Acta Med. Okayama, 2012
Vol. 66, No. 4, pp. 363–368

Acta Medica
Okayama

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Case Report

Segmental Pedicle Screw Fixation for a Scoliosis Patient with Post-laminectomy and Post-irradiation Thoracic Kyphoscoliosis of Spinal Astrocytoma

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Spinal deformity is an important clinical manifestation after surgery for spinal cord tumors. One-third of patients who receive laminectomies and irradiation of the spinal column develop scoliosis, kyphosis, or kyphoscoliosis. Recent reports indicate good results after scoliosis surgery using segmental pedicle screws and a navigation system, but these reported studies have not included surgery for post-laminectomy kyphosis. Hooks and wires are ineffective in such patients who undergo laminectomy, and there are also high perioperative risks with insertion of pedicle screws because landmarks have been lost. Here, we report on the 5-year follow-up of a 13-year-old male patient with post-laminectomy and post-irradiation thoracic kyphoscoliosis after surgical treatment of spinal astrocytoma. Posterior segmental pedicle screw fixation was performed safely using a computer-assisted technique. The authors present the first case report for treatment of this condition using a navigation system.

Key words: astrocytoma, scoliosis, kyphoscoliosis, navigation, segmental pedicle screw fixation

Although spinal deformities occur in one-third of children after resection of intramedullary spinal cord tumors [1, 2], postlaminectomy deformity is uncommon in adults, except in the cervical spine, because their spines are mature [3]. With aggressive surgical treatment, radiotherapy, and chemotherapy, patients with intraspinal tumors are likely to survive [4–6]; thus, we are seeing more late spinal deformities [1, 2, 7–11]. The main causes are vertebral growth arrest because of radiation therapy and posterior spinal muscle insufficiency due to laminectomy.

The prevention of spinal deformity using a brace is very important; unfortunately, spinal deformity cannot be avoided in some patients [12]. Although most researchers recommend surgical management with spinal fusion when the deformity becomes severe [7–9], hooks and wires are ineffective in such patients because the laminae have been lost or weakened. Furthermore, there are high perioperative risks when inserting pedicle screws because landmarks are lost with the laminectomy, but these risks may be reduced using a navigation system [13–15]. This is the first case report of segmental pedicle screw fixation for scoliosis with post-laminectomy kyphosis using a navigation system.

Received October 5, 2011; accepted February 14, 2012.
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Case Report

Patient's history. The authors present the results of a 5-year follow-up of a 13-year-old male patient with postlaminectomy and postirradiation thoracic kyphoscoliosis after surgical treatment of spinal astrocytoma. Total resection of spinal astrocytoma was performed on the patient at the age of 3 in another hospital. The laminectomies were from T3–9 and the spinal column irradiation was at 40 Gy. Histological diagnosis at that time revealed no infiltrative character, suggestive of the slow-growing nature of the tumor, a well-differentiated (Grade 2) astrocytoma. After the operation, the patient suffered slight paraplegia but could walk without any support. Spinal deformity was documented at age 10. Three years later, his scoliosis had gradually progressed and he visited our hospital at the age of 13 owing to severe spinal deformity.

Examination. On examination, he was able to walk without any support. He was 147 cm tall and 38 kg in weight. There was slight muscle weakness (Manual Muscle Testing grade 4) of both legs, some sensory disturbance of his left leg, and hyperreflexia of both legs. There was a 2–cm left rib hump on his back and severe kyphoscoliosis (Fig. 1).

Imaging. Plain radiographs demonstrated severe thoracic kyphoscoliosis from T5 to L2. The scoliosis curve pattern was single thoracic with a Cobb angle of 55 degrees (T5–11) and a kyphosis angle of 58 degrees (T6–L2) (Fig. 2). In the traction and bending radiographs, the spinal deformity proved to be very rigid. The patient underwent magnetic resonance imaging (MRI), which revealed no recurrence of spinal astrocytoma. Three-dimensional computerized tomography (CT) was performed for surgical planning and the computer-assisted procedure revealed that vertebral bodies had become wedged and were small, owing to radiation therapy. The spinous processes were resected and the laminae were not strong

Fig. 1 Preoperative appearance of postlaminectomy kyphoscoliosis. There was a 2-cm left rib hump on the patient's back and severe kyphoscoliosis.

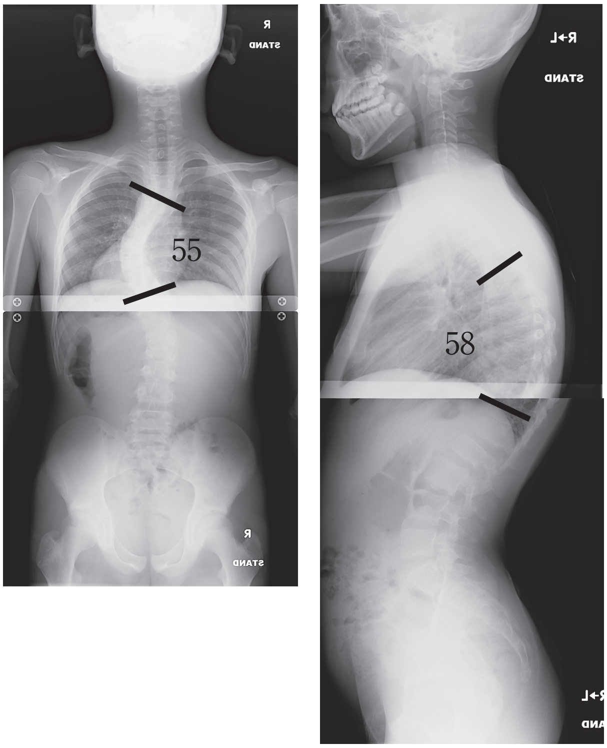

Fig. 2 Preoperative A-P, lateral radiography. Coronal Cobb angle was 55 degrees and kyphosis angle was 58 degrees.

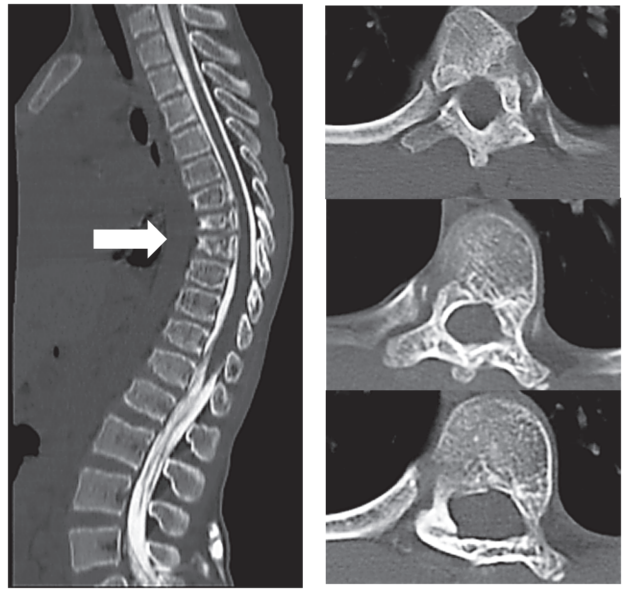

Fig. 3 Preoperative computerized tomography. The laminae seemed to be regenerated.

enough to maintain spinal instrumentation such as hooks or wires (Fig. 3).

Operation. Spinal correction surgery was planned because the kyphoscoliosis of the patient was both severe and progressive, with the possibility of deteriorating to paralysis. To achieve the optimal correction in our patient, we performed a segmental pedicle screw fixation from T5 to L2. We inserted the pedicle screws using the StealthStation^{R} navigation system (Medtronic Memphis, USA) (Fig. 4). Some lamina and spinous processes were too weak to hold the reference arc, in which cases we fixed the screw to the transverse process. Our navigation system requires surface registration, so the bilateral transverse process and remaining lamina were used for this. To minimize the registration time, the pedicle screws were inserted into 2 vertebrae at one registration: namely, into the registered vertebra and the one below. The registration time for each vertebra was approximately five minutes. The accuracy of the navigation was 0.3 mm. The operative time was 5 h and 45 min, and the estimated blood loss was 1,500 ml. Postoperative radiograms demonstrated good correction of the curve, in both sagittal and coronal alignment. Postoperative Cobb angles were 15 degrees in the coronal plane and 30 degrees in the sagittal plane. The correction rate was 73% in the coronal plane.

Postoperative course. There were no postoperative complications and no neurological compromise. Two weeks postoperatively, the patient could walk without support and was discharged from the hospital without a brace. He had good spinal balance at the 5-year follow-up examination (Fig. 5).

Discussion

Intramedullary spinal cord tumors are rare, accounting for 4–10% of all tumors in the central nervous system [16]. Approximately 30% of pediatric and adult intramedullary spinal cord tumors are astrocytomas, of which 80% are histologically low grade [17, 18]. Recently, these tumors have become more easily diagnosed with magnetic resonance imaging, which characteristically shows the spinal cord as expanded or enhanced [19]. Most intramedullary spinal cord tumors can be surgically removed with acceptable morbidity and mortality rates [4–6], but if the tumor is not completely excised, it will eventually undergo malignant change, and radiation therapy or

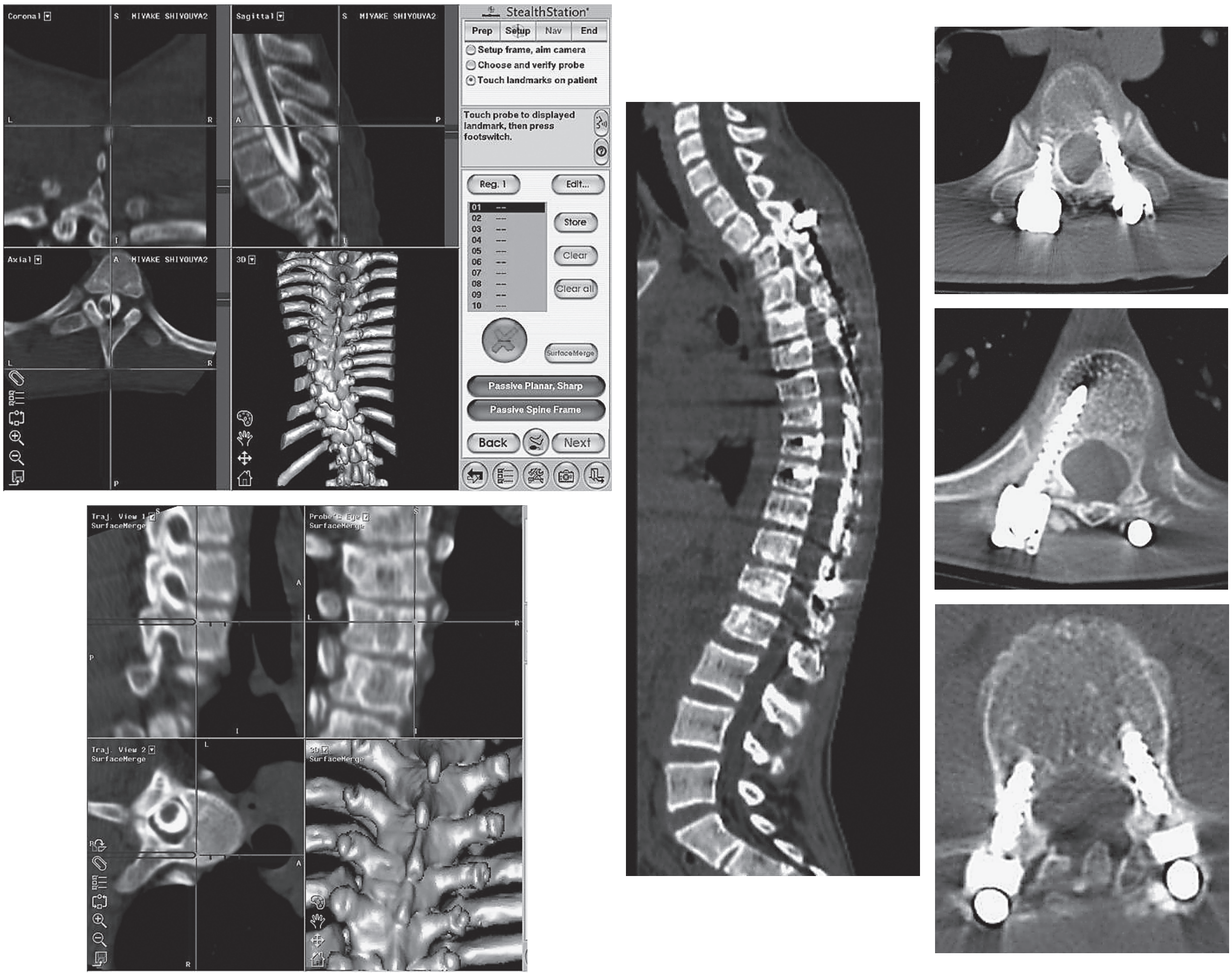

Fig. 4 Postoperative computerized tomography. The pedicle screws were inserted correctly.

chemotherapy will also be necessary [4-6]. The incidence of spinal deformity in children after irradiation is reported to be very high [7, 10, 11, 20]. Newhauser *et al.* in 1952 first described the vertebral changes that can be seen in growing spines after radiation [21]. Kevin *et al.* [2] reported that the incidences of post-laminectomy scoliosis, kyphosis, and kyphoscoliosis in children who had had spinal tumors removed were 8.7%, 9.3%, and 8.75%, respectively. Spinal deformity is more likely to occur when the patient is younger [22], and when the tumor is more cephalad [23], and encompasses more levels [22].

Post-irradiation and post-laminectomy kyphosis is best managed with prevention, and many researchers recommend preventing kyphosis by performing immediate spinal fusion of the involved area [9]. The fusion level should extend along the spine to encompass the field to be irradiated. The importance of closely observing anyone younger than 15 years old that has had a laminectomy with radiation has been stressed [23]. Norman *et al.* also concluded that there is no rule for bracing [12]. Mayfield *et al.* suggested that orthotic treatment can be expected to prevent progression of deformity in only half the patients [11]. If the post-laminectomy or post-irradiation spinal deformity becomes severe (>50 degrees scoliosis or >40 degrees kyphosis), and the patient develops severe neurologic compromise (gait disturbance), spinal correction surgery is indicated.

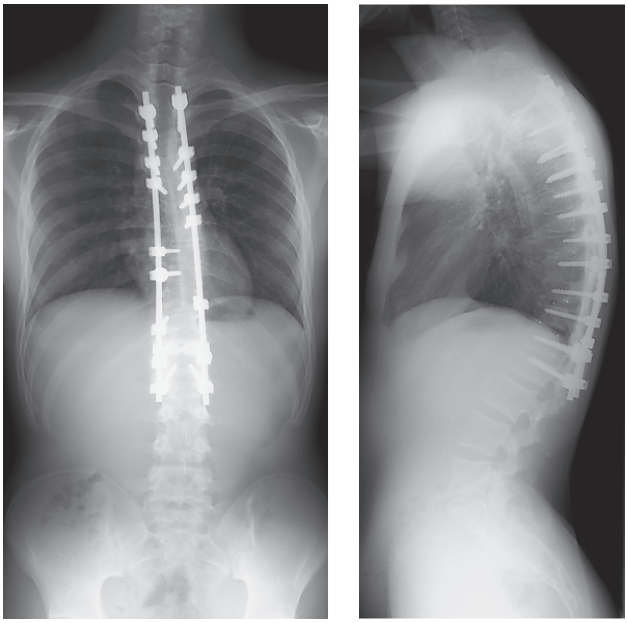

Fig. 5 Postoperative A-P, lateral radiography. Coronal Cobb angle was corrected from 55 degrees to 15 degrees and sagittal alignment became normal.

Posterior fusion alone has been contraindicated for this condition owing to the high rate of pseudarthrosis [1, 11, 12, 23]. Some researchers recommend anterior fusion [23], while others recommend staged anterior and posterior spinal surgeries [1, 11, 12]. Hooks and wires are ineffective in these patients because the laminae have usually been lost or weakened. The best procedure for excellent correction of the curve in the laminectomy spine is the insertion of strong segmental pedicle screw anchors [24–26]. In selective cases, the use of a posterior segmental pedicle screw and posterior fusion alone is a good solution for this deformity. Although the perioperative risks are high for pedicle screw insertion because landmarks are lost due to the laminectomy, these risks may be reduced with the use of a navigation system [13–15].

There are 2 types of CT-based navigation system that are now available. The first-generation system needs preoperative CT data and registration. The second-generation system, which is an intraoperative iso-C 3D-based navigation system, usually makes it possible to include 5 levels of vertebrae with a single registration without preoperative CT data. Furthermore, the accuracy of the second-generation system is greater than that of the first-generation system. However, the second-generation system usually uses an image intensifier to obtain fluoroscopic images, so its image quality is slightly inferior to that of preoperative CT in our first-generation system.

Both systems have been proven useful, however, Rajasekaran *et al.* reported on the use of an iso-C-based navigation system (second generation) for pedicle screw fixation in 27 patients with scoliosis [13]. There were 54 (23%) pedicle breaches in the non-navigation group compared with only 5 (2%) in the navigation group. Kotani *et al.* reported on 45 patients who received posterior correction surgeries with the first-generation navigation system. The navigation group (20 patients) had a perforation rate of 1.8% while the control group (25 patients) had an 11% perforation rate [14]. The current case report also suggests that navigation-guided, segmental pedicle screw fixation provides safe and satisfactory correction and safeguards against the occurrence of rigid spinal scoliosis that can develop post-laminectomy or post-irradiation. The authors here present the first case report of navigation-guided, segmental pedicle screw fixation for this type of scoliosis.

In conclusion, postlaminectomy kyphosis or kyphoscoliosis is a common clinical manifestation after surgery for spinal cord tumors. Although preventing this deformity is ideal, if the deformity progresses to such severity that it becomes unacceptable, early spinal fusion is needed to prevent life-threatening collapsing spine syndrome resulting in respiratory complications or paraplegia. A severe rigid deformity occurring in a postlaminectomy spine requires strong pedicle screw anchors and/or anterior fusion. To achieve safe segmental pedicle screw fixation, the use of a navigation system is needed.

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