with cervical OPLL, and must be based on careful patient selection, and both MR and CT documentation of the full extent of OPLL.

Key Words: Cervical spine, neurodiagnostic testing, ossification posterior longitudinal ligament, surgery, patient selection
INTRODUCTION

In the article What You Need to Know About Ossification of the Posterior Longitudinal Ligament (OPLL) To Optimize Cervical Spine Surgery: A Review by the author, the intent was to provide a primary resource/reference for performing cervical surgery for OPLL. Every attempt was made to discuss the literature, while limiting “bias”. Here, however, in this editorial, the focus is on one individual surgeon’s approach to cervical OPLL, paying particular attention to patient selection, preoperative evaluation (e.g. MR/CT), and factors that contribute to operative planning.

Patient selection

Careful patient selection is critical to optimizing outcomes of cervical OPLL surgery. The various indications for cervical OPLL surgery typically include symptomatic myelopathy with significant radiographic findings (e.g. MR/CT). For patients with minimal/mild myelopathy and only mild cord compression on MR/CT studies (e.g. without increased cord signals), conservative management may be appropriate. For those with moderate/severe myelopathy and moderate/marked cord compression (e.g. with increased MR cord signal), surgery may reverse the myelopathic deficit, and/or prevent further neurological deterioration.

Confounding factors leading to unanticipated operative and non-operative choices

However, other confounding factors may lead to the adoption of otherwise unanticipated operative vs. non-operative choices. First, the nearly asymptomatic patient with marked cord compression and an increased cord signal may require “prophylactic” surgical decompression to avoid the risk of acute traumatic and irreversible deterioration (e.g. some studies cite this risk at 10%). Second, patients with severe/multiple comorbidities, even if at risk for acute quadriparesis/plegia, may not be appropriate surgical candidates. The medical contraindications to surgery may include patients on anticoagulants or anti-platelet aggregants for the following major risk factors; recent heart attacks (less than 6 months), acute/subacute strokes, coated stents (less than 6 mos-1 year), and mechanical heart valves (typically cannot be off anticoagulation for more than 1-2/few days), just to name a few. For many of these patients, spinal surgery cannot be safely performed unless anticoagulants/anti-platelet aggregants are held for a sufficient time both preoperatively and postoperatively (e.g. to avoid postoperative hematomas/wound dehiscence). Therefore, when some of these patients present for potential cervical OPLL surgery, even with rapidly evolving quadriparesis, the surgical benefits (associated with the patient’s multiple comorbidities) must outweigh the substantial risks. Knowing when to say “no” under these circumstances is perhaps even more critical than offering the “right” operation to the “right” patient.

Both MR and CT studies best document the full extent of OPLL

Obtaining both MR and CT documentation of cervical OPLL is critical. Together, they best document not only the 4 different forms of classic OPLL (segmental, continuous, mixed, other), but also serve to distinguish early OPLL (hypertrophied PLL, a precursor to classic OPLL) from disc disease. MR uniquely provides an overview of the cord, while specifically highlighting intrinsic cord changes (e.g. hyperintense signals in the cord consistent with edema vs. myelomalacia). Adding CT scans to the MR also alerts spinal surgeons that performing multilevel anterior cervical diskectomy/fusion (ACDF) for classic “other” OPLL or HPLL (e.g. found opposite the disc space and mimicking disc disease), may result in inadvertent tethering of the cord over residual retrovertebral disease, and result in ischemia, cord infarction, and paralysis.

CT more fully demonstrates extent of ossified OPLL

CT more fully demonstrates the extent of ossified OPLL, particularly regarding the degree of single/multilevel retrovertebral extension. It also readily documents whether there is dural penetrance based on the single (central OPLL contiguous with the posterior vertebral body, that is irregular and may be accompanied by a unilateral or bilateral C sign indicating dural imbrication) or double layer signs (hyperdense ventral vertebral body, hypodense dura, and hyperdense intradural OPLL mass). Notably, if patients with the double layer sign are approached anteriorly, they will likely sustain a CSF fistula (at least 25% or more of the time). Therefore, knowing that these signs are present may prompt surgeons to adopt a posterior surgical approach (if feasible based on additional criteria). However, if CT readily documents kyphosis, along with the MR, it may prompt the performance of an anterior corpectomy(s) rather than a posterior surgical approach.

Anterior cervical surgery

Originally, I was a major proponent for direct anterior resection of OPLL. However, at this point, I would reserve anterior surgery for patients with significant kyphosis, where multilevel disease is solely anterior, and will not be adequately decompressed with a posterior approach (e.g. lack of lordosis).

Dural penetrance/CSF leak anticipated with CT studies: Preoperative discussion

With the availability of both MR and CT studies, where one can more readily anticipate the risk of a CSF leak based on documentation of the single/double layer signs, clear preoperative discussions of this risk may be held with the patient/family. Additionally, careful consideration of the consequences of anterior CSF leaks may be entertained (e.g. prolonged intubation/tracheostomy, wound-peritoneal (WP) (low pressure), and
lumboperitoneal (LP) shunts). Preoperatively, as the CT signals the increased risk of a CSF fistula, the operating room may assemble the necessary shunting equipment in anticipation of this complication; e.g. a low pressure WP shunt, and LP shunt (with a horizontal/vertical valve). Furthermore, the patient may undergo preoperative preparation and draping of the anterior cervical wound, the right-side of the chest, and right side of the abdomen in anticipation of the need for the WP shunt.

**Operating microscope helps reduce the risk of an anterior cervical CSF leak**

Anterior cervical OPLL surgical procedures routinely require the use of an operating microscope. Better visualization is, therefore, afforded to both the surgeon and the assistant; this allows for easier identification of a dural plane underlying the OPLL if it exists. Diamond burrs should also routinely be employed to complete diskectomy or more typically corpectomies; cutting burrs are relatively contraindicated, as they are more difficult to control, and pose a greater risk of neural, dural, vascular, and esophageal injury. Once an adequate dural plane is identified under the microscope, dissection and removal of OPLL may carried out (typically cephalad to caudal if performed form the patient’s side left) utilizing 1-2 mm rotating Kerrison rongeurs. In order to define this dural plane, one should usually begin at the disc space cephalad to the OPLL mass. This is often a critical maneuver, as dissecting in the midst/middle of the OPLL mass leads not only to the failure to define a clean dural plane and thus incur a CSF leak, but may also result in direct/inadvertent cord penetration and/or injury to the anterior spinal artery. If you start the dissection cephalad to the OPLL mass, in most cases, a thin but extant dural plane will be evident; only a smaller number (e.g. 25%) of cases will have completely absent dura resulting in CSF fistulous formation.

**Treating an anterior cervical CSF fistula**

If a CSF leak occurs, attempts should be made to primarily suture the defect (very difficult typically due insufficient dural tissue), or to sew in a pericardial dural graft. Repair of the defect is most readily performed utilizing; interrupted 7-0 Gortex sutures (needle is smaller than the suture), medium microdural staples (1.4 mm), fibrin sealant, and microfibrillar collagen (care must be taken to avoid creating a compressive mass with the latter two).

**Two or three level corpectomies typically require posterior stabilization**

Two or three level corpectomies, unlike single level corpectomies, typically warrant immediate posterior stabilization. As noted in the review article, extrusion rates for two level corpectomies (9%) and 3 level ACVF (may approach 50%) are high, therefore warranting posterior fusion. Dynamic plates are also preferred to constrained (fixed) or semi-constrained (partially fixed) plates, as they allow for compression by limiting stress shielding (e.g. the screws migrate in the slots which range from a few mm in the shorter plates to nearly 10 mm in the longer plates), thus limiting the risk for graft/plate extrusion.

**Posterior cervical surgery**

Many older patients (e.g. over 65 years of age) do not readily tolerate anterior cervical surgery for OPLL. Their poor quality bone (osteopenia/osteoporosis noted both in males and females) results in high anterior cervical fusion failure rates. Therefore, if an adequate lordosis is present, posterior operations are better tolerated and more readily address multilevel disease.

**Positioning and performing posterior cervical surgery for OPLL**

Most posterior cervical procedures for OPLL are now performed prone (e.g. in the 1980’s and 1990’s often performed sitting, and required Dopplers and Central Venous Lines to Monitor for air embolism). This is readily accomplished with the patient positioned on bilateral chest rolls, with the head immobilized in a neutral position in a 3 pin Mayfield head holder. The operating microscope is typically brought into the field early during the posterior cervical exposure. The laminar levels for the fusion are first skeletonized (e.g. typically C2-T2 and confirmed with a lateral radiograph). Next, the levels designated for laminectomy are clearly identified and marked. A 33 mm diamond burr (electric Midas Drill) followed by a 4 mm diamond burr are used to thin down the laminae over the lateral gutters. Next, a 1 mm Kerrison rongeur is used to dissect caudal to cephalad (if starting on the left side of the patient). One begins the dissection at the most inferior disc space; dissection is then sequentially carried out working toward the most cephalad disc space. Once the laminar bone is removed, the yellow ligament (OYL) is next excised. This must be done extremely carefully, as often it is densely calcified/ossified/hypertrphied, and often adherent to the underlying dura and overlying shingled laminae. Once the left gutter is freed, similar dissection is carried out in the right lateral gutter by standing now on the right side of the patient, and working cephalad to caudal under the operating microscope. The latter maneuver has the additional advantage of removing the superior lamina before the inferior lamina; thus where there is marked laminar shingling, the superior lamina can be directly lifted away from the underlying inferior shingled lamina. This avoids inadvertent “digging into the dura/cord”. During the process of working cephalad to caudal on the right side of the canal, the sweetheart clamp(s) are also used to sequentially immobilize/gently “lift” the spinous processes away from the cord. Of note, in some instances where acute decompression occurs, and the cord rapidly re-expands, acute transient
dropout of the monitoring potentials may transiently occur (e.g. either MEP or SSEPs but typically not both). Although they typically recover within 15-30 minutes, acute resuscitative maneuvers should be immediately instituted; hyperoxygenate the wound with peroxide, raise the blood pressure, administer additional steroids (e.g. 1 gm of Solumedrol), and stop all further manipulation/dissection.

Posterior cervical OPLL surgery limits risk of CSF leak and vascular injury
Posterior procedures for cervical OPLL facilitate multilevel decompression without incurring the inherent added risks of anterior cervical surgery (e.g. reduced incidence of CSF leak and vertebral injury, carotid/jugular injury, esophageal injury/fistula/dysphagia, and others).

Awake fiberoptic nasotracheal intubation/positioning
Careful intubation of patients with cervical OPLL, avoiding undue flexion/extension is critical. For anterior cervical procedures, a nasotracheal fiberoptic (NT) intubation is optimal, as endotracheal (ET) intubation has the disadvantage of dropping the chin, and further limiting the room for an anterior exposure. Furthermore, if patients have to be kept intubated overnight/longer, they will better tolerate the NT tube. Alternatively, for posterior cervical approaches, fiberoptic nasotracheal or endotracheal anesthesia may suffice. Furthermore, in select instances, intubation may be safely performed utilizing the Glidescope (e.g. data show it also limits cervical flexion/extension thus limiting the risk for cord damage with intubation).

Intraoperative monitoring and total intravenous anesthesia
SEP monitoring
For years, only SSEP/EMG monitoring were available for cervical spine/OPLL surgery. In theory, SSEP monitors the posterior but not the anterior cord. However, in practice, SSEP changes (before we had MEPs) appeared to adequately signal many impending spinal cord injuries. Of interest, when we first started using SSEP/EMG for OPLL surgery, distraction applied prior to complete anterior resection of OPLL resulted in almost immediate SSEP loss. Shortly thereafter, following just a handful of cases, little/no distraction was employed prior to complete OPLL removal, and the majority of these SSEP changes disappeared.

Motor evoked potential (MEP) monitoring
MEP are now routinely available for intraoperative monitoring. They offer direct monitoring of the anterior cord, and they have added to the efficacy of intraoperative neural monitoring (IONM) in avoiding spinal cord injury (e.g. greater sensitivity and specificity). They are optimally utilized during all cervical procedures, and certainly for OPLL surgery whether performed anteriorly or posteriorly, and at single or multiple levels.

EMG monitoring
EMG monitoring has continued to be useful with OPLL surgery, particularly when performing any lateral decompression, either anteriorly or posteriorly, where there is root compression. When/if EMG changes occur, cessation of manipulation, hyperoxygenating the wound with peroxide, and cessation of dissection allows for most of these findings to rapidly resolve (e.g. over minutes).

Table 1: Pearls and pitfalls of cervical OPLL surgery

| Points | Recommendations |
|--------|-----------------|
| Obtain MR and CT | Show full extent of OPLL: MR-Soft Tissue: CT- Ossification/Calcification |
| Single or Double layer signs on CT | Assess risk of CSF fistula with anterior cervical surgery: Higher with the double layer sign. |
| Cervical kyphosis | Increases need for anterior surgery |
| Adequate lordosis | Increases need for posterior surgery |
| Intubation for anterior OPLL surgery | Awake nasotracheal fiberoptic intubation: 1. Avoids chin reducing exposure. 2. Better tolerated than endotracheal anesthesia |
| Intubation for posterior OPLL surgery | Awake nasotracheal or endotracheal intubation. 1. Caudad displacement of the chin; no influence. 2. Select use of Glidescope |
| Intraoperative neural monitoring (IONM) | 3 modalities:SEP EMG MEP |
| Anesthesia with IONM | TIVA: Total Intravenous Anesthesia |
| Anterior cervical surgery: Decompress all levels before grafting | First, decompress OPLL at all levels. Second, fuse levels after decompressions are completed. Avoid sequential decompression/fusion |
| Anterior cervical CSF fistula dural grafting and repair | Graft (Bovine Pericardium) vs. Primary Dural Suture Dural Repair 7-0 Gortex Sutures/1.4 mm Microdural Staples Wound-Peritoneal shunts (low pressure) Lumbo-Peritoneal shunt (horizontal/vertical valve) Anticipate CSF leak with preoperative preparation and draping of neck/chest, and right side of the abdomen |
| Using a microscope decreased risks | Allows better visualization surgeon/assistant decreases risk of CSF fistula/CSF leak decreases risk of cord injury |
| Identify normal dural plane cephalad to OPLL | Many single or double layer signs of OPLL are at the mid-vertebral levels, and dissection should start above this level (e.g find a clean dural plane at the cephalad disc space). |
Total intravenous anesthesia or the “Balanced Technique”
The use of TIVA is critical for adequately monitoring cervical OPLL surgery. Having the surgeon interact with the anesthesiologist and physiologist is critical. The better the team understands the surgical pathology, the better they will be equipped to determine whether intraoperative neural monitoring (IONM) changes are real or not (e.g. due to the introduction of inhalation agents, hypotension, or other factors), and how they should be addressed.

Medicolegal messages regarding OPLL surgery
There are several important medicolegal messages arising from cervical OPLL surgery [Table 1]. First and foremost, is the failure to perform a CT in addition to the typically available MR. Classic OPLL and certainly hypertrophied posterior longitudinal ligament (HPLL) appear hypointense on MR. Unless one is very familiar with the variety of appearances of OPLL on MR (e.g. hyperintense signal within the ligament, indicating active bone marrow production within Haversian canals, long stretches of hypointense ligament etc.), OPLL or HPLL may be missed. Failure to adequately diagnose the presence/extent of OPLL, and choosing, therefore, to perform multilevel ACDF (e.g. rather than corpectomies) may result in quadriplegia as the cord is stretched over residual retrovertebral OPLL/HPLL as the graft is inserted. Additionally, decompressing and fusion each level sequentially, when performing multilevel ACDF, will also tether and infarct the cord over the yet unresected OPLL. Furthermore, ACDF exposures are restricted, and may increase the risk of a CSF leak (e.g. failure to visualize the single or double layer signs of dural penetration on the preoperative CT) and intradural cord damage during OPLL surgery. Another advantage of obtaining a preoperative CT scan is that a separate neuroradiologist may note various other factors not originally picked up, including an aberrant vertebral anomaly with intracanalaricular extension; their warnings may also, therefore, help avoid an inadvertent vertebral artery injury.

SUMMARY
Cervical OPLL surgery, in general, should be performed in carefully selected patients with moderate/severe myelopathy and significant moderate/severe MR/CT documented cord compression. On occasion, however, patients with mild/moderate myelopathy but moderate/severe OPLL (MR/CT) including not only cord compression but also MR-documented hypointense cord signals may warrant “prophylactic surgery”. When cervical OPLL procedures are performed, awake NT intubation/positioning, under SEP, MEP, and EMG monitoring is optimal, and should be accompanied by TIVA anesthesia.