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L5 nerve root injury caused by anterolateral malpositioning of loosened S1 pedicle screws: illustrative cases

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BACKGROUND Although malpositioning of pedicle screws into the spinal canal and intervertebral foramen can cause spinal nerve root injuries, there are few reports of L5 nerve root injuries when S1 pedicle screws have been inserted anterolaterally. The authors report two cases of L5 nerve root injury caused by anterolateral malpositioning of loosened S1 pedicle screws.

OBSERVATIONS In both patients, S1 pedicle screws were inserted toward the outside of the S1 anterior foramen, and the tip of the screws perforated the anterior sacral cortex. L5 nerve root impairment was not observed immediately after surgery. However, severe leg pain in the L5 area was observed after the S1 pedicle screws became loosened. In case 1, the symptoms could not be controlled with conservative treatment. Reoperation was performed 3 months after the initial surgery. In case 2, the symptoms gradually improved with conservative treatment because the area around the loosened S1 screw was surrounded by newly formed bone that stabilized the screws, as observed with computed tomography 1 year after surgery.

LESSONS Surgeons should recognize that anterolateral malpositioning of S1 pedicle screws can cause L5 nerve root injury. The screws should be inserted in the correct direction without loosening.

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KEYWORDS nerve root injury; pedicle screw; loosening; lumbosacral fixation; postoperative complications; revision surgery

Pedicle screws are commonly used for posterior fixation to treat various spinal disorders. However, malpositioning of pedicle screws can lead to disastrous complications, including neurological deficits and vascular injuries. Malpositioning of pedicle screws into the spinal canal and intervertebral foramen can cause spinal nerve root injuries.[1,2] S1 pedicle screws are used as the standard sacral anchor for fixation in patients with spondylolisthesis, spinal deformity, pelvic trauma, vertebral metastatic tumor, and infection.[3–5] The bicortical method is often used, in which the S1 pedicle screws penetrate the anterior sacral cortex to achieve greater stability than that achieved using the monocortical method.[6–9] Several reports have described the risk of neurovascular injury when S1 pedicle screws are inserted into the anteromedial side of the sacrum;[10–12] however, few reports have focused on the complications of an L5 nerve root injury when the screws are inserted anterolaterally.[13,14] In this study, we report the cases of two patients with postoperative L5 nerve root injury caused by anterolateral malpositioning of S1 pedicle screws.

Illustrative Cases

Case 1

A 78-year-old man was referred to our hospital with a 2-year history of lateral pain in the right lower extremity and intermittent claudication. Pain and numbness were observed in the right L4 and L5 areas, but muscle strength was normal. Preoperative radiographic evaluation indicated L3–4 and L4–5 canal stenosis and right L5–S1 foraminal stenosis. Thus, L3–4 posterolateral fusion (PLF), L4–5 transforaminal lumbar interbody fusion (TLIF), and L5–S1 PLF were performed. The preoperative symptoms disappeared immediately after surgery, but pain and numbness were experienced in the right L5 area 2 weeks after surgery. Computed tomography (CT) scanning

ABBREVIATIONS CT = computed tomography; PLF = posterolateral fusion; TLIF = transforaminal lumbar interbody fusion.
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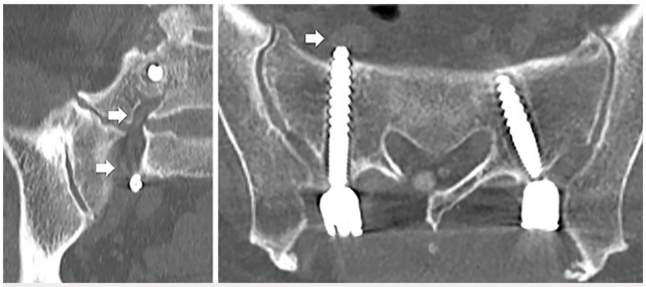

FIG. 1. CT scans after right L5 rootgraphy. **Left:** Coronal CT image showing lateral compression of the right L5 nerve root (*arrows*) by the outwardly malpositioned S1 pedicle screw. **Right:** Axial CT image showing contact of the right L5 nerve root (*arrow*) with the perforating S1 pedicle screw and the radiolucent area of bilateral S1 pedicle screws, which indicates screw loosening.

after right L5 nerve rootgraphy revealed compression of the L5 nerve root by the tip of the perforating S1 screw and loosening of pedicle screws (Fig. 1). We suspected that loosening of the pedicle screws occurred 2 weeks after surgery because the patient started hard exercise early after surgery, and he had poor bone quality with a history of diabetes mellitus and heavy smoking. We recommended reoperation, but he wanted to be discharged early and could not take time off from work, so he requested conservative treatment. Radicular pain disappeared immediately after infiltration of the L5 nerve root with lidocaine, but the effect was temporary and the pain recurred within a few hours. L5 radicular pain was caused by the tip of the loosened S1 screw, and the symptoms could not be controlled with conservative treatment. Reoperation was performed 3 months after the initial surgery. The S1 screw was markedly loosened, and the right L5 nerve root was stimulated by movement of the screw. We reinserted the misplaced S1 pedicle screw inward and toward the apex of the sacral promontory and performed L5–S1 TLIF for the L5–S1 nonunion (Fig. 2). The patient's right radicular pain improved immediately after reoperation, and no relapse was observed at the final follow-up 3 years after reoperation.

Case 2

A 59-year-old man was referred to our hospital with a 6-month history of lateral pain in the left lower extremity and intermittent claudication. Pain and numbness in the left L5 area were observed, but muscle strength was normal. Preoperative radiographic evaluation indicated L4–5 canal stenosis and left L5–S1 foraminal

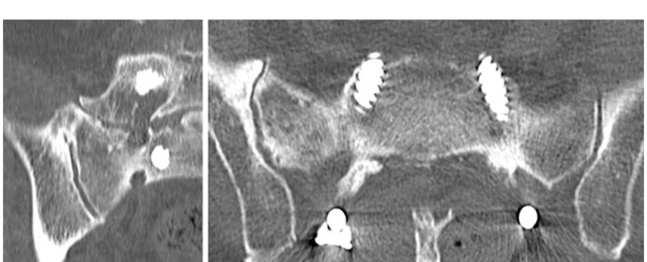

FIG. 2. CT scans after reoperation. **Left:** Coronal CT image showing reinsertion of the right S1 pedicle screw toward the inside of the S1 anterior foramen. **Right:** Axial CT image showing reinsertion of the bilateral S1 pedicle screws toward the apex of the sacral promontory over bicortical fixation.

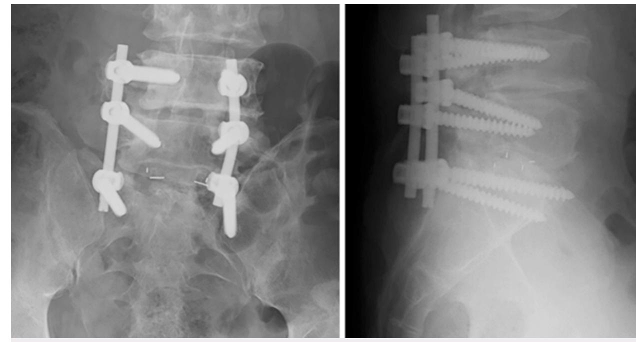

FIG. 3. Postoperative radiographs. **Left:** Anteroposterior image showing the outwardly malpositioned bilateral S1 pedicle screws. The screws were inserted toward the outside of the S1 anterior foramen, especially on the left side. **Right:** Lateral image showing the tips of bilateral S1 pedicle screws perforating the anterior sacral cortex.

stenosis. Thus, L4–5 PLF and L5–S1 posterior lumbar interbody fusion were performed. Postoperative radiographs showed that the bilateral S1 pedicle screws were inserted anterolaterally (Fig. 3); however, as the preoperative symptoms improved, the patient was followed up without screw reinsertion. Pain in the left L5 area gradually developed from 4 months after the surgery, but the patient exhibited no lower extremity muscle weakness. Furthermore, 6 months after surgery, radiographs showed loosening of the left S1 pedicle screw (Fig. 4). Radicular pain disappeared immediately after infiltration of the L5 nerve root with lidocaine, but the effect was temporary and radicular pain recurred within a week. L5 radicular pain was caused by the tip of the loosened S1 screw. The symptoms were controlled by administering oral painkillers; thus, the patient was followed up with conservative treatment. The symptoms gradually improved as the area around the left loosened S1 screw was surrounded by newly formed bone and stabilized with interbody fusion 1 year after surgery, as observed with CT (Fig. 5). Numbness in the lower leg

FIG. 4. Anteroposterior radiograph 6 months after surgery showing the radiolucent area of the left S1 pedicle screw, which indicates screw loosening.

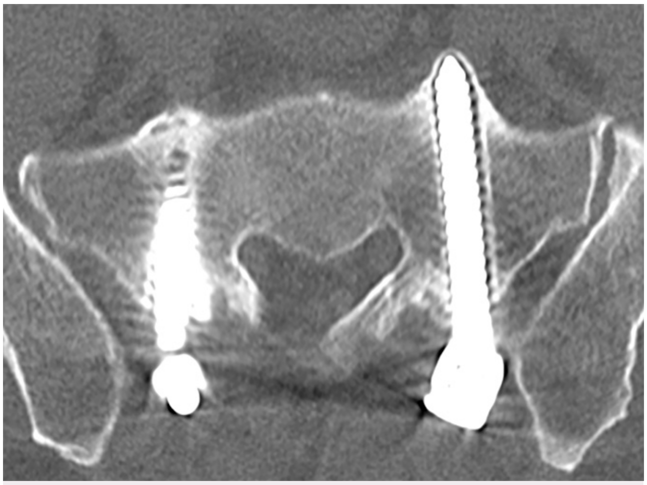

FIG. 5. Axial CT scan 1 year after surgery showing the area around the left loosened S1 pedicle screw surrounded by newly formed bone.

persisted, but the patient could walk independently without pain 5 years after surgery.

Discussion

Observations

Although several studies using cadavers have revealed the anatomical relationship between the lumbar pedicle and adjacent neural structures,[15,16] few have described the anatomy of the L5 spinal nerve in the pelvis. The L5 nerve root exits the intervertebral foramen, joins the L4 nerve root, passes through the craniolateral side of the S1 anterior foramen, and joins the S1 nerve root at the lumbosacral plexus.[17] Waikakul et al.[18] reported that the distance from the most anterior part of the sacroiliac joint to the L5 nerve root in the coronal plane varied from 7.0 to 20.7 mm and that the L5 nerve root was positioned close to the ala of the sacrum in the sagittal plane. Moreover, Ishak et al.[17] reported that significant movement or displacement of the L5 nerve root during flexion and extension of the hip and lower lumbar spine could not be measured (<1 mm). On the basis of these reports, the L5 nerve root is considered to have poor mobility. Ebraheim et al.[19] reported that the mean lateral angle of the S1 screw trajectory toward the L5 nerve, starting inferolaterally to the S1 superior facet, was $21° \pm 8°$. The L5 nerve passes over the inner third of the superior ala and inner third of the lateral mass.

In both cases described in this study, the S1 pedicle screws were inserted toward the outside of the S1 anterior foramen, and the tip of the screws perforated the anterior sacral cortex during the initial surgery. L5 nerve root impairment was not observed immediately after surgery; however, the L5 nerve root was stimulated by the tip of the screws after the screws were loosened. In case 2, the bilateral S1 pedicle screws were inserted outward and the tip of the screws perforated the anterior sacral cortex; however, L5 nerve root impairment was observed only on the left side, where the screw was loosened. We speculated that the reason for the improvement with conservative treatment was that the area around the loosened S1 pedicle screw on the left side was surrounded by newly formed bone that stabilized the screws, as CT showed 1 year after surgery. Thus, we believe that loosening of the pedicle screws may cause L5 nerve root injury when the S1 pedicle screws are inserted anterolaterally. Symptoms may improve without reinsertion if the movement of the screw tip disappears because of subsequent bone formation.

Inoue et al.[13] reported two cases of L5 nerve root injury caused by misplacement of outwardly inserted S1 pedicle screws, similar to those in our cases. They stated that the difference in morphology during L5 nerve rootgraphy may be one of the reasons for the different prognosis. In one case, the L5 nerve root passed outside of the S1 pedicle screw and there was space lateral to the screw; thus, the symptoms improved without reinsertion. By contrast, in the second case, the L5 nerve root passed inside of the S1 pedicle screw and was crushed between the screw and the sacral body, and there was no space for movement; thus, reinsertion was necessary. We also performed L5 rootgraphy in case 1, in which the L5 nerve root passed outside of the S1 pedicle screw, but reinsertion was considered necessary. This result is contrary to their theory. The L5 nerve root was likely stimulated by the loosened screw, and the severe symptoms necessitated reinsertion. On the basis of these cases, we determined that the problems of screw insertion direction and depth and screw loosening occur at the same time, causing L5 nerve root injury. Therefore, it is important to not only insert the screws in the correct position but also insert the screws stably without loosening. Screw augmentation with bone cement and expandable screws exhibited better results in preclinical tests than standard pedicle screws,[20,21] thereby demonstrating potential as a good solution to reduce the possibility of screw loosening in patients with osteoporosis who have undergone posterior fixation.[22]

Anatomical and biomechanical data suggest that S1 pedicle screw fixation is optimal in the anteromedial direction into the apex of the sacral promontory using bicortical fixation.[6–9] Moreover, the recommended S1 pedicle anteromedial screw trajectory angle is approximately 25° to 35°, which is similar to the S1 facet angle, using an entry point just inferolateral to the S1 superior facet.[23–27] However, S1 pedicle screws are frequently inserted more outwardly because of the prominent dorsal overhang of the posterior iliac crest and paravertebral muscle.[27–29] Therefore, many reports have recommended using radiological assistance such as fluoroscopy or CT or navigation systems during surgery to confirm the accuracy of the screw position.[30–33] In the present two cases, we confirmed the screw position using only the lateral view of intraoperative fluoroscopy; therefore, we did not notice the anterolateral malpositioning of the S1 pedicle screws. On the basis of the experience gained from these cases, we believe the screw position should be completely confirmed using the frontal view of fluoroscopy. While inserting S1 pedicle screws, careful attention should be given to the insertion direction, considering that anterolateral malpositioning of S1 pedicle screws may cause L5 nerve root injury.

Lessons

In this study, we reported two cases of L5 nerve root injury caused by anterolateral malpositioning of loosened S1 pedicle screws, which is a rare but possible complication because L5 nerve roots course outward through the ala of sacrum after exiting the intervertebral foramen. In addition, we believe that loosening of the pedicle screws may be involved in the onset of symptoms. Therefore, surgeons should keep in mind that such complications can occur and insert pedicle screws in the correct direction using radiological assistance without loosening the screws.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Okuda, Tamagawa, Momomura, Ishijima. Acquisition of data: Okuda, Tamagawa. Analysis and interpretation of data: Okuda, Tamagawa. Drafting the article: Okuda, Tamagawa. Critically revising the article: Okuda, Nojiri, Ishijima. Reviewed submitted version of manuscript: Okuda, Tamagawa, Nojiri, Ishijima. Approved the final version of the manuscript on behalf of all authors: Okuda. Statistical analysis: Okuda, Tamagawa. Administrative/technical/material support: Okuda, Nojiri. Study supervision: Okuda, Nojiri.

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