CASE REPORT

A Technical Pitfall of Decompression with Direct Repair of a Ragged Edge Using the Smiley-Face Rod Method : A Case Report

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Abstract : The smiley-face rod method has been reported to be a successful technique for reducing slippage and repairing pars defects in lumbar spondylolisthesis. However, we encountered a patient who developed right L5 radiculopathy with muscle weakness after use of the smiley-face rod method. The patient was a 19-year-old female judo player who had undergone direct repair surgery using the smiley-face rod method for terminal-stage lumbar spondylolysis. Postoperatively, she developed paresthesia on the lateral side of the right thigh with weakness of the right tibialis anterior and extensor hallucis longus. Computed tomography showed right foraminal stenosis at L5 with the floating lamina shifted ventrally and apophyseal ring fracture. In this case, the spondylolysis fracture angle differed between the left and right sides, with the fracture line on the right side running more sagittally. As a result, the floating lamina was shifted ventrally on the right side by compression and the right L5 intervertebral foraminal space was narrowed due to the ventral shift in the floating lamina and the apophyseal ring bone fragment. The shape of the fracture line should be examined carefully before surgery to avoid this technical pitfall. J. Med. Invest. 69 : 308-311, August, 2022

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INTRODUCTION

Lumbar spondylolysis is a stress fracture of the pars interarticularis (1, 2). A study of lumbar motion segments in a three-dimensional finite element model indicated that repetitive hyperextension and rotation contribute to lumbar spondylolysis (3). In 2000 Japanese adults in the general population, the incidence of lumbar spondylolysis was reported to be 5.9% and occurred mainly in athletes (4, 5).

The treatment strategy for lumbar spondylolysis is usually determined by its stage (6). The aim in patients with early or progressive lumbar spondylolysis is bone union by conservative treatment using a hard brace with prohibition of exercise. The goal in the terminal stage is pain control because bone union cannot be expected (7).

There are three main problems with lumbar spondylolysis in the terminal stage : (i) a risk of progression to spondylolisthesis (8) ; (ii) low back pain due to synovitis involving the defect and the adjacent facet joints (9-11) ; and (iii) the possibility of nerve root irritation due to a fibrocartilaginous ragged edge (12). About 40% of patients with lumbar spondylolysis have symptoms (13), and surgery should be considered when conservative treatment fails.

There are three types of surgical treatment for lumbar spondylolysis : decompression, posterior lumbar interbody fusion, and direct repair of the pars interarticularis. Direct repair surgery has the advantage of preserving segmental motion. We perform direct repair surgery using the smiley-face rod method with the aim of simplifying the surgical procedure and shortening the operating time. This method is based on the pedicle screw and V-shaped rod technique reported by Gillet *et al*. in 1999 (14) but with a smaller skin incision.

The surgical indications for the smiley-face rod method at our institution are terminal-stage spondylolysis, symptoms caused by a defect that is resistant to conservative treatment, and slippage limited to Meyerding grade 1.

The smiley-face rod method has several advantages : it preserves segmental motion ; the pedicle screws and U-shaped rod provide biomechanically rigid stability, meaning that the implant will not fall out unless there is pedicle screw loosening ; early return to sports is possible ; and (4) grade 1 spondylolisthesis can be reduced (13). However, we encountered a patient who developed right L5 radiculopathy with muscle weakness after this surgery. Here, we describe a pitfall of decompression with direct repair of a ragged edge using the smiley-face rod method.

CASE REPORT

A 19-year-old female Judo player was referred to our clinic because of low back and left leg pain, which she had noticed during sports activity during the previous year. The pain had gradually worsened. On clinical examination, she had low back pain during extension and tenderness at the L5 spinous processes. All manual muscle test scores were 5 and sensory and deep tendon reflexes were normal. Computed tomography (CT) revealed bilateral terminal spondylolysis at L5 and an apophyseal ring fracture at the endplate (Fig 1). She did not respond to conservative treatment ; therefore, direct repair surgery with decompression was performed using the smiley-face rod method (Fig 2).

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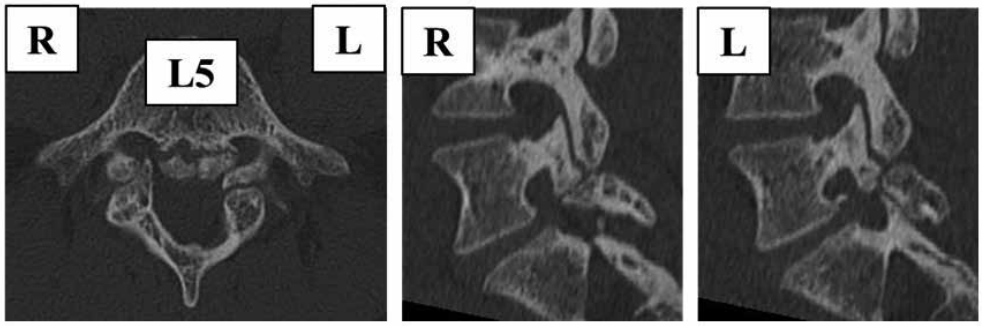

Fig 1. Preoperative computed tomography scans show bilateral L5 spondylolysis in the terminal stage and an apophyseal ring fracture at the endplate.
R ; Right, L ; Left

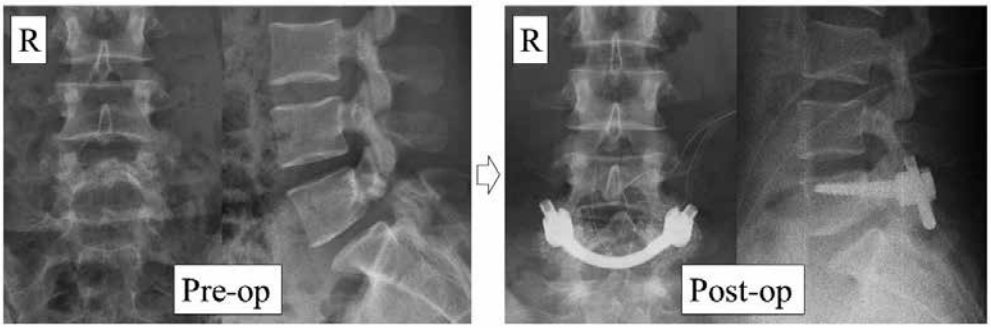

Fig 2. Pre-op and post-op X-rays
R ; Right, Pre-op ; before initial surgery, Post-op ; after initial surgery

SURGICAL METHODS

The patient was placed prone in a neutral lumbar position on a Hall frame under the intraoperative motor evoked potentials. A 5-cm midline incision was made. The paraspinal musculature was elevated laterally to expose the lamina, pars, and base of the transverse process. The pars interarticularis defect was exposed and the fibrocartilaginous defect curetted. Part of the inferior articular process of the upper lamina was removed to allow effective decompression and to obtain a better bone bed for fusion. The ragged edge was also removed to decompress the nerve root. The apophyseal ring bone fragment was impacted rather than removed because the kinking of the nerve root was adequately released.

Two small 1.5-cm skin incisions were made for insertion of a percutaneous pedicle screw (PPS) 6 cm lateral from the midline on each side. Before insertion of the screws, a cancellous bone graft was harvested from the iliac crest via one of the PPS incisions. Multiaxial PPS systems were inserted bilaterally under fluoroscopy using the Weinstein method. A 10-cm-long rod was bent into a U-shape and placed just caudal to the spinous process. Next, the bent rod was attached to the head of each PPS using a screw extender as a guide. The reduction tool was then inserted over the screw extender, twisting clockwise, and the bent rod was pushed into the screw head, thereby reducing the vertebral slippage. By pressing the bent rod against the spinous process using a rod pusher, we were able to fix the floating lamina more firmly. Fluoroscopic imaging after insertion of the screws confirmed correct screw and rod placement. Finally, bone grafts were implanted onto the pars defects and the wound was closed.

Postoperatively, the patient developed paresthesia on the lateral side of the right thigh and weakness of the right tibialis anterior and extensor hallucis longus. A CT scan showed right foraminal stenosis at L5 with the floating lamina shifted ventrally and apophyseal ring fragments (Fig 3A).

We performed revision surgery to repair impingement of the L5 nerve root. The floating lamina was pulled up to the dorsal side and the right L5 root was confirmed. The ragged edge and

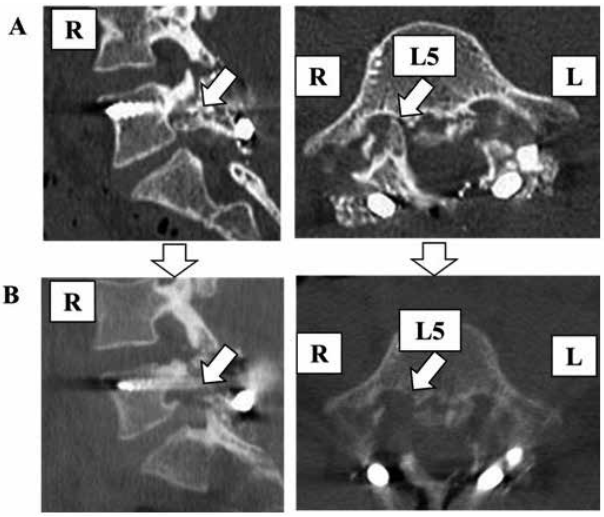

Fig 3. Images obtained (A) after initial surgery using the smiley-face rod method, in which the arrows show right-sided foraminal stenosis at L5 due to the floating lamina being shifted ventrally and the presence of an apophyseal ring fragment, and (B) after revision surgery, in which the arrows indicate decompression of the foraminal space at L5 after additional resection.
R ; Right, L ; Left

the edge of the floating lamina were resected and fixed again (Fig 3B). The patient's numbness disappeared and her muscle strength improved immediately after revision surgery.

DISCUSSION

Historically, surgical management of spondylolysis has included posterior and posterolateral fusion. Intersegmental fusion results in loss of a motion segment and may be complicated by degenerative disease at an adjacent segment. Pars interarticularis repair has the advantage of sparing motion segments.

In 1970, Buck *et al*. described fixation of the pars with instrumentation (14). This technique involves fixation of screws that penetrate directly through the pars. However, many surgeons found it technically difficult to fix the screws across the defect. Several alternative techniques have been described but have had variable success. In 1986, Nicol *et al*. described a method for fixation around the transverse and spinous processes that included tension band wiring (15) while Morscher *et al*. developed a hook and screw method (16). Furthermore, following the introduction of PS in the 1990s, direct repair techniques were developed. Salib *et al*. described a method of pedicle screw and segmental wiring (17) and Tokuhashi *et al*. reported a pedicle screw and hook method (18). In 1998, Songer *et al*. reported a surgical procedure using a cable-screw construct (19), and in the following year, Gillet *et al*. reported a method that used a V-shaped rod (20). Since 2000, minimally invasive surgery consisting of spinal endoscopy and PPS placement has been developed and used to treat spondylolysis (12, 21).

We repaired the pars defect in our patient using the smiley-face rod method with the aims of simplifying the procedure, shortening the operating time, and allowing an early return to sports. This was the "V-rod" method first reported in 1999 by Gillet *et al*. (20). When the screw heads and rod were subsequently noticed to resemble a smiling face on anteroposterior plain radiographs, Yamashita *et al*. (16) coined the term "smiley-face rod" method. Lumbar spondylolisthesis is more common in patients who are very active and wish to return to sports or work as soon as possible. Minimally invasive surgery has many benefits in these patients. However, in this case we encountered a patient who developed right L5 radiculopathy with muscle weakness after use of the smiley-face method. Below, we discuss this potential pitfall and how it might be avoided.

The direction of the fracture line at the point of separation depends on the type of sport played (22). The spondylolysis fracture angle (SFA) seen on a CT scan indicates the main lumbar motion that resulted in the stress fracture at the pars interarticularis. Extension loading may cause a more coronally oriented spondylolysis whereas rotational loading causes a more sagittally oriented fracture line.

In this case, the CT scans obtained before surgery showed that the SFA was larger on the right than on the left and that the fracture line on the right ran more sagittally (Fig 4). Therefore, we consider it likely that the floating lamina was shifted ventrally on the right side by compression and the right L5 intervertebral foraminal space was narrowed by the ventral shift of the floating lamina and the apophyseal ring bone fragment (Fig 5). Our case highlights two potential issues that surgeons should be aware of when using the smiley-face rod method. First, if there is a difference in SFA between the left and right sides, there is a risk that the floating lamina may be shifted ventrally on the side with the larger SFA during fixation. Second, particular care is needed if there is an anterior lesion, such as an apophyseal ring fracture. Care should also be taken in patients with a sagittally oriented fracture to avoid ventral shift of the floating lamina. In this case, we monitored the intraoperative motor evoked potentials, but there was no reaction such as a decrease in amplitude or free running electromyography. To date, there have been no reports of the postoperative impingement at foramen. If the fracture line occurs more sagittally, intraoperative CT after reduction should be done in order to detect the ventral shift of the floating lamina. The defect should be thoroughly dissected. Impaction should also be considered if there is a residual anterior apophyseal ring bone fragment.

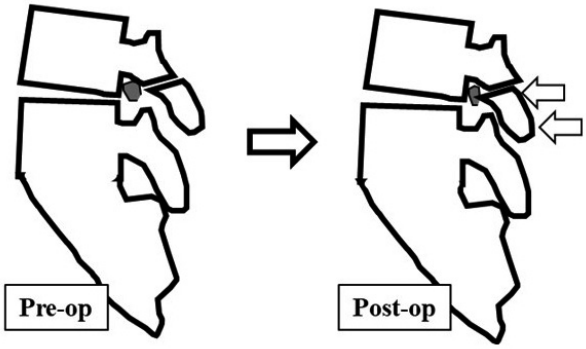

Fig 5. During the surgical reduction procedure, the floating lamina was shifted ventrally on the right side and the right L5 foraminal space was narrowed.
Pre-op ; before initial surgery, Post-op ; after initial surgery

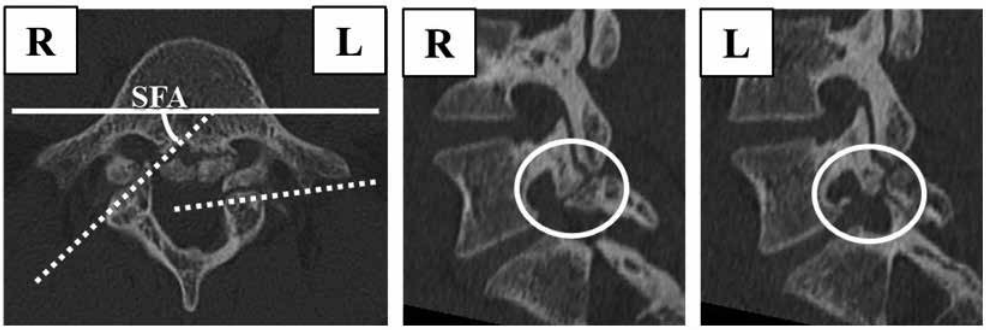

Fig 4. Computed tomography images show a difference in SFA between the left and right sides.
SFA ; spondylolysis fracture angle, R ; Right, L ; Left

CONCLUSION

When performing the smiley-face rod method, the direction of the fracture line should be carefully evaluated preoperatively. Surgeons should be aware of the possibility of intervertebral foraminal stenosis after surgery.

DISCLOSURE OF CONFLICT OF INTEREST

All authors have no conflict of interest.

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