Considerations in the Treatment of Cervical Ossification of the Posterior Longitudinal Ligament

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Ossification of the posterior longitudinal ligament (OPLL), defined as pathological hypertrophy and prominent bony formation of the posterior longitudinal ligament, compresses the spinal cord and results in myelopathy.[6,12] The first report of OPLL was made in 1839.[16] Tsukimoto presented the first Japanese autopsy case of cervical OPLL in 1960[40] and Terayama et al. gave the disease its name.[38] There is a geographical difference in the prevalence of OPLL. In Japan, the reported incidence ranges from 1.7 to 2.4% and includes asymptomatic cases. In non-Asians, it is 0.16%.[19,31,41]

OPLL tends to present in the fifth and sixth decades of life. It is most frequent in the cervical region and fewer than 10% are observed in the thoracic or lumbar region. There is an association between OPLL and ossification of yellow ligament (OYL) or ankylosing spondylotic hyperostosis.

The precise etiology of OPLL remains obscure. Laboratory examinations return normal results, although an association with diabetes mellitus and generalized hyperostosis of the spinal ligaments such as diffuse idiopathic skeletal hyperostosis has been noted in patients with OPLL. Siblings of patients with OPLL who share an increased number of human leukocyte antigen haplotypes are at increased risk for developing OPLL, suggesting a genetic factor. An abnormality in the N-propeptide of the COL 11A2 gene that is related to Type II collagen has been reported in patients with OPLL.[33]

Diagnosis

OPLL is demonstrated on conventional lateral radiographs and tomographs (*Fig. 15.1*). Based on lateral cervical x-ray images, OPLL is classified as segmental, continuous, mixed, and other type (*Fig. 15.2*)[11]; this classification is simple and clinically useful. According to Tsuyama,[41] 39% of patients with OPLL had segmental, 27% continuous, 29% mixed, and 7.5% other type OPLL.

However, small OPLL and OPLL in lower cervical regions are often missed. Computerized tomography (CT) scanning, especially bone window CT, is useful for an accurate diagnosis of OPLL (*Fig. 2*) and CT-based classifications have been proposed. Hirabayashi et al. suggested square, mushroom, and hill type OPLL to reflect its lateral extension.[12] Hida et al. described two types, single- and double-layer OPLL.[8] The latter includes ossification of the superficial and deep layer of the posterior longitudinal ligament separated by a hypertrophied portion of posterior longitudinal ligament. Mizuno et al. classified OPLL into three types, i.e., an isolated, double layer, and en bloc type.[29]

Because ossified lesions do not emit a proton signal, OPLL is not detected by magnetic resonance imaging. However, it does show compression of the spinal cord and intramedullary changes, including edema or myelomalacia. Magnetic resonance imaging also provides information regarding associated disc protrusions and hypertrophy of the posterior longitudinal ligament.[7,21]

Development of Neurological Deficits

The neurological deficits in patients with cervical OPLL involve two factors. These are static factors, including spinal canal stenosis and associated hypertrophy of the posterior longitudinal ligament or OYL, and dynamic factors that include instability and association with a protruded disc.[21,22]

Compared with other cervical disc diseases and cervical spondylosis, the symptoms of OPLL tend to be insidious despite marked compression of the spinal cord. Matsunaga et al. reported that all individuals whose spinal canal was less than 6 mm manifested myelopathy.[26] However, when their spinal canal was between 6 and 14 mm, patients with a high range of motion also showed myelopathy.[26]

In some patients with segmental or mixed type OPLL, myelopathy is attributable to associated cervical disc protrusion. It has been reported that 81% of patients with segmental type OPLL had disc protrusion; this was true of 46% with mixed and 25% with continuous type OPLL.[7,21] According to Matsunaga et al. who performed a retrospective study, cervical trauma was the trigger for myelopathy in 13% of their 552 patients with cervical OPLL.[27]

Conservative Treatments

Conservative treatment with a neck collar or anti-inflammatory medications sometimes improves the symptoms of cervical OPLL. However, in most patients with

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FIGURE 15.1. Lateral cervical tomograph showing OPLL from C3 to C6.

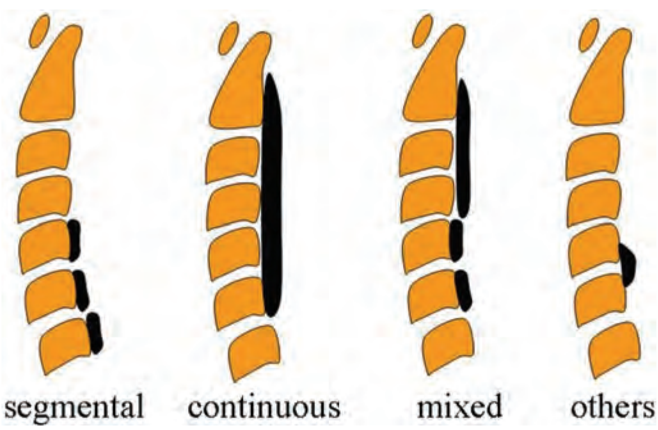

FIGURE 15.2. Types of cervical OPLL, e.g., segmental type, continuous type, mixed type, other type.

severe myelopathy, conservative treatment is inadequate as a result of marked compression of the spinal cord. Matsunaga found that only 17% of 323 asymptomatic patients developed myelopathy in the course of a 17.6-year follow-up study.[28] This suggests that a decision to perform preventive surgery requires careful deliberation.

Surgical Indication for Cervical Ossification of the Posterior Longitudinal Ligament

In patients with cervical OPLL unresponsive to conservative treatment, surgery may be indicated. In addition, patients with localized OPLL may be candidates for two-level corpectomy and anterior fusion, and patients with extensive OPLL and associated narrow spinal canal or with associated OYL may require laminoplasty.

ANTERIOR APPROACH

Although the ossified lesion can be removed through the anterior approach, this requires advanced surgical skills.[1,2] We consider the anterior approach appropriate when 1) there is localized OPLL requiring corpectomy involving two and a half vertebrae; or 2) the upper limit of the OPLL is at the lower end of C2 and the lower limit is the upper portion of the T1 vertebra.

Intraoperative Monitoring

In terms of intraoperative monitoring, somatosensory evoked potential and/or motor-evoked potential (MEP) monitoring is useful. Somatosensory evoked potential monitoring assesses the integrity of the dorsal column. MEP monitoring is a relatively new technique to evaluate the integrity of the corticospinal tracts.

Procedure

Awake nasotracheal fiberoptic intubation may limit the morbidity associated with OPLL surgery. A transverse skin incision is placed for single corpectomy. An oblique incision may be safer when two or more corpectomies are required. Standard anterior cervical soft tissue dissection is performed between the omohyoid and the sternocleidal muscle and then between the trachea and esophagus medially and the carotid sheath laterally to the ventral cervical spine. The longus colli muscles are dissected bilaterally and a self-retaining retractor is placed. After confirming the target level, complete discectomy is carried out at the upper and lower level of the corpectomy. We prefer to perform osteophytectomy before corpectomy because it is easy to use a spreader to remove the osteophyte.

The corpectomy should be sufficiently wide; we recommend it be between 18 and 20 mm in width (*Fig. 15.3A*). Care must be taken not to lateralize the corpectomy. We prefer diamond burrs for drilling because they are much safer than cutting burrs and make it possible to produce hemostasis on the cancellous bone (*Fig. 15.3B*). Bleeding from the internal vertebral plexus located laterally in the posterior longitudinal ligament should be avoided. We induce hemostasis with a curved bipolar and microfibrillar collagen hemostat (Avitene; Davol Inc., Woburn, MA). After thinning the ossified lesion, it is dissected from the dura mater and removed (*Fig. 15.3C*). However, when the dura mater is ossified and adheres to the posterior longitudinal ligament, complete removal of the ossified lesion may produce a dural tear and leakage of cerebrospinal fluid. Because this is hazardous, we sometimes use microfloating methods to thin ossified lesions and decompress the dura mater without tearing (*Fig. 15.4A–B*). When cerebrospinal fluid leakage occurs, we use muscle and fibrin glue to seal the dura mater and place spinal drainage for 5 to 7 days.

For implants, we have used iliac crest material (*Fig. 15.5A–B*). To prevent bone graft extrusion, we found that

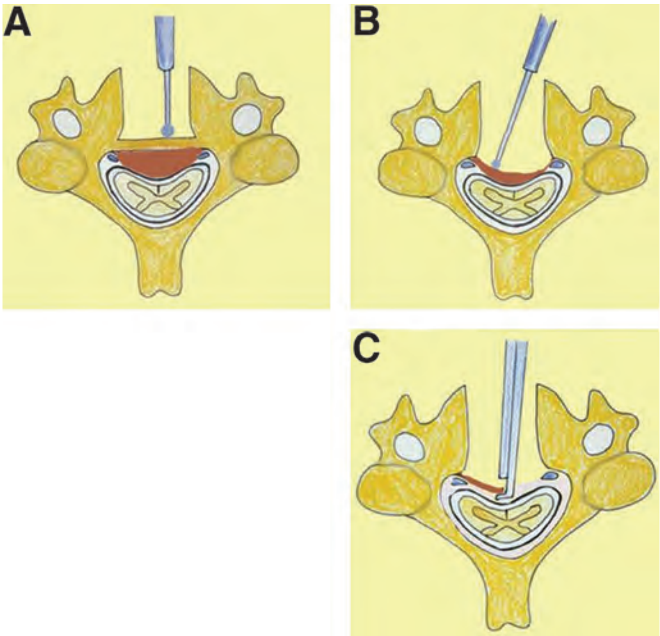

FIGURE 15.3. Schematic drawings of corpectomy operating methods to treat cervical OPLL. *A,* Sufficiently wide corpectomy. *B,* Drilling OPLL using a diamond bar. *C,* Removing OPLL with a Kerrison punch.

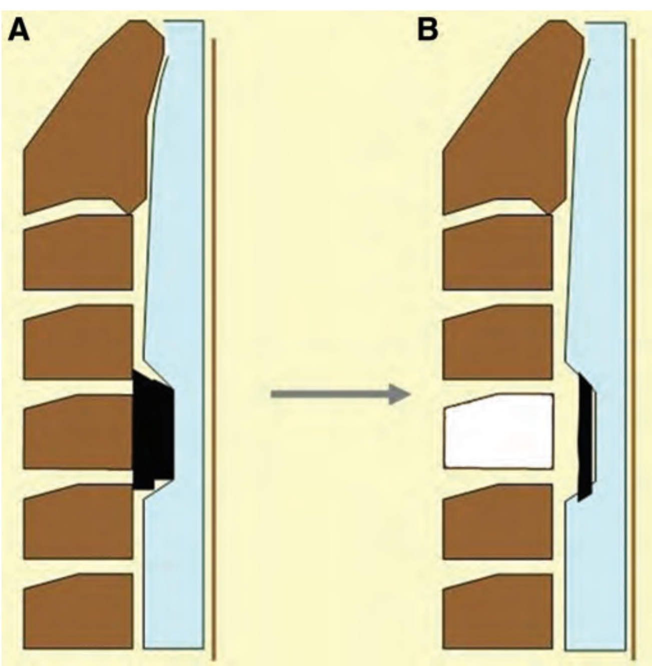

FIGURE 15.4. Schematic drawings of microfloating methods. *A,* Before corpectomy. *B,* After corpectomy and thinning of the OPLL, the dura mater is decompressed.

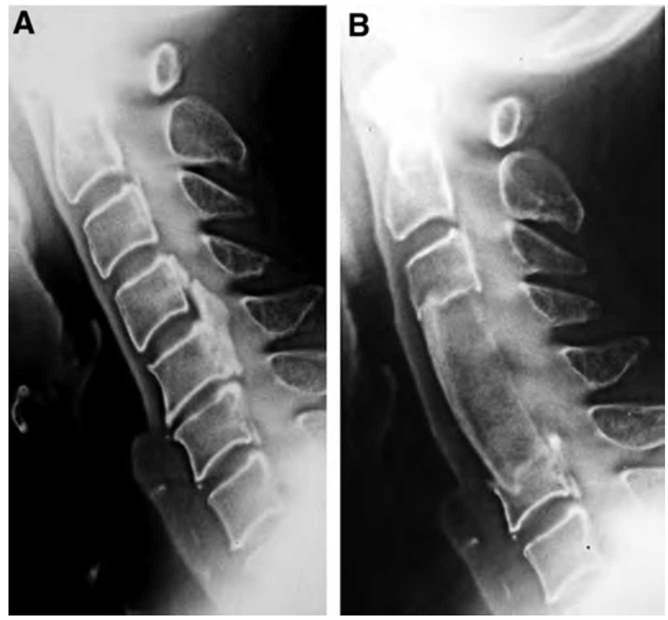

FIGURE 15.5. Cervical OPLL. *A,* Before surgery. *B,* After OPLL removal and iliac crest insertion.

FIGURE 15.6. Cervical OPLL. *A,* Before surgery. *B,* After OPLL removal and iliac crest and anterior cervical plate insertion.

anterior cervical plate grafts were effective (*Fig. 15.6A–B*), although persistent donor site pain, graft bone collapse, and extrusion can occur. Therefore, in our most recent cases, we used titanium cage implants after corpectomy (*Fig. 15.7A–B*).

LAMINOPLASTY

Laminectomy has been regarded as the standard posterior approach for cervical myelopathy. However, cervical laminectomy may result in instability; progressive kyphotic deformity occurred in children and even in adults subjected to extensive facet resection. Late neurological deterioration resulting from compression by the "laminectomy membrane"

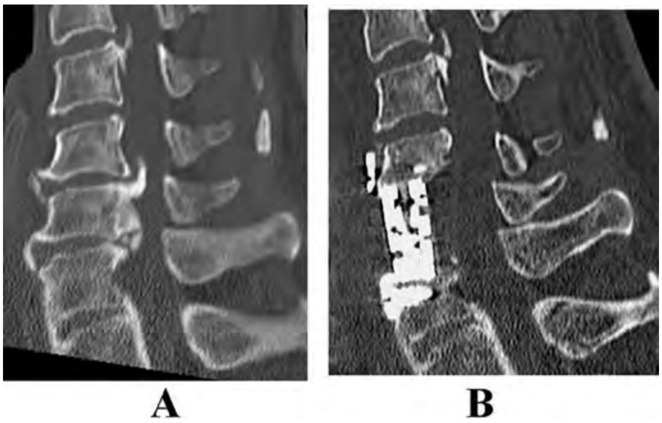

FIGURE 15.7. Three-dimensional CT reconstruction sagittal image of cervical OPLL. *A,* Before surgery. *B,* After OPLL removal and titanium cage insertion.

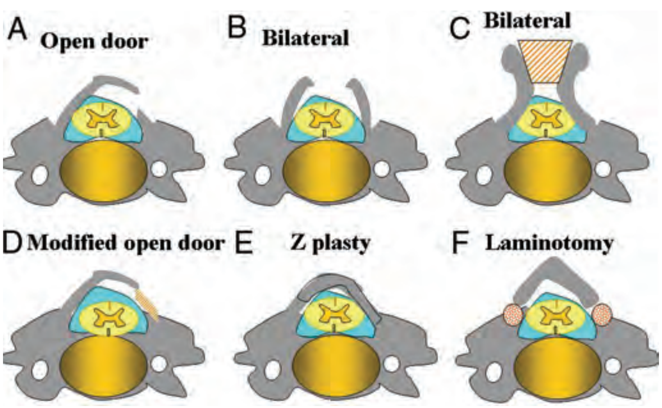

FIGURE 15.8. Schematic drawings of various laminoplasty methods. *A,* Open door method. *B,* Bilateral French door method. *C,* Splitting the spinous process and lamina with a spacer. *D,* Modified open door method using a spacer. *E,* Z-shaped laminoplasty. *F,* Laminotomy and fusion with ceramics.

has also been reported. To address these problems, laminoplasty methods were developed primarily by Japanese orthopedists (*Fig. 15.8*).

The purpose of laminoplasty is reconstruction of the opened lamina. However, to minimize the surgical insult and postoperative pain, attempts have been made to preserve the paravertebral muscles and ligaments.[17,18,36,37]

Procedure

We use the posterior approach in patients with extensive OPLL compressing the spinal cord over three vertebrae and in the presence of associated degenerative canal stenosis or associated OYL.

We perform simple bilateral open door cervical expansive laminoplasty (*Fig. 15.9*). After the induction of endotracheal general anesthesia, the patient is placed in the prone position with the head secured in a three-point rigid fixation device and the neck slightly flexed. MEPs are monitored. A posterior midline skin incision is made along the nuchal ligament as required by the laminoplasty level; this usually involves C2 to C7. After exposing the spinous process and lamina, the spinous process is cut at the bottom. If there was preoperative CT evidence of a narrow intervertebral foramen, we use a microscope to carry out posterior foraminotomy.

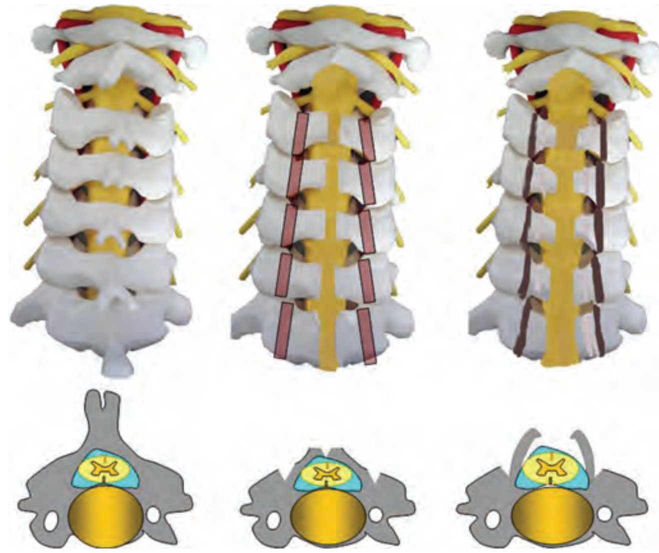

FIGURE 15.9. Our simple laminoplasty using the French window method.

FIGURE 15.10. Extensive cervical OPLL from C3 to T2. *A,* Before laminoplasty. *B,* After laminoplasty, the spinal cord was well compressed.

Then we perform midline laminotomy and place a bilateral groove with a high-speed drill and open the lamina with fracturing. The opened lamina is sutured to the paravertebral muscle bilaterally with silk sutures. Although adequate decompression of the dura mater can be confirmed by its pulsation, we found intraoperative sonography highly useful to confirm proper decompression in patients with cervical OPLL (*Fig. 15.10*). After placing the lumbar drainage system, the muscle, subcutaneous, and skin layers are closed in the usual manner. Patients are instructed to wear a soft cervical collar for 3 weeks after the operation.

DISCUSSION

An understanding of the posterior longitudinal ligament microanatomy is important when considering the anterior approach. The posterior longitudinal ligament is approximately 1 to 2 mm in thickness and consists of two layers, a deep layer located ventral and a superficial layer located dorsal to the spinal cord. The superficial layer joins the dura mater at its lateral portion. The anterior internal vertebral venous plexus is narrow at the disc and wide at the vertebral level.[23] The venous plexus is located in the interposterior longitudinal ligament space.[23]

In many instances, OPLL is visualized as a double layer at bone window CT. In these cases, the incidence of dura mater ossification tends to be increased; dural tears with cerebrospinal fluid leakage occurred in 10 of 12 patients.[8,29]

Ideally, treatment through the anterior approach produces sufficient decompression without a dural tear. To achieve such outcomes, Kamikozzuru and Yamaura developed the original floating method that does not remove the OPLL.[14,44,45] We use microfloating, i.e., we render the OPLL paper thin by using a high-speed drill and an ultrasonic device under a microscope. This procedure enables us safer decompression of cervical OPLL in the anterior approach.

In the past, autologous iliac bone grafts were used to achieve interbody fusion. Although this technique produced solid fusion, there was a high rate of so-called “donor site morbidity,” including painful iliac bone fractures, meralgia paresthetica, and donor site infection. Sawin et al. reported a morbidity rate of 25.3%; their patients manifested pain, hematoma, fracture, and meralgia paresthetica.[34] According to Thome et al.,[39] 22% of their patients reported ongoing donor site pain for more than 6 months and Silber et al. found that 26.1% of patients had chronic pain and more than 10% exhibited functional impairment 48 months after undergoing iliac crest autografts.[35]

To overcome these complications, various implants using ceramic and titanium materials were developed. Oda et al.[30] used ceramic implant materials and others[18,20] reported the effectiveness of hydroxyapatite ceramics. Later, anterior cervical plate implants were introduced to treat patients with cervical spondylosis. Anterior cervical plate allografting is the favored method in the United States. However, the use of allografts is prohibited in Japan where the implantation of titanium cages was introduced in the late 1990s. It is currently the most highly favored treatment method in Japan.[2–4,15,25]

Graft bone displacement occurred in 4.2, 5.3, 9.9%, and 16.7% of patients treated at one, two, three, and four levels, respectively.[42] The use of anterior cervical plate material was introduced to prevent implant displacement; however, the reported rate of plate failure ranges from 2 to 28.5%.[5] Patients with anterior cervical plate implants must be followed carefully until solid fusion is confirmed.

Problems Encountered in Adjacent Segments

Kadoya et al. reported that among 139 patients followed between 1 and 22.5 years, 11 (7.9%) required reoperation because of myelopathy resulting from disc degeneration adjacent to the fused level.[13] Hilibrand et al. pointed out that symptomatic adjacent segment disease occurred at a relatively constant rate of 2.9% per year and survivorship analysis predicted that 25.6% of patients would present with new disease at an adjacent level within 10 years of the first operation.[10] On the other hand, Kulkarni et al. observed accelerated spondylotic changes adjacent to the level of the fused segment after cervical corpectomy in as many as 75% of patients.[24] Adjacent segment disease is not directly related to anterior fusion; in some cases, it developed after expansile laminoplasty.[43]

Although it is considered safer and easier, the posterior approach achieves spinal cord decompression indirectly. Sufficient decompression one level above and one level below the OPLL lesion is important and intraoperative MEP monitoring and ultrasonography are useful to ascertain adequate decompression. An important rationale for choosing laminoplasty is the prevention of kyphotic deformity. However, postoperative changes tend to lead from preoperative lordotic to postoperative straight or kyphotic alignment.[32] Furthermore, some patients treated by laminoplasty experienced a decrease in the cervical movement range of motion.

At our institute, 3% of patients treated for cervical spondylosis manifested intraoperative complications;[9] the complication rate was 10% in patients operated on for cervical OPLL (*Table 15.1*). The anterior approach for cervical spondylosis and OPLL resulted in a 4% complication rate; it was 6% with the posterior approach and the difference was not significant. The types of complication we encountered with the two different approaches are shown in *Table 15.2*. Although iliac bone fracture and meralgia paresthetica are often encountered after titanium cage implantation, these complications can occur in patients treated by the other methods. Therefore, patients scheduled for surgery must be clearly informed of the benefits and dangers of treatment and informed consent must be obtained irrespective of the chosen treatment method.

TABLE 15.1. Complications encountered at our institute during surgery for cervical spondylosis (CS) and cervical ossification of the posterior longitudinal ligament (OPLL)

Among 1005 spinal disorders treated in the course of 5 years, 442 (44%) were CS or OPLL	
CS: 373 (84.4%)	
OPLL: 69 (15.6%)	
Anterior approach	300/442 (68%)
Posterior approach	142/442 (32%)
Complications: 20/442 (4.5%)	
CS: 13/373 (3.5%)	
OPLL: 7/69 (10%)	
Anterior approach	12/20 (60%)
Posterior approach	8/20 (40%)

TABLE 15.2. Complications encountered at our institute during surgery for cervical spondylosis (CS) and cervical ossification of the posterior longitudinal ligament (OPLL)

Anterior approach: 300/442	
Complication rate: 12/300 (4%)	
Posterior approach: 142/442	
Complication rate: 8/142 (5.6%)	
Type of complication	
C5 palsy	4/20
Hoarseness	4/20
Iliac bone fracture	2/20
Meralgia	1/20
Cerebrospinal fluid leakage	1/20
Plate screw failure	1/20
Restenosis	2/20
Tethering	2/20
Wound opening	1/20
Epidural hematoma	1/20
Deformity	1/20

CONCLUSION

There are two major alternative surgical treatments for cervical OPLL. One uses the anterior approach and corpectomy and fusion; the other applies the posterior approach and mainly laminoplasty. We prefer the anterior approach in patients with localized cervical OPLL and perform laminoplasty in patients with extensive OPLL. For the operation to be safe and adequate, it is important to verify radiological findings, to consider the neurological findings and the patient's condition, and to establish a rapport with the patient.

Acknowledgments

This paper was presented at the 2007 Annual Meeting of the Congress of Neurological Surgeons in San Diego, CA.

Disclosure

The authors did not receive financial support in conjunction with the generation of this article. The authors have no personal or institutional financial interest in drugs, materials, or devices described in this article.

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