Cervical Ossification of the Posterior Longitudinal Ligament: Anterior or Posterior surgery

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Object:
Ossification of the posterior longitudinal ligament (OPLL) is a complex multifactorial disease process combining both metabolic and biomechanical factors, most commonly found in men, the elderly and Asian patients. There are many diseases. There are many diseases associated with OPLL, such as diffuse idiopathic skeletal hyperostosis, ankylosing spondylitis, and other spondyloarthropathies. Several factors have been reported to be associated with OPLL formation and progression, including genetic, hormonal, environmental, and lifestyle factors. However, the pathogenesis of OPLL is still unclear. Plain radiography, CT, and MR imaging are used to evaluate OPLL extension and the area of spinal cord compression. Management of OPLL continues to be controversial. Each surgical technique has some advantages and disadvantages, and the choice of operation should be made case by case, depending on the patient's condition, level of pathology, type of OPLL, and the surgeon's experience. In this paper, the authors attempt to review the incidence, pathology, pathogenesis, natural history, clinical presentation, classification, radiological evaluation, and management of OPLL.

Methods:
The authors performed a retrospective review of their institutional experience with surgical intervention for cervical OPLL. They also reviewed the English-language literature regarding the epidemiology, pathophysiology, natural history, and surgical intervention for OPLL.

Results:
Review of the literature suggests an improved benefit for anterior decompression and stabilization or posterior decompression and stabilization compared with posterior decompression via laminectomy or laminoplasty. Both anterior and posterior approaches are safe and effective means of decompression of cervical stenosis in the setting of OPLL.

Conclusions:
Anterior cervical decompression and reconstruction is a safe and appropriate treatment for cervical spondylitic myelopathy in the setting of OPLL. For patients with maintained cervical lordosis, posterior cervical decompression and stabilization is advocated. The use of laminectomy or laminoplasty is indicated in patients with preserved cervical lordosis and less than 60% of the spinal canal occupied by calcified ligament in a "hill-shaped" contour. However, it is subject to progressive kyphosis, expansion of the ossification, and limited neurological improvement.

Introduction

Ossification of the posterior longitudinal ligament is an important cause of cervical myelopathy that results from heterotopic ossification of the cervical or thoracic PLL. It has been estimated that up to 25% of patients presenting with cervical myelopathy have features of OPLL.[1] There has been considerable debate in recent years regarding the optimal surgi- cal approach for addressing these compressive lesions. Ventral approaches consist of variations of the cervical corpectomy, whereas dorsal approaches include a wide range of techniques including laminoplasty, laminecto- my, and laminectomy with instrumented fusion. With the evolution of surgical technique and a greater understand- ing of the biomechanics of cervical deformity, the criteria for selecting one approach over the other has been the subject of increased study.

Of the many factors to consider when deciding on either a dorsal or ventral approach, the degree of steno- sis related to the severity of ventral compression of the spinal cord by the ossified lesion is critical to decision making as patients with greater degrees of stenosis have historically shown less improvement following either dorsal or ventral surgery.[4-6] In this review, we discuss the epidemiology, natural history, and common radiographic findings associated with OPLL. The advantages and disadvantages of current treatment options, including anterior corpectomy, laminectomy, and laminoplasty are reviewed.

Patophysiology

The PLL (posterior longitudinal ligament) extends from the occiput to the sacrum along the posterior aspects of the vertebral bodies and the dorsal aspects of each intervertebral disc. As it becomes hypertrophied and ossifies, it results in a significant restriction of the cervical canal diameter. This compresses the spinal cord and leads to ischemia and myelopathy. In addition to this direct compression, repeated impacts of the ventral cord over the hypertrophied and ossified ligament can further lead to damage to the cord parenchyma.[2] The pathogenesis of OPLL remains poorly understood. There is some evidence that ligament cells from patients with OPLL have osteoblast-like characteristics.[3] Several factors have been reported to be associated with OPLL formation and progression, including genetic, hormonal, environmental, and lifestyle factors. However, the pathogenesis of OPLL is still unclear.

Biomechanical Considerations

Determining which surgical approach will best achieve the goals of decompression while preserving regional sagittal balance requires an understanding of biomechanics and a consideration of the preexisting deformity. Although there are insufficient clinical data to suggest that correction of any preexisting deformity improves out- comes associated with OPLL, there are retrospective data indicating that patients who undergo dorsal procedures without instrumentation may worsen neurologically as a result of progressive kyphosis.[8] With regard to OPLL, the presence of a compressive lesion ventral to the spinal cord increases the risk of neurological deterioration during any attempt at deformity correction, particularly if a dorsal procedure is planned. For this reason, careful assessment of the presurgical sagittal alignment and the occupying volume of the ossified mass are critical to selecting the best approach as correction of deformity may not always be feasible without significant morbidity.

Cervical kyphosis may be the result of iatrogenic de- stabilization, trauma, degeneration, and systemic inflammatory diseases. However, it is most commonly observed after multilevel dorsal decompression, with rates of clinically significant kyphosis as high as 21%.[6,10]

If a kyphotic deformity is present, a flexion moment is created with the head pitched forward relative to the normal alignment of the cervical spine.[2,3] This abnormal posture shifts the normally neutral axial force of the head ventral to the instantaneous axis of rotation, thus creating a flexion bending moment. This leads to further kyphosis.[,5] Thus, a vicious cycle of abnormal forces and progressive deformity is created.[2,3,6] If kyphosis becomes severe, the spinal cord may stretch over the apex of the deformity and lead to further neurological decline.[5]

Pathology

OPLL is believed to form through endochondral ossification. McAfee et al. described the histopathology of OPLL, which is composed largely of lamellar bone with mature Haversian canals. Ultrastructural study of the ligamentum flavum in patients with OPLL revealed atrophic elastic bundles with a 2-layer structure, disappearance of microfibrils, irregular alignment of collagen fibrils, and many extracellular plasma membrane-invested particles that resemble matrix vesicles.

Pathogenesis

The pathogenesis of OPLL remains poorly under- stood. There is some evidence that ligament cells from patients with OPLL have osteoblast-like characteristics. Ishida and Kawai41 studied cell lines from nonossified sites in patients with OPLL and found that they have high alkaline phosphatase activity, response to calcitonin, and calcitriol. Parathyroid hormone and dinoprostone can also stimulate an increase in cyclic adenosine monophos- phate in these cell lines. There are many proposed genetic, hormonal, environmental, and lifestyle factors that relate to pathogenesis and progression of OPLL, but most of these theories are still controversial.

An immunohistochemical study of extracellular matrix components in the twy (tiptoe walking Yoshimura) mouse, an animal model for the study of OPLL, shows that degeneration and subsequent herniation of the nu- cleus pulposus is the potent regional factor that initiates OPLL formation. At 14 weeks, the discs herniated into the thickened posterior longitudinal ligament, then cartilaginous tissue appeared in the posterior longitudinal ligament as if to repair the intervertebral disc degeneration.

Hypertrophy of the posterior longitudinal ligament is believed to be an early stage of OPLL. Histological and biochemical study of hypertrophy of the posterior longi- tudinal ligament shows hyalinoid degeneration, proliferation of chondrocytes and fibroblast-like spindle cells, infiltration of vessels and small ossification, and staining by BMP, TGF-b, and proliferating cell nuclear antigen, which are all similar to OPLL.

Classification

The Investigation Committee on OPLL of the Japanese Ministry of Public Health and Welfare described the OPLL classification that is most widely used in the literature. Based on lateral plain radiography, cervical OPLL can be classified into 4 types (Fig. 1): continuous, segmental, mixed, or circumscribed type. Continuous type is classified as a long lesion extending over several vertebral bodies. Segmental type is classified as one or several separate lesions behind the vertebral bodies. Mixed type is classified as a combination of continuous and segmental types. Circumscribed type is classified as the lesion mainly located posterior to a disc space.

Clinical Presentation

The prevalence of OPLL has been shown to be higher in East Asian countries, most significantly in Japan (1.9%–4.3%), Korea (3.6%), and Taiwan (2.8%). The prevalence of OPLL in the North American Caucasian population has been reported as only 0.12% historically,[4] but more recently, Epstein[1] has reported that as many as 25% of patients who present with cervical myelopathy have some evidence of OPLL. Clinical presentation of OPLL depends on the size of the OPLL, spinal canal diameter, and range of motion of the spine. Some patients have no symptoms, but others present with neurological deficits such as radiculopathy, myelopathy, and in severe cases, bowel and bladder symptoms. The onset of symptoms is usually gradual, but there are also some reports of patients with trauma-induced sudden onset myelopathy.

Imaging

Based on lateral plain radiography, cervical OPLL can be classified into 4 types (Figure 1): continuous, segmental, mixed, or circumscribed type. Continuous type is classified as a long lesion extending over several vertebral bodies. Segmental type is classified as one or several separate lesions behind the vertebral bodies. Mixed type is classified as a combination of continuous and segmental types. Circumscribed type is classified as the lesion mainly located posterior to a disc space.

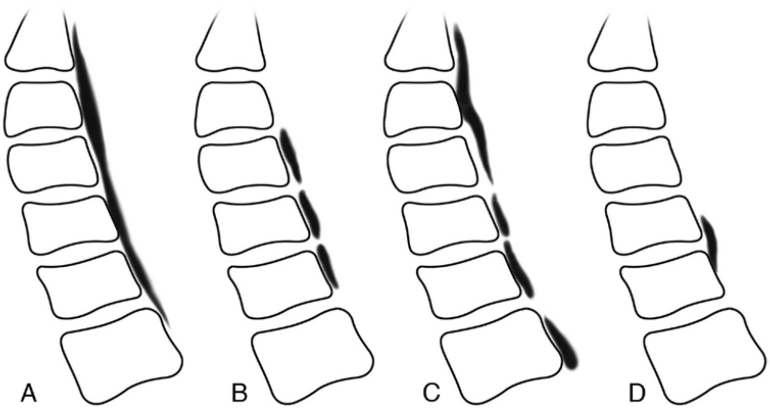

Figure 1. Illustrations of the 4 types of OPLL: continuous (A), segmental (B), mixed (C), and cicumscribed (D).

Plain radiography is the simplest method for detecting OPLL but it has some limitations. Computed tomography and/or myelography are useful tools for detecting and accurately locating OPLL. The exact dimensions and extent of cervical canal stenosis are precisely depicted on CT. Figure 2 shows CT scans of patients with OPLL. A mushroom or hill shape on an axial CT scan typifies OPLL, and a sharp radiolucent line between the posterior vertebral body and ossified ligament is also characteristic feature.[6]

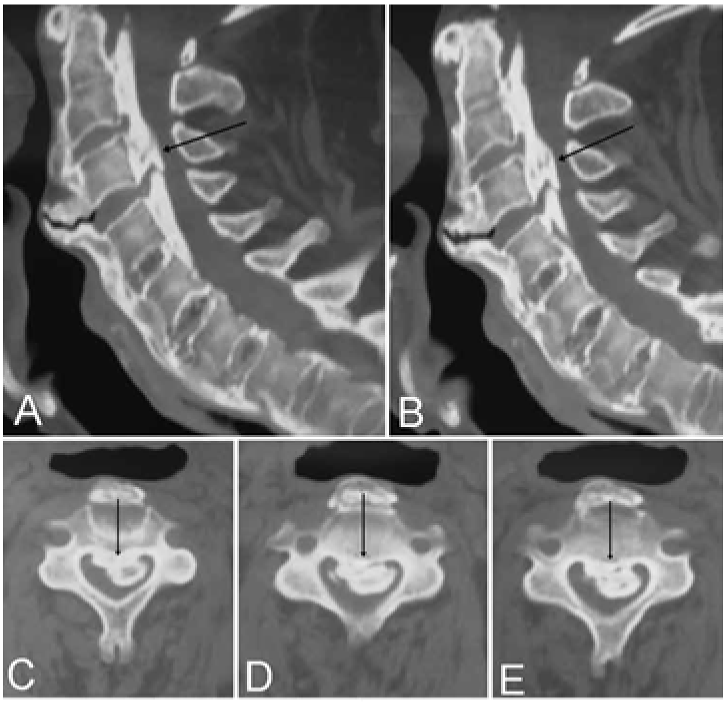

Figure 2. Computed tomography scans showing OPLL in different locations.

On MR imaging, early OPLL appears dorsal to the interspaces and can be seen on axial and sagittal views. As the disease progresses, the dense signal behind the vertebral bodies and interbody spaces becomes hypointense on all MR imaging sequences. However, in the progressed disease, there are smaller areas of increased signal. These areas are indicative of new bone formation within the ligament. In addition, OPLL does not enhance with Gd. Thus, on enhanced MR images, it is possible to differentiate between a hypertrophied ligament and postoperative scarring. Associated changes in the spinal cord may be seen on T2-weighted imaging in association with OPLL. This includes areas of increased T2-signal associated with cord edema.

Radiographic Criteria for Approach Selection

The criteria used to select either a dorsal or ventral approach should be based on a number of factors including patient age, comorbidities, severity of symptoms, previous surgery, type of OPLL, extent of OPLL, degree of stenosis, surgeon preference, and assessment of cervical deformity.

Various radiographic schemes have been proposed to help select the best approach for patients with cervical myelopathy. Gwinn et al.14 proposed a simple straight-line method to measure effective spinal canal lordosis in patients with cervical myelopathy. In this scheme, a straight line is drawn from the dorsal-caudal aspect of the C-2 VB to the dorsal-caudal aspect of the C-7 VB (Fig. 1). Effective lordosis is maintained if no ventral bone structure such as VBs, disc-osteophyte complexes, or hypertrophic calcifications project dorsal to this line. Otherwise, effective lordosis is considered lost (Fig. 2). This straight-line method of assessing cervical lordosis was compared with traditional methods of measuring cervical alignment including the Cobb and dorsal tangent methods. It was found to be a reliable indicator of overall alignment of the cervical spine as well as compression ventral to the spinal cord. It is proposed that this loss of effective lordosis due to the presence of a compressive mass may have a role in determining the best surgical approach as ventral surgery may better achieve decompression in these patients. In 2008, Fujiyoshi et al. proposed a new concept for decision making regarding the surgical approach for cervical OPLL. They introduced a new index called the K-line to help determine the effectiveness of a dorsal approach. This line was defined as a line on a lateral radiograph drawn between the midpoints of the spinal canal at C-2 and C-7. According to this line, 2 groups of patients with OPLL were identified. In the K-line (+) group, the OPLL lies ventral to the K-line. In the K-line (-) group, the OPLL passes the line and lies dorsal to the line. In their series, 27 patients with myelopathy as a result of OPLL underwent either laminoplasty or laminectomy with instrumented fusion. Intraoperative ultrasonography was also used to evaluate the dorsal shift of the spinal cord from the OPLL. The relationship between the dorsal shift of the spinal cord and the K-line classification was made. Clinical outcomes were assessed using the JOA scores before surgery and at 1 year after surgery.

Fig. 1. In this digital radiograph, the line drawn from the dorsal cau- dal aspect of C-2 to the dorsal caudal aspect of C-7 is used as a ref- erence to measure effective cervical lordosis. In this image, effective spinal canal lordosis is maintained, as no bone from the VBs or disc space is projecting dorsal to the line.

Overall, statistically significant improvement in JOA scores was found in the K-line (+) group. Complications and neurological worsening were not reported. Based on these findings, Fujiyoshi et al. proposed that patients with cervical OPLL that extend dorsal to the K-line have a better chance for neurological improvement with a ven- tral approach, but no patients were studied to support this recommendation. Based on their outcomes and correla- tion with intraoperative ultrasound, it is their assertion that K-line (-) patients have kyphosis that prohibits a dor- sal approach as the spinal cord has less potential to shift following decompression.

Management

Nonoperative management of OPLL.

Nonoperative management of OPLL is reserved for patients who have few neurological symptoms or for those whose overall medical health precludes them from surgical treatment. Pharmacological pain management with the guidance of multidisciplinary pain specialists is recommended. Nonsteroidal antiinflammatory medications and steroid injections are the mainstays of nonoperative therapy. Unfortunately, despite the inflammatory nature of the disease, there have been few pharmacological advances in the specific antiinflammatory agents designed for OPLL, as compared with other inflammatory disease such as rheumatoid arthritis or ankylosing spondylitis. The most common location of OPLL is at the cervical spine. There are several reports of surgical management of cervical OPLL with options including the posterior approach (laminectomy, laminectomy with fusion, laminoplasty, and open-door and double-door laminoplasty), the anterior approach (ACDF, anterior cervical corpectomy with fusion, open-window corpectomy, oblique corpectomy, skip corpectomy, and anterior decompression via a trans- vertebral approach), and the combined anterior and posterior approach. The advantages and disadvantages of each approach are summarized in Figure 3.

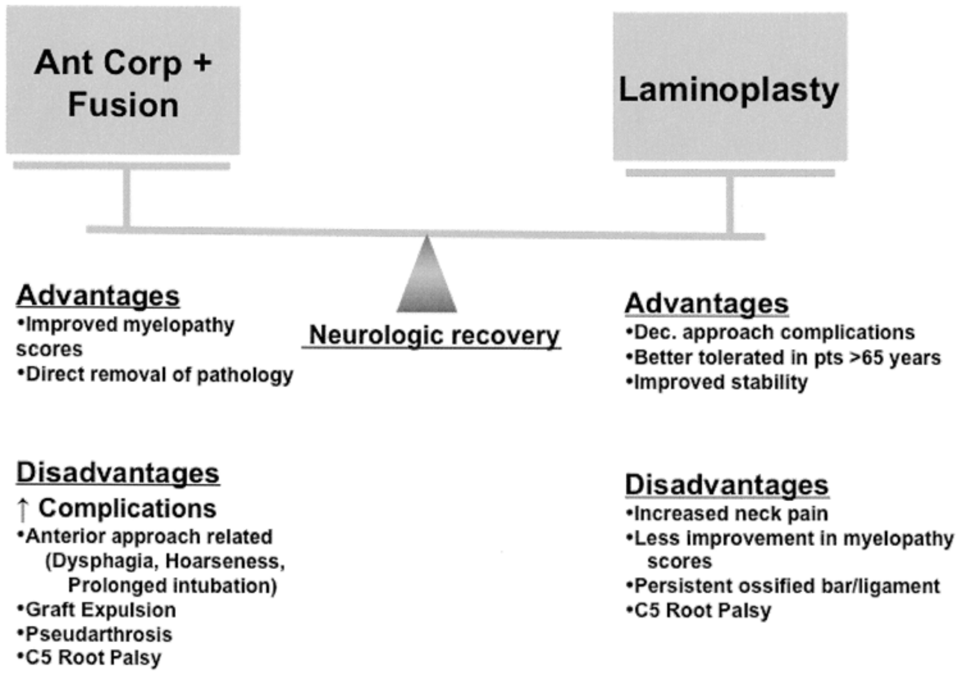

Figure 3. Advantages and disadvantages of anterior versus posterior techniques for decompression in OPLL.[10]

Surgical Management of OPLL

Patients with OPLL commonly present with symp-toms in their 40s or 50s. This commonly begins with symptoms of numbness or axial neck pain. Without surgi-cal decompression, symptomatic OPLL tends to progress with time. In a long-term follow-up study, Matsunaga et al. demonstrated that 38% of patients presenting with baseline myelopathy had progressive worsening of their symptoms. Ossification of the PLL has been addition-ally found to progress following decompression as well as during routine radiographic follow-up in the patient in whom decompression has not been performed. For these reasons, especially for younger patients without es-tablished deficits, it is our practice to obtain strict radio-graphic follow-up. In patients with progressive deficits, including severe weakness or myelopathy, surgery is con-sidered. Like other authors, we believe that older patients with significant comorbid conditions and severe, long-standing deficits may be poor surgical candidates.[10]

Anterior Cervical Corpectomy and Fusion

The majority of patients with OPLL present with multilevel cervical disease that often requires extensive decompression. Some controversy persists regarding the most appropriate method for treating cervical compression and myelopathy in these patients. Some authors argue that since the ossification in cases of OPLL remains ventral to the spinal cord and can continue to progress after surgery, posterior decompression fails to prevent "hill-shaped" and massive ossification in the years after a successful posterior decompression. Furthermore, clinical myelopathy scores have been shown to improve most significantly with ACC. Several studies have shown better outcomes following anterior rather than posterior decompression for OPLL.[7] Fessler et al.[8] found that patients treated by an anterior approach had an average improvement of 1.24 Nurick grades when compared with laminectomy patients who only improved by 0.07. In addition, laminectomy and fusion or laminoplasty is not appropriate in patients with poorly preserved cervical lordosis.

Posterior Cervical Approaches

Cervical laminectomy and decompression can often be augmented by lateral mass fusion to correct instability or to prevent loss of future sagittal alignment. Laminoplasty is also offered as an alternative to lateral mass fusion. In patients undergoing posterior decompression surgery, there should be evidence of preoperative cervical lordosis of at least 10° and less than 7 mm of anterior-posterior OPLL for indirect decompression to be successful.[9] The most significant advantage of a posterior approach is that it avoids the potential soft-tissue complications of the anterior approach. Furthermore, there is no risk of graft extrusion, but there is a decreased incidence of postoperative pseudarthrosis. However, posterior decompression should be avoided in patients with a kyphotic alignment, spondylolisthesis, suggested instability, or high disc spaces.

Conclusion

OPLL is a common cause of myelopathy in Asian populations. While the pathogenesis of this disease is still unclear, genetic, hormonal, environmental, and life- style factors are believed to cause OPLL formation and progression. Occurrence of myelopathy in patients with OPLL is related to both static and dynamic factors. Radiological evaluation of OPLL includes plain radiography, CT, and MR imaging. Surgical management of OPLL remains controversial; each approach has its own limitations, advantages, and disadvantages. The choice of operation should be made on a case by case basis, depending on the patient's condition, level of pathology, and type of OPLL, as well as the experience of the surgeon.

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