Clinical Factors that Predict the Surgical Outcome of Ossification of Ligamentum Flavum of Spine – Series of 31 Cases

S. John Christopher[1], M. Chockaiah Raja[2], Heber Anandan[3]

ABSTRACT

Introduction: Ossification of the Ligamentum Flavum (OLF) is a pathological ailment that affects the ligament and causes slowly progressive myeloradiculopathy in adults. Current study aimed to find out the Radiological and Pathological factors that are predictive of the surgical outcome of patients with OLF.

Material and Methods: A prospective study of 31 patients studied for radio-pathological factors: number of segments affected by OLF, Sato's CT–based classification, and the presence of intramedullary hyper-intensity on T_2w MRI and CPPD Crystal deposition (pseudogout). All cases underwent decompressive laminectomies. Specimen sent for Polarized-light microscopic studies and analyzed for characteristic rod-shaped, birefringent CPPD crystals. Follow up done with a mean duration of 5 months. Recovery rate was calculated with pre-op and post-op "Modified JOA" scoring system.

Results: Recovery was Excellent in 10 cases, Good in 6 cases, Fair in 12 cases, Poor in 3 cases. The author conducted a review of literature in English, Japanese and Korean literature and compared their studies.

Conclusion: Early and correct diagnosis is required to avoid poorer results. Long-term follow up needed to determine the factors that predict the surgical outcome. This study also shows how this disease is highly under-reported in India

Keywords: Ossification of Ligamentum Flavum, Modified JOA Score, CPPD Crystals, *Sato's* Classification, Pseudo Gout, Prognostic Factors

INTRODUCTION

Ossification of the Ligamentum Flavum (OLF) is a pathological ailment that creates myelopathy, radiculopathy or both in a patient. It is comparatively prevalent in the Japanese population compared to that in American or European people. However, nowadays it has been reported from other areas also, especially from Asian countries. It has been highly underreported in India.[1] The causes of hypertrophy and Ossification of the Ligamentum Flavum is yet to be learned, but a relationship with ossification of the posterior longitudinal ligament (OPLL) or scattered idiopathic skeletal hyperostosis (DISH) has been found.[2] Microscopic verdicts in OLF specimens revealed an overgrowth of Type II collagen managing the development of ossification. There was also a decrease in the quantity of elastin (picture 2). OLF was proved to be essentially enchondral ossification. Additional intramembranous ossification was, however, seen at the tip of the nodule-shaped ossification.[3] Ossification stretched beside the superficial layer of the hypertrophied ligament, as in OPLL. It was recommended that the mechanism of OLF progress depends closely not only on dynamic and static mechanical stresses but also on the role of some growth factors as well. OLF can be diagnosed by lateral radiographs, manifesting as ossification of the spinal foramen (Picture 3). When matching the reduction of the spinal canal as seen by computed tomography (CT) or magnetic resonance imaging (MRI), the CT scan may give knowledge superior to that of MRI because it shows accurately the areas where there is protruding ossification from the posterior to the anterior aspect of the spinal canal.[4]

Historically, OLF was first observed on lateral radiographs (Picture 3(a) Lateral radiograph shows oval nodular masses in the posterior spinal canal a the C3-C4 and C5-C6 levels. 3(b) Sagittal T1 weighted MRI shows a round area of very low signal intensity at the corresponding location that indents the posterior aspect of the spinal cord at the C5-C6 level. Intervertebral disc herniation is also seen at C4-C5 level.) and reported by Polgarin 1920. In 1938, Anza described the first case with neurological symptoms and identified OLF in a specimen removed during the operation. Oppenheimer also mentioned OLF on plain radiographs in diffuse idiopathic skeletal hyperostosis and ankylosing spondylitis. He considered that such Ossification might be qualified for a radicular neuropathy. In 1960 Yamaguchi et al. described an operative case with severe myelopathy; Koizumi, Yanagi, and Nagashima subsequently stated similar cases.[5-8]

Maximum cases of OLF happen in the thoracic spine, particularly the lower third of Thoracic or the thoracolumbar spine; OLF rarely occurs in the cervical spine (figure 1-3). Because thoracic spinal canal stenosis occurring in thoracic myelopathy or radiculopathy has been seen recently, OLF is now identified as a clinical entity making thoracic myelopathy exposing as OPLL and spondylosis. When OLF

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was thought a relevant factor in patients with herniated thoracic discs, the surgical outcomes were weaker than those in patients without OLF. However, outside Japan, unlike OPLL in the cervical spine, thoracic myelopathy secondary to OLF is seldom neglected or misdiagnosed as degenerative overgrowth by the posterior spinal portion consisting of the superior articular processes.[9] This error occurs from a lack of knowledge about this pathological condition. OLF has been seen as a composite lesion because of the sequence of ossification of the spinal ligaments with hyperostotic changes. Small degrees of OLF may be considered a degenerative transformation, as its incidence in radiographic studies of the spinal columns of aged persons has ranged from 4.5% to 25.0%. It has been suggested that the mechanism of hypertrophy, overgrowth, and progression of ossification of the ligaments plays a vital role in the pathological process of myelopathy. Study aimed to identify clinical factors that is predictive of the surgical outcome of patients with OLF.

MATERIAL AND METHODS

This was a prospective study, which was done on patients suffering from Ossified Ligamentum Flavum of Spine. This study was conducted over the period from February 2013 to February 2016. Due clearance was obtained from the ethical committee of Government Rajaji Hospital and Madurai Medical College, Madurai before this study. Exclusion criteria: Patients with significant anterior compressive lesions causing thecal sac indentation and also those patients with spondylotic compressive myelo-radiculopathy.

Thirty-one patients consecutively diagnosed with Ossified Ligamentum Flavum of Spine with Myelopathy. They were diagnosed on the basis of clinical Examination, Radiological Imaging and Histopathological Confirmation. All the surgeries were done at the same Operation theatre in Government Rajaji Hospital, Madurai

Following data were collected; Age, Gender, Level of the Spine involved, Coexisting other spinal disorders, Duration of symptoms, Preoperative modified JOA neurological score.

RESULTS

During the period from Feb 2013 to Feb 2016, following 31 patients who underwent surgical management, were analyzed for these following six clinical factors and their significance in predicting the outcome of surgery. Mean age of these patients were 50.1 years with range of 19 to 70 years, and standard deviation of 12.2 years. 48% of these patients were above 50 years of age as shown in figure 4.

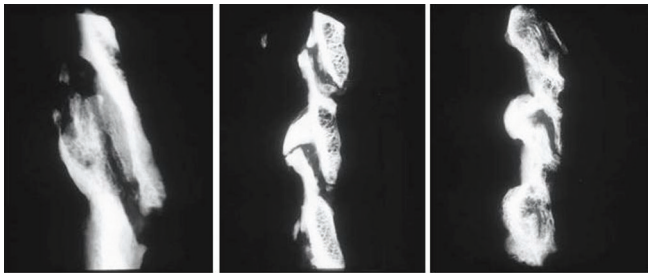

Figure-1: Development of Ossification of Ligamentum Flavum

Among these 31 patients, 24 were male patients comprising 77.4% of cases and 7 were female patients comprising 22.6% of cases.

Patients were grouped according to the level of spine involvement. Cervical spines were involved in 10 cases (32%) and dorsal spines were involved in 21 cases (68%). None of the case involves lumbar spine as shown in figure 5. Co-existing other spinal disorders like Ossified posterior longitudinal ligament, facetal hypertrophy, disc prolapsed were analyzed whether it predicts the surgical outcome in these cases. It was positive in 72% of cases and negative in 28% of cases as shown in figure 6.

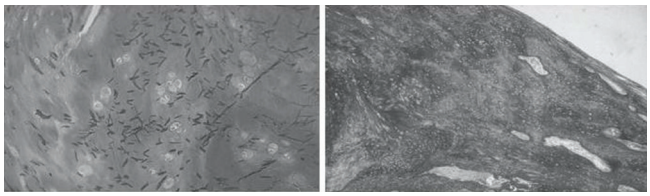

Figure-2: Photomicrograph of Ossification of Ligamentum Flavum

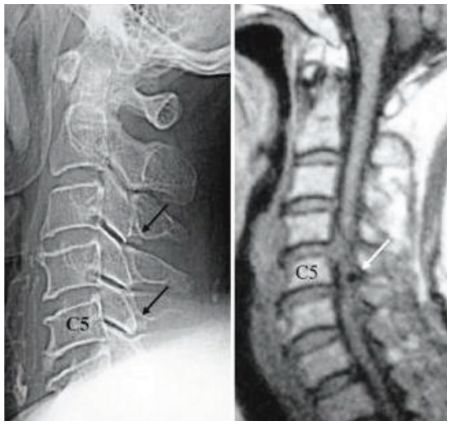

Figure-3: OLF in a 74 years old women

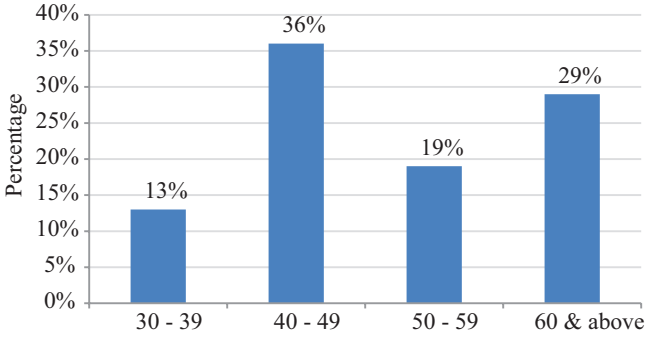

Figure-4: Patient Age distribution

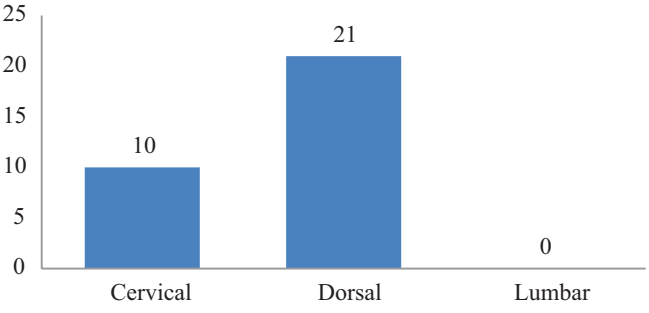

Figure-5: Spinal Level of OLF

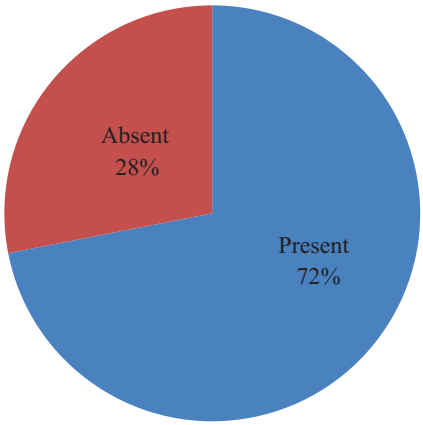

Figure-6: Co existing other Spinal Disorders

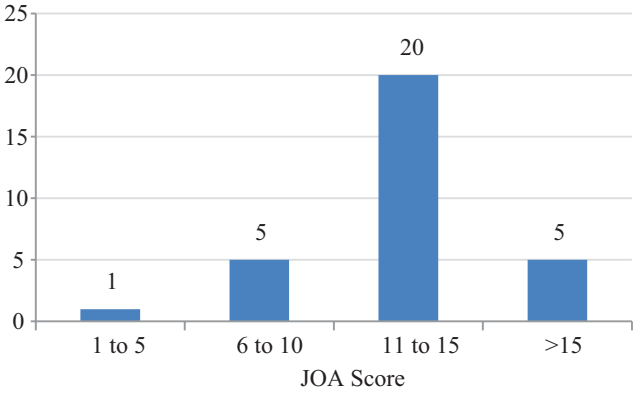

Figure-7: Pre op Modified JOA Score

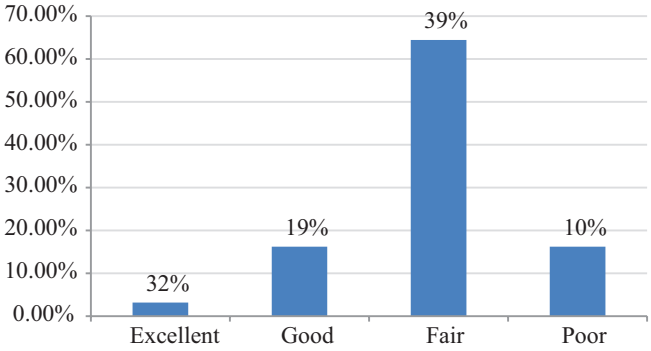

Figure-8: Recovery from symptoms - Types

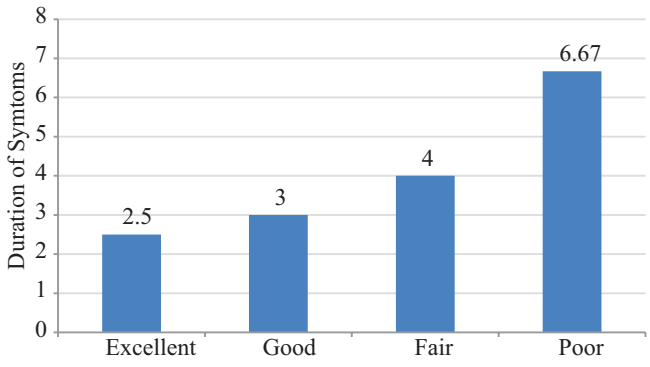

Figure-9: Recovery and Duration of Symptoms

The most common initial symptom was a tingling sensation, numbness, or pain in the lower extremities, which was present in 49% of the patients. Twenty-five percent of patients

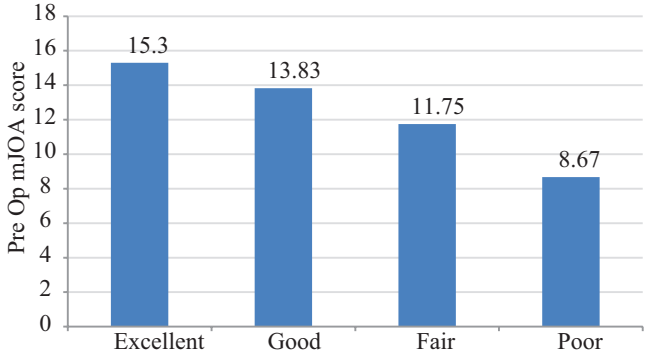

Figure-10: Recovery and Preoperative modified JOA neurological score

complained of gait disturbance due to lower-limb weakness or spasticity, and 11% complained of back pain. The mean preoperative duration of symptoms was 3.5 months, with the range of 1 to 8 months and standard deviation of 1.8 months. Out of Total 31 cases; up to 4 months are 16 cases (51.6%), 4 to 6 months are 14 cases (45.2%), more than 6 months is 1 case (3.2%)

Using "modified Japanese Orthopedic Association" scoring system which has the maximum score of 18, each patient's pre and post-operative neurological deficit was measured. Range was 4-17, mean 13 with standard deviation 2.89. They are group into 4 as in figure 4.

Recovery rate from symptoms was calculated using the following formula;

Recovery Rate (%) =

$$\frac{\text{(Post operative mJOA Score – Pre operative mJOA score)}}{\text{(11 – Pre operative mJOA Score)}}$$

Based on the results the patients were grouped into 4 types of Recovery. They are Excellent (>75%), Good (50%- 75%), Fair (25% - 50%) and Poor (<25%) as shown in figure 8.

All the patients were followed up post operatively at OPD. Out of 31 patients, 14 cases (14%) for less than 3 months, 15 cases (48%) for 4 to 6 months, 1 case (3%) for 7 to 12 months and 1 case (3%) for more than a year done. Only short term follow up were possible for most cases. We need to continue the follow up for longer term for more accurate prediction of surgical outcome for OLF of Spine.

Relationship between Recovery and Clinical Factors

All the above six clinical factors analyzed were statistically evaluated and determined whether it has significant influence in predicting the surgical outcome of OLF of Spine. The results were as follows

1. Recovery and Age of the patients; p value - 0.5509; Not Significant
2. Recovery and Gender of the patients; p value - 0.4606; Not Significant
3. Recovery and Level of the Spines involved; p value 0.5696; Not Significant
4. Recovery and Coexisting spinal disorders; p value - 0.4676; Not significant
5. Recovery and Duration of symptoms; p value - 0.0062; Significant as shown in figure 9.

6. Recovery and Preoperative modified JOA neurological score; p value - 0.0011; Significant as shown in figure 10

Above statistical analysis results shows that among the six Clinical Factors, that likely to predict the Outcome for surgery for OLF spine are duration of preoperative symptoms and pre-operative neurological score.

DISCUSSION

Development of OLF

In most OLF cases, the initial changes in the Ligamentum Flavum occur at the site of attachment of the caudal portions (figure 1), and ossification extends from the lateral aspect to the center along the superficial layer of the hypertrophied Ligamentum Flavum and then above to the anterior parts of cephalic portions. Ossification of the cephalic portions progresses to the caudal portions, and hyperostosis of the pedicle occurs, resulting in nodular formations. However, the cephalic and caudal parts of OLF never unite completely in the intervening space, even in specimens with thickened nodular OLF in the fibrocartilaginous matrix.

Histopathology of the Ligamentum Flavum

Anatomically 20, the ligamentum flavum exists in the interlaminar space and supporting tissue, forming part of the posterior wall of the spinal canal. The Ligamentum Flavum has two portions at each intervertebral disc level: the central (inter-laminar) and lateral (capsular) portions. The average composition of the fibers is 80% elastin and 20% collagen, as described by Yong-Hing et al.[10] This composition changes with age, however, and it has been reported that collagen increases in relation to decreasing elastin (Figure 2). The bony attachment of the Ligamentum Flavum is a Four-layered structure, the enthesis, as described by Niepel and Sitaj.[11] The four layers are the ossification layer, calcified cartilage, non-mineralized cartilage, and ligament. The enthesis also occupies a key position in the pathological process of the diseases or so-called enthesopathy. It is well known that the enthesis has a rich vascular supply, highly active metabolism, an ample and specialized nerve supply, and a few scattered fibrocartilage cells with reserved activity, among other structures. With aging, small osteophytes develop in the Ligamentum Flavum at the ligamento-osseous junction (enthesis), which shows marked intraligamentous calcification, swelling, and hyalinization of the collagen fibers, the appearance of fibrocartilagenous cells, and a reduction in the elastic fibers (Figure 2). It is thought that this small OLF is a degenerative enthesophytes that developed from the enthesis

Differentiation between Degenerative Osteophytes and OLF

To understand the cause of the overgrowth of cartilaginous tissue that precedes the development of OLF, we investigated the changes in the enthesis of the Ligamentum Flavum immunohistochemically using type-specific human monoclonal anti-collagen antibodies I-VI. Collagen types I, Ill, and VI were found in the unossified ligaments. Type II collagen was demonstrated only in the ossified cartilage and non-mineralized cartilage layers of the enthesis (Figure 2). There was no significant difference in the width of the ossified cartilage layer, but the difference in the width of the non-mineralized layer between the OLF group and the controls was substantial.

Active production of type II collagen by the chondrocytes was revealed in the hyperplastic extracellular matrix. Therefore, it was thought that proliferation of type II collagen at the enthesis resulted in the formation of a hypertrophied ligament before it developed into OLF.[12]

Pathology of Ossification of the Ligamentum Flavum

The OLF extended along the superficial layer of the hypertrophied ligament, as in OPLL. However, numerous fibro-cartilaginous cells with abundant matrices including type II collagen were seen more abundantly in OLF than in OPLL. At the transitional areas adjacent to the ossified areas, there were various morphological phenomena: irregular arrangement of the fibrous structures; abundant collagen fibers; irregular, ruptured, and fewer elastic fibers; numerous cartilage cells; calcified tissues; premature ostens; and proliferating vessels. These characteristic histological findings suggest that numerous Fibro cartilaginous cells existed in the abundant collagen fibers and produced a large amount of type II collagen. Thus, the developmental mode of OLF was confirmed to be mainly endochondral ossification. The accompanying hypertrophic cartilaginous proliferation, however, showed additional intramembranous ossification at the margin of the thickened OLF.[13]

Factors Related to the Development of Ossification

Role of Mechanical Stress

When considering the mechanism of ossification development, the theory states that both dynamic and static mechanical stresses act as local factors in the development of OLF under a general ossifying diathesis. Yamazaki et al. described disc degeneration and vertebral wedging acting as local factors that increase the tension of the Ligamentum Flavum. They, therefore, indicated that localized mechanical stress that affected the Ligamentum Flavum was a contributing factor to ossification development.[14] Anatomically, the Ligamentum Flavum in the thoracic region is subjected to static stress continuously, and it is greater in flexion than in extension. Therefore, it is thought that the development of OLF depends on mechanical stress. However, the formation of the ossified tissue at the enthesis (enthesopathy) is self-limited, and massive ossification is uncommon. OLF is therefore due to something more than enthesopathy.

Role of Growth Factors

Growth factors are believed to be important in the pathogenesis of the ossification of both the posterior longitudinal ligament and the Ligamentum Flavum. Bone morphogenetic proteins (BMPs) and transforming growth factor-β (TGF-β) may have important roles in the pathogenesis of OPLL and OLF. BMPs initiate cartilage and bone differentiation and induce new cartilage and bone formation in vivo, whereas TGF-β stimulates cartilage and bone formation via determined chondroprogenitor and

osteoprogenitor cells in vivo. On the other hand, Ono et al. examined the appearance and localization of TGFβ1, fibronectin, and bone alkaline phosphatase in OLF lesions from four patients.[3] Based on these results, it is believed that TGFβ1 and fibronectin may contribute to the hypertrophy and ossification of the ligamentum flavum. Recently, a key molecule called cartilage-derived morphogenetic protein (CDMP)-1 and has been identified as a member of the TGFβ super family. Nakase et al. reported that CDMP-1 was immunolocalized in spindle-shaped cells distant from the ossification front.[15]

CONCLUSION

Clinical factors that are likely to predict short-term outcome include the duration of symptoms and preoperative neurological status. Thus early and correct diagnosis is required to avoid poorer results. Long-term follow up needed to determine the factors that predict the surgical outcome.

REFERENCES

1. Yonenobu. K, K. Nakamura.Y. Toyama (Eds.) OPLL Ossification of the Posterior longitudinal Ligament 2nd Edition
2. Resnick D, Guerra J, Robinson C, Vint V. Association of diffuse idiopathic skeletal hyperostosis (DISH) and calcification and ossification of the posterior longitudinal ligament. American Journal of Roentgenology. 1978;131:1049-1053.
3. Ono K, Yonenobu K, Miyamoto S, Okada K. Pathology of Ossification of the Posterior Longitudinal Ligament and Ligamentum Flavum. Clinical Orthopaedics and Related Research. 1999;359:18-26.
4. Yonenobu K, Ebara S, Fujiwara K, Yamashita K, Ono K, Yamamoto T, Harada N, Ogino H, Ojima S. Thoracic myelopathy secondary to ossification of the spinal ligament. J Neurosurg. 1987;66:511–518.
5. Anzai N. Four cases with radiculomyelopathy due to hypertrophic changes of the ligamentum fl avum (in Japanese). J Jpn Orthop Assoc, 1938;13:305–316.
6. Koizumi M. Three cases of spinal cord paralysis proved by ligamenta fl ava ossifi cation (in Japanese). Rinsho Geka, 1962;17:1181–1188.
7. Yanagi T, Kato H, Shiozawa Z. Ossifi cation of ligamenta fl ava of the thoracic spine assosiation with radiculomyelopathy. Clin Neurol, 1972;12:571–577 11.
8. Nagashima C. Myelopathy due to ossifi cation of the posterior longitudinal and the yellow ligament (in Japanese). Saigai Igaku, 1975;18:671–683.
9. Saiki K, Hattori S, Kawai S. The ossification of the yellow ligament in the thoracic spine (in Japanese). Seikei Geka, 1981;24:191–198.
10. Yong-Hing K, Reilly J, Kirkaldy-Willis W. The Ligamentum Flavum. Spine. 1976;1:226-234.
11. Niepel GA, Sitaj S. Enthesopathy. Clin Rheum Dis. 1979;5:857-871.
12. Guo JJ, Luk KD, Karppinen J, Yang H, Cheung KM. Prevalence, distribution, and morphology of ossification of the ligamentum flavum: a population study of one thousand seven hundred thirty-six magnetic resonance imaging scans. Spine (Phila Pa 1976) 2010;35:51â€“56.
13. Ahn DK, Lee S, Moon SH, Boo KH, Chang BK, Lee JI. Ossification of the Ligamentum Flavum. Asian Spine Journal. 2014;8:89-96.
14. Yamazaki M, Koda M, Okawa A, Aiba A. Transient paraparesis after laminectomy for thoracic ossification of the posterior longitudinal ligament and ossification of the ligamentum flavum. Spinal Cord. 2005;44:130-4.
15. Nakase T., Ariga K., Yonenobu K., et al. Activation and localization of cartilage-derived morphogenetic protein-1 at the site of ossification of the ligamentum flavum. European Spine Journal. 2001;10:289-294.

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