Experience of using MySpine: a pedicle screw placement guide made by a three-dimensional printer

Dr. Otani Kazuyuki
Director, Department of Orthopedic Surgery, Kudanzaka Hospital

INTRODUCTION

In correction surgery for spinal deformity, pedicle screws are often placed in the thoracolumbar vertebrae as anchors for correction, although placing a screw in a pedicle with a small diameter in the presence of a severe rotational deformity can be technically demanding. The accuracy of pedicle screw placement can be improved by navigation with intraoperative computed tomography (CT) guidance. However, this technology is only available in a limited number of institutions because of its high cost and the associated increased radiation exposure in patients.

Starting from a pre-operative low dose CT scan the patient's spine anatomy is three-dimensional (3-D) reconstructed, this allows the surgeon to plan the screw placement in advance of the surgery. To guide the surgeon intra-operatively a bone model and a MySpine screw placement guide are 3-D printed. The use of this innovative guide avoids unnecessary radiation exposure both in patients and surgeons during surgery and enables accurate screw placement[1-2]. This report presents a successful case of deformity correction using a MySpine screw placement guide.

CASE REPORT

A 41-year-old woman presented with spinal kyphoscoliosis (Fig.1).

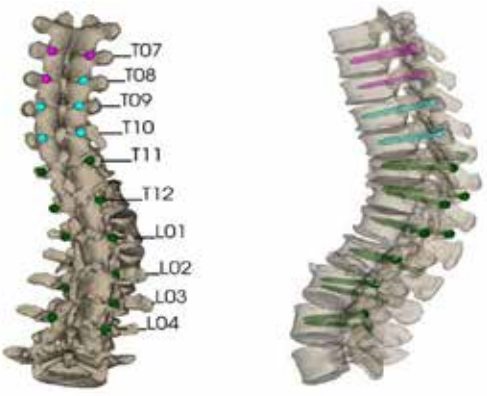
1.

Figure 1: A preoperative whole-body standing radiograph showing severe thoracolumbar kyphoscoliosis, with scoliosis of 41° at T5–T10 and 60° at T10–L3, kyphosis of 80° at T10–L2, thoracic kyphosis (T5–12) of 55°, lumbar lordosis (L1–S) of 46°, sacral slope of 21°, pelvic tilt of 35°, pelvic incidence of 56°, T1 pelvic angle of 29°, sagittal vertical axis of 47 mm, and C7-central sacral vertical line– of 15 mm.

During her elementary and middle school years, she was not diagnosed with scoliosis despite the usual school health checkups. While she was a college student, she became aware that she had spinal kyphosis and attempted to treat her condition with alternative therapies. In her thirties, she left the problem unattended, although she had been aware of her decreasing height. At age 39 years, she was diagnosed as having scoliosis during a health checkup at her new workplace. She consulted a scoliosis specialist 6 months before surgery and was referred to our hospital.

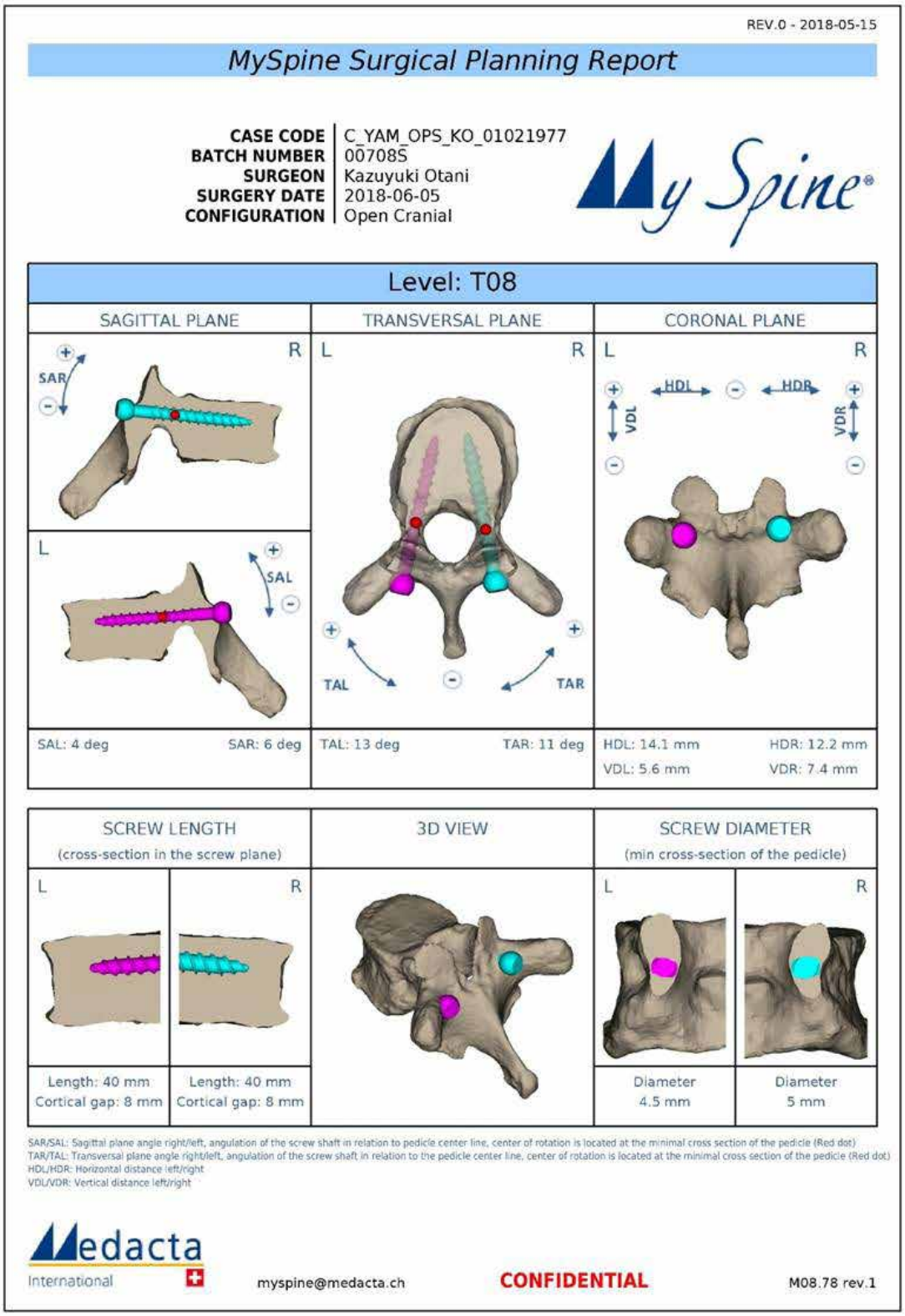
SURGICAL PROCEDURE

For severe thoracolumbar kyphoscoliosis, posterior correction and fusion of the T7–L4 vertebrae with pedicle screws alone were planned (Fig.2, 3).



2.

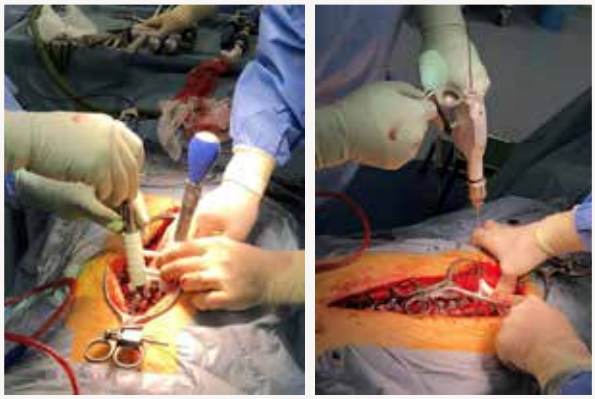
Figure 2: Simulation of screw placement using preoperative 3-D computed tomography data.



3.

Figure 3: A schematic of the preoperative plan for screw placement. The screw insertion points of each vertebra; the insertion angles in the sagittal, horizontal, and coronal planes; and the screw diameter and length are determined preoperatively on the schematic. A MySpine screw placement guide is created on the basis of this planning report.

After the surgical field was exposed, the pedicle screws were placed between T7 and L4 by using a MySpine screw placement guide created based on the preoperative CT data. A low profile-type guide was used for the uppermost part and lower lumbar spine; and a standard-type guide, for the middle part (Fig.4).



4.

Figure 4: Photographs of the surgical field taken during surgery. Left: A standard-type screw placement guide. The guide is pressed against the spinous process, lamina, and transverse process to guide screw placement. Right: A low profile-type screw placement guide. The guide is pressed against the spinous process, lamina, and superior articular process, and a Kirschner wire is inserted in the pedicle. The guide is then removed, and cannulated screws are placed.

Grade 2 (Ponte) osteotomy was made in three intervertebral spaces at T10/T11/T12/L1 for the correction of kyphosis, and a grade 1 osteotomy was made in the other fused intervertebral spaces. At L4, the lowest instrumented vertebra, a lamina hook was also used to prevent screws from backing out, and deformity correction was achieved by the cantilever technique combined with the rod rotation technique with two 5.5-mm Co-Cr rods (Fig.5).

5.

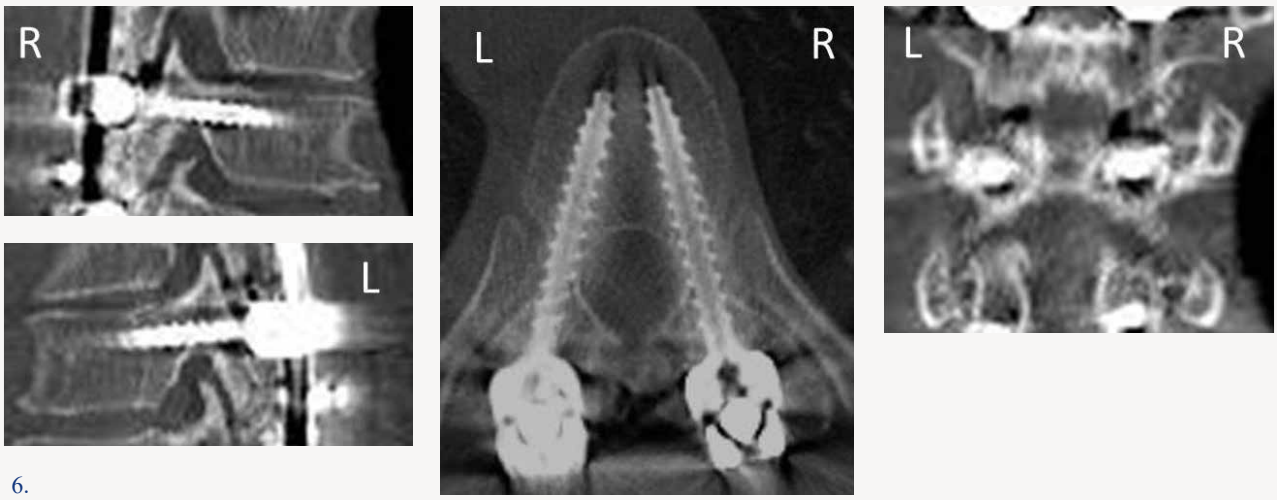
Figure 5: Whole-body standing radiograph taken 2 months after surgery. Both scoliosis and kyphosis were corrected properly, although mild vertebral fracture of T7, the uppermost instrumented vertebra, was noted. The findings included a scoliosis of 7° at T5–T10 and 21° at T10–L3, kyphosis of 12° at T10–L2, thoracic kyphosis (T5–12) of 46°, lumbar lordosis (L1–S) of 49°, °sacral slope of 29°, pelvic tilt of 28°, pelvic incidence of 57°, T1 pelvic angle of 23°, sagittal vertical axis of 33 mm, and C7-central sacral vertical line of 6 mm.

POSTOPERATIVE COURSE

The patient could get up from bed the day after the surgery and received a rigid orthosis for external fixation for 4 months. A vertebral fracture at T7, the uppermost instrumented vertebra, occurred early after surgery but was managed conservatively because the proximal junctional kyphosis was only mild.

DISCUSSION

The MySpine screw placement guide provides a high level of accuracy in pedicle screw placement, which we feel is comparable with the level of accuracy provided by navigation with intraoperative CT guidance. The major advantage of using this guide is that patient's radiation exposure from multiple fluoroscopies can be avoided and screws can be placed accurately. As the guide can be used to determine the screw placement points and insertion angle according to the preoperative plan (Fig.6), it is also beneficial for rod placement and deformity correction.



6.

Figure 6: A postoperative computed tomography scan showing screws placed as planned preoperatively in the sagittal, horizontal, and coronal planes.

This guide is also useful for training for pedicle screw placement, allowing spinal surgeons who have not mastered the free-hand screw placement technique to get familiar with the technique of screw insertion.

Limitations include the possibility of the guide being lifted from the bone, which could lead to screw misplacement. This is rarely the case because if the operator has any doubts during the operative maneuver, the operator can always palpate the pedicle wall with a feeler or other devices, as in conventional surgery.

The standard- and low profile-type (used with Kirschner wires) guides are available. The former is recommended for kyphotic higher thoracic spines located in the middle of the surgical field; and the latter is recommended for the uppermost part and lordotic lower lumbar spine, where there is less interference between the paraspinal muscles and the guide.

References

1. *Lamartina C, Cecchinato R, Fekete Z, Lipari A, Fiechter M, Berjano P. Pedicle screw placement accuracy in thoracic and lumbar spinal surgery with a patient-matched targeting guide: a cadaveric study. Eur Spine J 2015 Nov;24 Suppl 7:937-41*
2. *Putzier M, Strube P, Cecchinato R, Lamartina C, Hoff EK . A new navigational tool for pedicle screw placement in patients with severe scoliosis. Clin Spine Surg. 2016 May 26. [Epub ahead of print]*

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