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Case Report

Maximal Resection of Intramedullary Lipoma Using Intraoperative Ultrasonography: A Technical Note

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One of the problems during surgery for intramedullary lipoma is the ambiguous boundary between the lipoma and the spinal cord, resulting in either incomplete resection or damage to the spinal cord. We report a case of intramedullary lipoma resection on a 61-year-old man in which the boundary between the tumor and spinal cord was repeatedly visualized with intraoperative ultrasonography. We focused on the distinctive features of fat as hyperechoic, in contrast to low-echo neural tissue. Subtotal resection of the tumor was achieved without any aggravation of neurological symptoms. Intraoperative ultrasonography may be useful for confirming tumor boundaries during intramedullary lipoma resection.

Key words: intramedullary lipoma, subtotal resection, ultrasonography, intraoperative guidance

Intramedullary lipomas are relatively rare, accounting for less than 1% of intraspinal tumors [1]. Surgery is recommended for patients with neurological symptoms. As intramedullary lipomas are benign, the primary purpose of surgery is to decompress the spinal cord. However, such tumors can infiltrate the spinal cord, and the margin between tumor and spinal cord tissues can be ambiguous. Therefore, there is a potential risk of spinal cord injury during total resection, and several reports have recommended incomplete resection [2-4]. However, the outcomes of total resection have been better than those of partial resection, especially in the long term [5]. For safer operations, there have been reports demonstrating the usefulness of technologies such as ultrasonic aspiration, laser surgical methods, and intraoperative nerve monitoring (INM) [1,4-6]. Only one method for visually determining the boundary between the tumor and spinal cord has been reported [5]. In the present case report, we show how the boundary between tumor and spinal cord can be visualized via ultrasonography at any time during the operation. We report a patient with an intramedullary spinal cord lipoma who underwent subtotal resection under the guidance of intraoperative ultrasonography.

Case Report

The case was a 61-year-old man with left lower limb pain. He had been aware of his gradually worsening symptoms for 18 years, and finally visited a local doctor. He was referred to our hospital after an abnormality was noted on magnetic resonance imaging (MRI). On physical exam, mild motor weakness and numbness were observed in his left leg. The MRI showed an intramedullary spinal cord lipoma at the T12 to L1 level. The signal intensities of the tumor were high on T1- and T2-weighted images and reduced on the fat-suppressed T2-weighted image (Fig. 1A-C). The spinal cord was evacuated and deformed into a crescent shape (Fig. 1D-E). We planned a surgical resection for decompression of the spinal cord. After laminectomy at

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T12 and L1, the tumor was visible as a yellow mass (Fig. 2A). The dura and arachnoid were incised adequately for resection. The yellow tumor of the lipoma was covered by the pia mater, but the margins of the tumor and spinal cord were still unclear after incising the pia mater (Fig. 2B). We undertook tumor resection using SONOPET (ultrasonic surgical aspirator, Stryker) while observing the surgical field with a surgical microscope. All procedures were performed under INM using both somatosensory-evoked potentials and motor-evoked potentials. On ultrasonography the lipoma was shown as a very bright, high-echoic lesion while the spinal cord had relative lower echoic resonance (Fig. 3A-B). The margins of the tumor and spinal cord were clear on this imaging. The tumor was debulked little by little while observing the residual size of the tumor, the morphology of the spinal cord, and the boundary between the tumor and the spinal cord by frequent ultrasonic observations. At first, the tumor was large, and the spinal cord was compressed and deformed like a crescent (Fig. 3A-B). As the tumor was resected, the shape of the spinal cord was gradually restored (Fig. 3C-D). Ultrasonography ultimately showed a spinal cord with normal morphology, with the tumor remaining as a thin layer on its surface (Fig. 3E-F). The surgery was then completed. The nerve roots, spinal cord, and residual tumor could be seen under a microscope (Fig. 2C), but the boundaries were still unclear. During the procedure, there were no warning signs on INM. The pathological diagnosis after resection was lipoma. No neurological deteriorations were observed after the surgery. A previous report has suggested that lipomas remaining after surgery can be reduced via nutritional restrictions [7]. Although we did not implement a special diet, the patient was instructed to be careful not to gain excessive weight. His leg pain improved soon after surgery, and his left-leg motor weakness recovered in 3 months. MRI

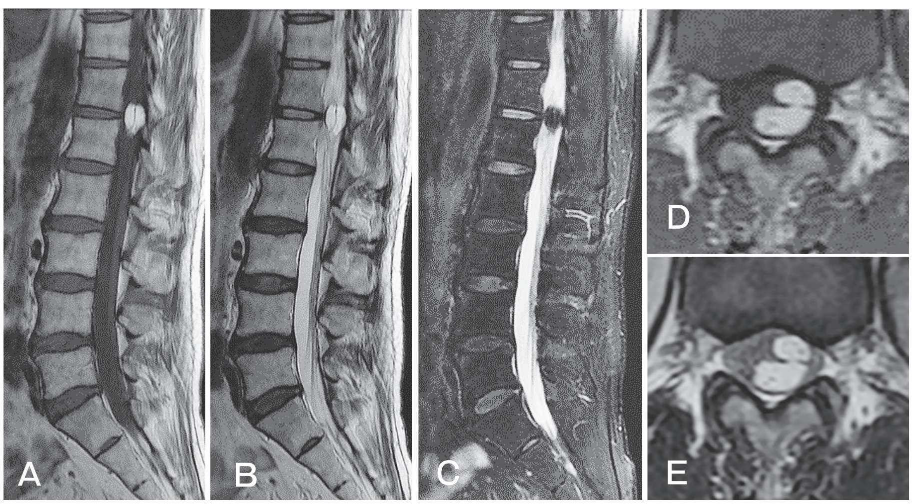

Fig. 1 Sagittal T1- (A) and T2-weighted (B) preoperative MRIs showing the tumor with high intensity at the T12-L1 level. The signal was low in the fat-suppressed T2-weighted image (C). Axial T1- (D) and T2-weighted (E) MRIs showing the tumor on the left side of the spinal cord. The tumor is attached to the spinal cord, and the spinal cord is displaced to the right and deformed.

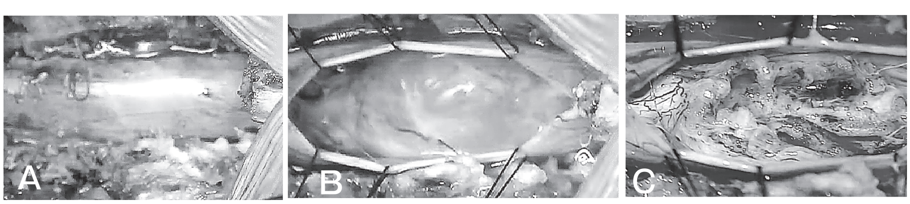

Fig. 2 (A) After laminectomy of T12 and L1, the lipoma was seen through the dura on intraoperative photographs. (B) Incision of the dura and arachnoid revealed the spinal cord and lipoma. The boundaries were not clear. (C) A small amount of lipoma remained after the tumor resection. The degree of resection was unknown in this photograph.

showed adequate tumor resection and decompression of the spinal cord at 3 months after surgery (Fig. 4A-D). At one year post surgery, he had no difficulties in his daily life and work; mild numbness of his left leg remained. A follow-up MRI confirmed that the tumor size had not increased, and the spinal cord was not compressed by the residual tumor.

Discussion

In surgery for subpial lipoma, the amount of tumor removed is related to the postoperative outcome. There have been several reports demonstrating that insufficient tumor resection may lead to early relapse of symptoms. Dorward et al reported that 48% of cases had relapse of symptoms 2.2 years after partial resection [8]. Colak reported 10-year relapse rate of 52% after partial resection [9]. Pierre-Kahn *et al*. reported a similarly high 10-year relapse rate of 46% [6]. By contrast, Pang reported that 88.1% of patients who underwent total excision remained asymptomatic after 20 years, while 65.4% of patients who underwent partial resection had relapse of symptoms in 10 years. They argued that surgeons should aim for total resection as much as possible

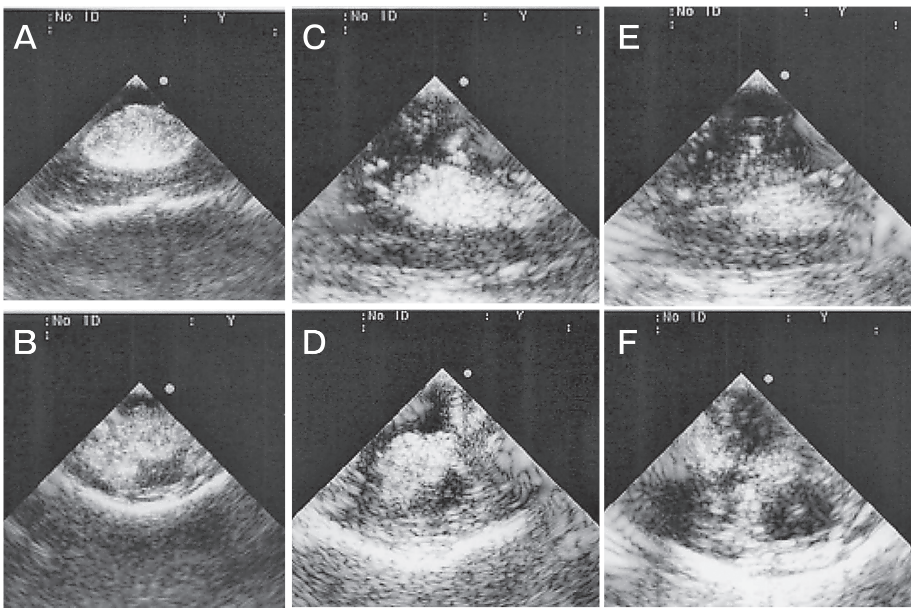

Fig. 3 Intraoperative ultrasonographic images. Sagittal (**A**) and axial (**B**) images before the excision show the lipoma as high echo and the spinal cord as low echo. The boundary between the tumor and the spinal cord was clear. Sagittal (**C**) and axial (**D**) images in the middle of the excision showed volume reduction of the tumor and improvement in the spinal cord deformity. The boundaries were still clear. Sagittal (**E**) and axial (**F**) images after tumor excision showed a thin hyperechoic region, indicative of the residual tumor, on the surface of the spinal cord, which was released from its compression and returned to normal morphology.

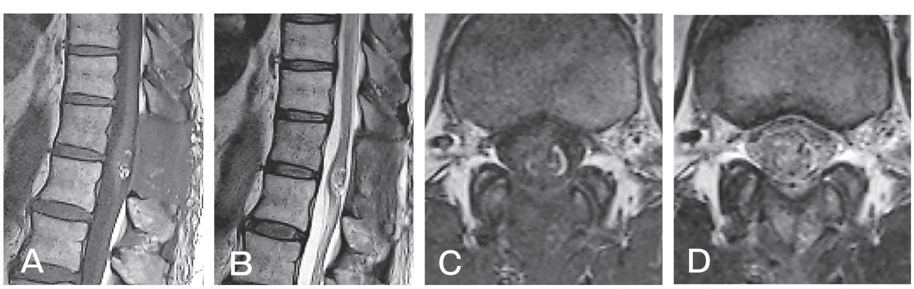

Fig. 4 T1- (**A**, **C**) and T2-weighted (**B**, **D**) MRIs 3 months after surgery. Displacement of the spinal cord was resolved, and a small amount of residual tumor was observed. The tumor volume was significantly reduced and the spinal cord was decompressed.

[5].

Surgery for subpial lipoma can be impeded by issues such as the ambiguous margin between the tumor and spinal cord and the presence of nerve roots in the lipoma. Unfortunately, neurological damage is likely to occur when complete tumor resection is the goal. Bai *et al.* reported that 18 of 122 patients (14.8%) who underwent aggressive tumor resection showed worsened neurological symptoms after surgery [10]. The surgeon's job is defined by two, equally important objectives: removing as much of the lipoma as possible while avoiding nerve damage as much as possible. Thus, the success of surgery for this disease hinges on the visualization of the boundary between the spinal cord and tumor [2]. Pang *et al.* reported that the white surface of the spinal cord on the border between the tumor and the spinal cord is an important landmark [5]. Although there have been reports of the usefulness of instruments such as ultrasonic aspirators [10], laser devices [1,5,11], or INM [1,5] for safely resecting tumors, there have been no reports utilizing visualizations of the boundary between the tumor and spinal cord other than microscopic findings.

Intraoperative ultrasonography is commonly used for spinal cord tumors to determine the extent of the incision in the dura and spinal cord during the approach [4,12]. In this case, we performed intramedullary lipoma resection with frequent reference to intraoperative ultrasonography, focusing on the hyperechoic signature of fat. In the echo image, the boundary between the lipoma and spinal cord was observed as the boundary between high and low echoes. As tumor resection progressed, the deformed spinal cord resumed its normal shape. Surgery was concluded with only a small amount of lipoma remaining, such that a sufficient amount of the lipoma had been removed and no nerve damage had occurred. No previous reports have used ultrasonography to confirm the boundary of the intramedullary lipoma and spinal cord. Overall, we showed how intraoperative ultrasonography can be particularly useful for resection of such tumors.

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