CASE REPORT

The reduction and direct repair of isthmic spondylolisthesis using the smiley face rod method in adolescent athlete : Technical note

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Abstract : Presently, lumbar spondylolisthesis did not have the indication of direct repair surgery because of the difficulty to reduce the slippage. In this report, we presented a case and described a minimally invasive direct repair surgery to reduce and repair the pars interarticularis defects of lumbar spondylolisthesis. First, curettage and removal of the synovium of the pars interarticularis and decompression of nerve root are conducted. Next, cancellous bone is harvested from the iliac crest. And then the Percutaneous Pedicle Screws are inserted bilaterally. A rod is bended and placed just caudal to the spinous process. We can make reposition of slipped vertebra and stabilize the loose lamina more firmly using a reduction tool and a rod pusher. Finally, bone grafts are implanted onto the pars defects. The Smiley face rod method is very useful to reduce the slippage and repair the pars defects in the lumbar spondylolisthesis especially in adolescent athletes. J. Med. Invest. 64 : 168-172, February, 2017

Keywords **:** *Spondylolisthesis, Adolescent, Repair surgery, Reduction, Minimally invasive surgery*

INTRODUCTION

Lumbar spondylolysis is a relatively common disorder that causes low back pain in athletic adolescents (1-3). The cause of spondylolysis in these patients is repetitive stress of the pars interarticularis with subsequent microfracture (4, 5). And it may lead to a bony defect and cause progressive spondylolisthesis in up to 25% of cases (6). In some patients progressive back and radicular pain occur. Treatment for this disorder varies from conservative to surgical, depending on the stage of the fracture and the symptoms.

Surgical treatment for lumbar spondylolysis can be grouped into 3 categories ; decompression, lumbar intersegmental posterior fusion, and direct repair of the pars interarticularis. The direct repair surgery has advantage of preserving the segmental motion, and of unnecessity removal of some anatomic structures. There are several methods of direct repair, and good or excellent results have been reported (7-13). However, direct repair of pars defects has been basically used to treat for younger patients with no evidence of vertebrae instability. Until now, lumbar spondylolisthesis did not have the indication of direct repair surgery because of the difficulty to reduce the slippage.

In this paper, we report an adolescent athlete case having grade 2 lumbar spondylolisthesis that was reduced and fixed by direct repair surgery. For this case, the smiley face rod method was used to repair the pseudoarthrotic pars defects.

SURGICAL METHODS

Our procedure include 5 steps (Fig. 1) : Step 1) Exposure and curettage of the defect in the pars interarticularis. Step 2) Collection of cancellous bone from the pelvis. Step 3) Insertion of a percutaneous pedicular screw (PPS). Step 4) Bending rod insertion, reduction of the slippage, and fixation with PPS. Step 5) Bone graft placement.

The patient is placed prone and lumbar neutral position on a Hall frame. Step 1) A midline skin incision is made (5 cm in length). Using a deep Gerpi retractor the paraspinal musculature is retracted laterally to expose the lamina, pars, and transverse process base. Care is taken not to injure the facet joint capsule. At the patient has radiculopathy due to intervertebral disc and ragged age, we have to perform foraminoplasty. It is necessary to remove a part of the inferior articular process of the upper lamina to perform effective decompression and to obtain a better bone bed. Using a diamond surgical bur and rongeurs, curettage and removal of the synovium of the pars interarticularis and decompression of nerve root are conducted. Step 2) Next, two small skin incision (1.5 cm in length) are made for PPS 6-8 cm lateral from midline. Before insertion of PPS, cancellous bone graft is harvested from the iliac crest through the incision for PPS. Step 3) Anatomic landmarks and fluoroscopy are then used to determine the PPS starting point. It is also possible to confirm the appropriate entry point under the direct vision. A starting hole is burred, and a pedicle probe is used to enter the pedicle. Walls and floor are assessed with a ball-tip sounder, and the hall is tapped for multiaxial PS (Alphatec spine, ILLICO SE-MIS Posterior Fixation System), and then PPSs (usually 35 mm length, 6.5 mm diameter) are inserted bilaterally. Step 4) After insertion of PPSs bilaterally, a rod (usually 100 mm length) is bended to fit, and placed just caudal to the spinous process, an attached to each tulip head of PPS using a screw extender as a guide. In case of slipped vertebra, we use a reduction tool. When the reduction tool is inserted over the screw extender twisting clockwise, the bended rod is pushed into screw head, and then the slipped vertebra is reduced. With bumping the bended rod against the spinous process using a rod pusher, we can fix the loose lamina more firmly. After insertion of the set screw, final fluoroscopic im-

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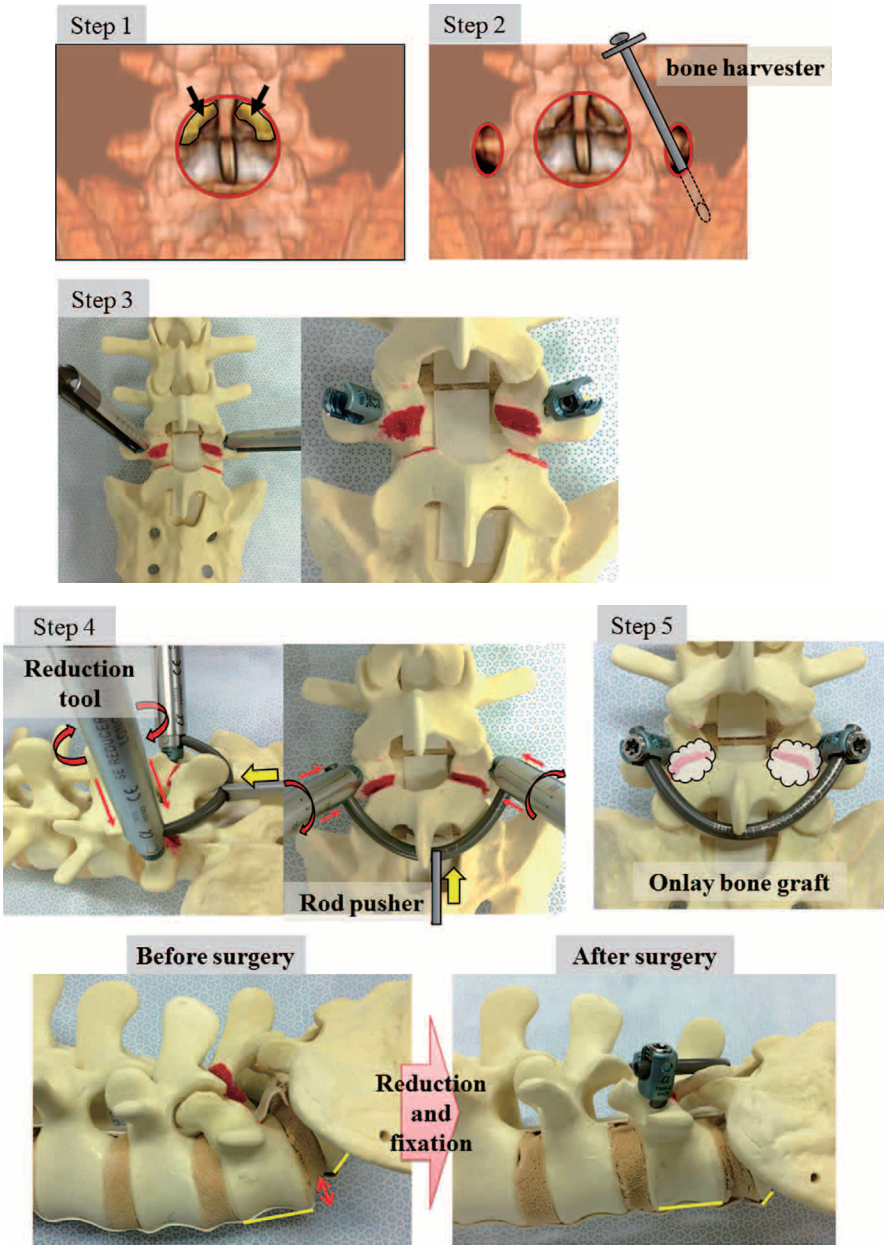

Figure 1. Intraoperative photographs of the steps of the surgical procedure. Step 1. A midline skin incision is made (3-4 cm in length). Exposure and curettage of the defect in the pars interarticularis. It is necessary to remove a part of the inferior articular process of the upper lamina (arrow) to perform effective decompression. Step 2. Two small skin incision (1.5 cm in length) are made for PPS 6-8 cm lateral from midline. Cancellous bone graft is harvested from the iliac crest using the bone harvester. Step 3. Insertion of a percutaneous pedicular screw (PPS) bilaterally. Step 4. Bending rod insertion and fixation with PPS using a reduction tool and a rod pusher. Step 5. Bone graft placement onto the refreshed pars defect. Before (Left) and After (Right) surgery of Smiley face rod method.

aging confirms correct screw and rod placement. Step 5) Finally, bone grafts are implanted onto pars defects. Closure of the wound is performed as routine, and a drainage tube is left.

POSTOPERATIVE MANAGEMENT

The drain is removed about 48 hours after surgery. And the patient begins to stand and walk two or three days after the surgery with a soft brace. Although the soft brace is used for 3 months usually, the wearing the brace is not kept strictly because the construct is solid enough to secure the posterior arch until fusion. The patient performs trunk muscle isometric exercises and stretching for tight hamstrings. Almost six months after surgery, the patient was allowed to start light exercise such as jogging.

ILLUSTRATIVE CASE

A 13-year old boy presented with a 12-month history of chronic severe low back pain and bilateral buttock pain. He was a very active baseball player as a catcher. Plain radiograph and CT scan revealed terminal stage of bilateral spondylolysis of L5 and grade 2 spondylolisthesis (Fig. 2). The anterior translational movement was 10 mm and percent slip was 39%. A severe rounding of the sacrum was observed. The rounding index of sacrum (14) was 43%. And

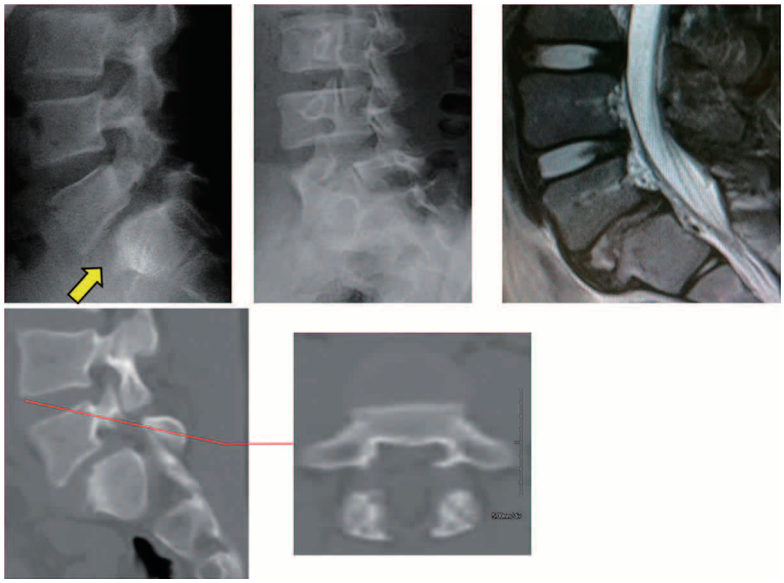

Figure 2. Preoperative X-ray and CT scans revealed terminal stage of bilateral spondylolysis of L5 and grade 2 spondylolisthesis. A severe rounding of the sacrum was observed (arrow). And MRI showed a little degenerative L5/S disc.

MRI showed a little degenerative L5/S disc. Conservative treatment including NSAIDs and orthosis for 6 months had been unsuccessfully. The boy and his parents decided to visit a special sports medicine clinic for a second opinion regarding the treatment. When he consulted to our hospital, he had no muscle weakness and tendon reflex abnormality, but he could not walk without a stick because of severe low back and buttock pain. Therefore, he and his parents have hoped for surgical treatment.

We completed the procedure described above without any complications (Fig. 3). The slippage was reduced to 11% from 39%. Postoperative course was uneventful, and he did not complain of any low back and buttock pain. Three months postoperatively, the remodeling of sacrum was identified in the lateral plain radiograph without loosening of PS and a recurrence of vertebral slippage (Fig. 4). The rounding deformity index of sacrum was also improved to 22% from 43% due to remodeling of the sacrum dome. Now, it is 1 year postoperatively, he has kept good clinical course.

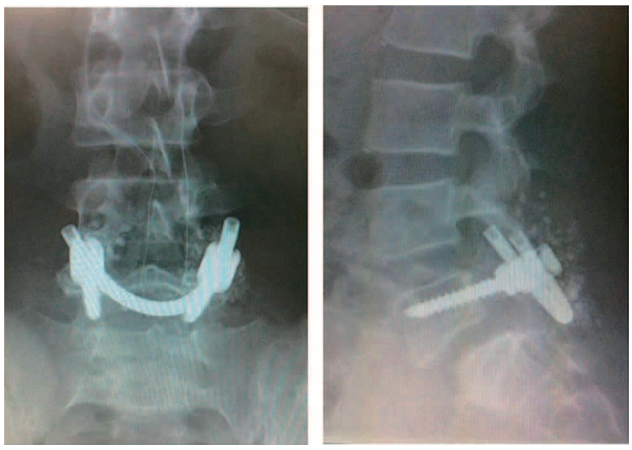

Figure 3. Postoperative X-ray obtained in the case (Smiley face rod method).

DISCUSSION

Historically, surgical management of isthmic spondylolisthesis has included posterior fusion, and pars interarticularis repair. The pars interarticularis repair surgery seems to be a most ideal procedure for lumbar spondylolysis due to its advantage of low invasiveness and sparing motion segment. A lot of reports which describes the good or excellent outcomes of direct repair surgery (7-13). On the other hand, direct repair surgery does not have indication for spondylolisthesis until now, because it is difficult to reduce slipped vertebra. It has been general to select posterior segmental fusion surgery, e.g. posterior lumbar interbody fusion (PLIF) or transforaminal lumbar interbody fusion (TLIF), for severe lumbar spondylolisthesis. However, as consequence of fusion surgery, the affected level becomes motionless, leading to the possible appearance of degenerative changes at the adjacent levels above the fusion, although this has never shown in adolescents (15-19).

Several techniques have been reported, including screw placement into the defects (Buck's technique (11)), the wiring method (8), and the PS and hook method (10, 12). Buck's technique is a

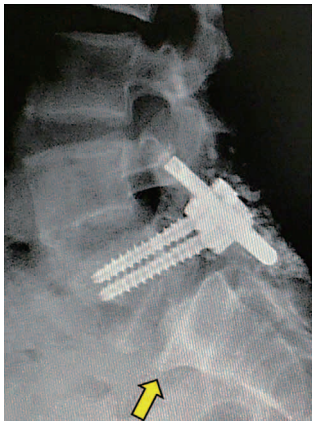

Figure 4. Lateral plain X-ray of 3 months after surgery. The remodeling of sacrum was identified (arrow).

procedure to fix with screws penetrating directly through the pars. Although a lot of surgeons have reported satisfactory outcomes with the Buck's technique, the technique has two shortcomings (19-21). One is the difficulty of proper placement of screws, and the other is a decrease of the area for bone grafting. The wiring method is a procedure to stabilize the loose posterior arch using wire. However, the placement of the wires under the transverse process is difficult, and can lead to significant bleeding (22). The PS and hook method is a procedure to fix and compress the pars defects using pedicle screws and angled lamina hooks. Also about its method, good or excellent results have been reported clinically and biomechanically. However, when the affected lamina have to be removed partially for decompression, it may become difficult to fix loose lamina firmly (14). And it is very difficult to make reposition of the slipped vertebra by the PS and hook method.

In this paper, we introduced the effectiveness of Smiley face rod method as a direct repair surgery for an adolescent athlete having severe spondylolisthesis. At the beginning, the smiley face rod method was called "V-rod method" (23). The screw head and rod on the Anterior-posterior plain radiograph looks like a smiley face, thus recently this technique is called "smiley face rod method". Ulibarri *et al.* (24) reported that biomechanical evaluation of the Smiley face rod method showed excellent stability of a spondylolytic defect in comparison to the other direct repair surgery. For appropriate reduction of slipped vertebra, the reduction tool and rod pusher we have used were very effective and easy to use (Fig. 5). We can easily make reposition of the slipped vertebra with only twisting the reduction tool over screw extender. There are two demanding points in the procedure. One is appropriate bending rod. The rod is bended symmetrically in a character of "U" and set up from a midline wound. The other is setting the rod tightly to the inferior of spinous process. At that time, the rod is hammered to spinous process using rod pusher.

The sacral dome of the case in this paper showed severe rounding deformity. High grade slippage was recently reported to be closely related to rounding deformity (25). Sairyo *et al.* (26) radiographically examined 46 athletes under 18 years of age with spondylolysis at L5 and revealed that the deformity occurred secondary to the slippage. Higashino *et al.* (27) histologically analyzed the anterior corner of the deformed vertebra, and concluded that deficient endochondral ossification of the growth plate in the anterior upper corner of the vertebra could be the pathomechanism of the rounding deformity of the sacrum. And they assumed that the repetitive overstresses at the anterior corner of the vertebral body might be the crucial factor that led to dysfunction of the ossification mechanism of the growth plate. Terai *et al.* (28) demonstrated that in pediatric patients with spondylolisthesis, reducing the mechanical stress may restore the normal function of the growth plate with the subsequent normalization of the rounding deformity. In our case, we considered that reducing the mechanical stress because of the entirely reduction and firmly fixation surgery was the cause of rapid normalization of the sacral rounding deformity.

Figure 5. Photograph of surgical instrument for Smiley face rod method. Left ; rod pusher Center ; reduction tool Right ; screw extender

Although the follow-up period in this case is short, it seemed sufficient to show the effectiveness of Smiley face rod method. Studies with longer follow-up are needed to evaluate how much sliding and disc degeneration does it become the adaptation of this method.

CONCLUSIONS

The Smiley face rod method is very useful to reduce the slippage and repair the pars defects especially in adolescent athletes.

DISCLOSURE

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

CONFLICTS OF INTEREST

There are no conflicts of interest with people or organizations that could bias the nature of this report.

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