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Technical Notes & Surgical Techniques

Reduction of high-grade lumbosacral spondylolisthesis by minimally invasive transforaminal lumbar interbody fusion: A technical note☆

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ABSTRACT

Objective: To demonstrate the feasibility and efficacy of reduction of high-grade lumbosacral spondylolisthesis via a minimally invasive approach.
Summary of background data: Reduction of high-grade spondylolisthesis remains controversial and technically challenging. Although minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) has gained wide acceptance in recent years, it still has not been reported to achieve complete reduction of high grade slips.
Methods: In this technical note, the authors present a case of L5/S1 Meyerding Grade III fixed spondylolisthesis managed by MI-TLIF with percutaneous screws. Surgical techniques and key steps for reduction are described in detail.
Results: A 50-year-old woman had low back pain for 8 years. She also presented with radiculopathy of lower limbs and frequency/urgency of urination. The radiographs and computed tomography (CT) of the lumbar spine demonstrated degenerative spondylolisthesis, Meyerding grade III, at the level of L5/S1. The slippage was fixed on dynamic radiographs and there was neuroforaminal stenosis on the magnetic resonance image. The patient underwent MI-TLIF with percutaneous pedicle screw-rod fixation for arthrodesis at L5/S1. Her symptoms subsided after the operation. The one-and-half year follow-up radiographs, including CT, demonstrated complete reduction of the high-grade slippage and fusion of the lumbosacral spondylolisthesis.
Conclusion: Minimally invasive TLIF is a viable option for reduction of high-grade spondylolisthesis at L5/S1.

Introduction

Arthrodesis has become a widely accepted option for surgical management of symptomatic lumbosacral spondylolisthesis. Meyerding classification, one of the most commonly used grading systems, grades the slippage in accordance to the vertebra below [1]. Various surgical approaches have been applied to treat low-grade spondylolisthesis (Meyerding grade I and II), including open and minimally invasive procedures [2–7]. However, the surgical procedure of choice for high-grade spondylolisthesis is still uncertain [8–10]. Fusion in situ, partial, or complete reduction has been reported. Reduction of high-grade lumbosacral spondylolisthesis and arthrodesis with interbody graft remain controversial. Attempts to reduce the slippage are technically challenging and usually achieved via a standard open approach. Minimally invasive transforaminal lumbar interbody fusion (TLIF) has not been reported to reduce high-grade slip.

In this report, we present a case of high-grade lumbosacral spondylolisthesis managed by minimally invasive TLIF, which achieved complete reduction and fusion. The technique is described in detail.

Illustrative case

A 50-year-old woman (157 cm, 54 kg, BMI: 21.9 kg/m^2, non-smoking), who did not have any systemic diseases and trauma, had suffered from low back pain for 8 years. She started to have radicular pain and numbness of the bilateral lower limbs three months prior to presentation. There were also frequency and urgency of urination. These symptoms were refractory to medical treatment and rehabilitation. The radiographs and computed tomography (CT) of the lumbar spine demonstrated degenerative spondylolisthesis, Meyerding grade III, at the level of L5/S1 (Fig. 1). The slippage was fixed on dynamic radiographs and there was neuroforaminal stenosis on the magnetic resonance image (MRI). She had a normal score (T-score = 0.2) on dual-energy X-ray absorptiometry.

The patient underwent minimally invasive TLIF for arthrodesis at L5/S1. The peri-operative course was uneventful and her symptoms

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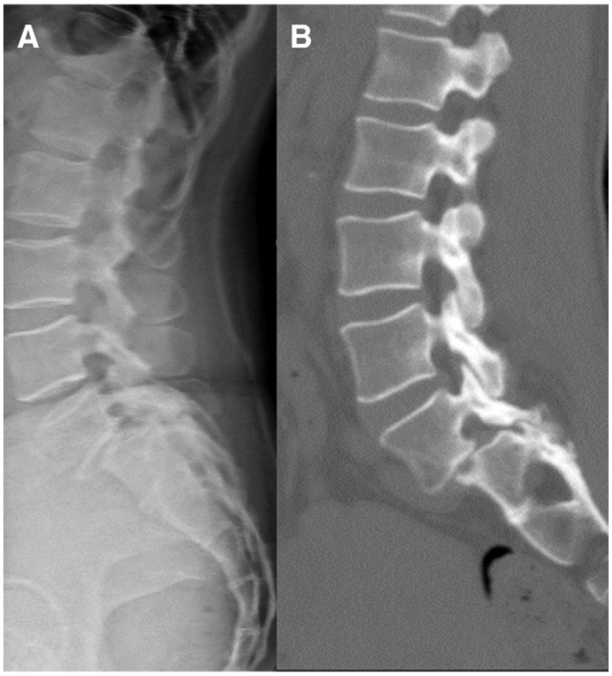

Fig. 1. Pre-operative radiographs: Degenerative lumbosacral spondylolisthesis, Meyerding grade III, L5/S1. (A) Lateral radiograph (B) Computed tomography, sagittal view.

improved after the operation. She no longer took narcotics and benzodiazepines afterwards. One month after the operation, the wounds healed well (Fig. 2). The one-and-half year follow-up radiographs demonstrated complete reduction of the high-grade slippage and fusion of the lumbosacral spondylolisthesis without any adjacent lucencies (Fig. 3). The surgical techniques are described below.

Surgical TECHNIQUE

After general anesthesia and intubation, the patient was placed in a prone position on the radiolucent operating table (Allen Spine, Allen Medical System, MA). Natural lumbar lordosis was maintained with

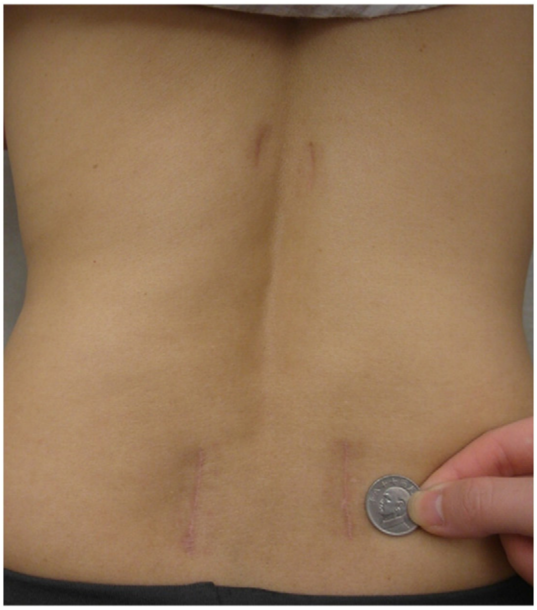

Fig. 2. Post-operative photo, one month post-operation, the wounds healed well.

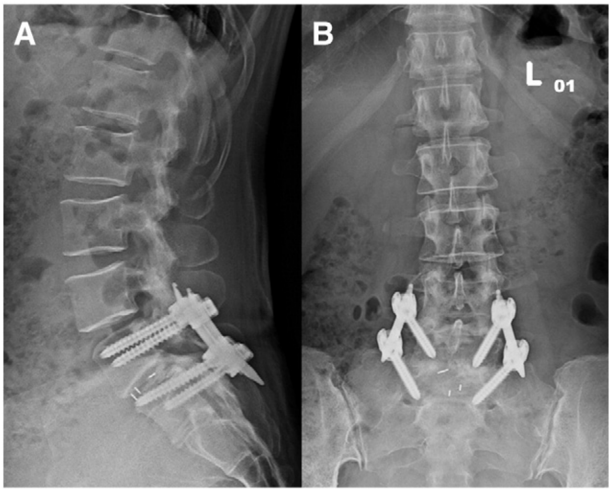

Fig. 3. One-and-half year post-operative radiographs, demonstrating complete reduction of lumbosacral spondylolisthesis by minimally invasive TLIF. (A) Lateral radiograph (B) Antero-posterior radiograph.

adequate cushion. Bi-planar fluoroscopy was used to identify and mark the skin overlying the indexed facet complex. The C-arm was slightly angled (approximately 15°–20°) to obtain optimal visualization of the targeted pedicles and disc spaces on an anteroposterior view of the L5/S1 level. An initial skin incision was made approximately 35 mm from the midline, the length of which contained the upper and lower levels of the targeted pedicles. The incision was then made deep in to the superficial fascia of the paraspinous muscles. Using progressively larger dilator tubes from the METRx set (Medtronic Spine and Biologics, Memphis, TN), a muscle sparing surgical corridor (Wiltse approach) was created, and a final 26-mm diameter tubular retractor was set up. Under operating microscopes, a facetectomy was carried out using high-speed drills and Kerrison rongeurs through the working channel. The removed bone was later used for interbody fusion graft material. After the targeted annulus and the exiting/traversing nerve roots were identified, a discectomy was performed. Osteophytes and bony spurs which obstructed the disc space were resected with shavers and Kerrison rongeurs. Serial disc space distractors were used to facilitate opening of the disc space. The endplates of the superior and inferior vertebras were meticulously prepared for subsequent interbody fusion. Visualization of adequate discectomy and parallel endplates was confirmed under microscopes. Local bone chips, harvested from the facetectomy, together with Grafton demineralized bone matrix putty (Osteotech, Medtronic Spine and Biologics, Memphis, TN) were then placed into the anterior disc space and pushed toward the opposite side to maximize the amount of graft. After insertion of an appropriately sized trial cage, a Capstone cage (Medtronic Spine and Biologics, Memphis, TN) 22 mm in length and 8 mm in height filled with locally harvested autologous bone and demineralized bone matrix, was inserted. The position of the interbody cage was then confirmed by lateral fluoroscopy. In the contralateral side, similar procedures were performed, including skin incision, muscle dilation, and facetectomy for foraminal decompression, but there was no need for discectomy or interbody work.

Percutaneous screws and rods were subsequently placed for reduction and fixation of the L5/S1 spondylolisthesis. In the following steps, the trajectory/position of each instrument was checked by C-arm fluoroscopy (both angled anteroposterior and lateral views), and each step was performed at both sides simultaneously by the surgeon and the first assistant. A simple PAK (Pedicle Access Kit) needle was advanced at the intersection of the lateral facet and the transverse process into the medullary canal of each pedicle. A guidewire was inserted through the PAK needle into the body of the vertebra, and the PAK needle was then removed. Serial dilators were used to make paths of appropriate dimensions, and the largest one served as a tissue protection sleeve during the taping step. The pedicle was prepared by placing the tap over the guidewire and through the dilation sleeve. During the process of tapping, the screw length could be estimated by referencing the depth marks on the tap. The Sextant II pedicle screw system (Medtronic Spine and Biologics, Memphis, TN) was used. In our practice, CT scans were routinely performed on every patient and the diameter of each pedicle could be measured. The diameter of 6.5 mm had been our primary choice unless the pedicle appeared thinner on the preoperative CT scan. Larger screws came in sizes of 7.5 mm and 8.5 mm, and were preserved for screw revision if necessary.

For reduction of high-grade spondylolisthesis, we measured and calculated the required loading length differences of the cannulated screws before performing the reduction step. The amount of reduction could be estimated with a depth gauge inserted against the listhesed vertebra and the neutral vertebral body (Fig. 4A). The difference of depth could be demonstrated on the top of the depth gauge (Fig. 4B), and the space, or the "laxity", of both extenders could be adjusted according to the measured difference (Fig. 4C).

After proper adjustment of both extenders, the extenders were then connected and mounted with the rod inserter. The rod should be able to pass through the extenders easily if the "laxity" is sufficient (Fig. 5A). When the rod is in the appropriate position, the extender on the listhesed vertebral level was reduced to the same depth as the one on the neutral level. Both extenders were then evenly reduced to the final position which was "RD" in the system (Fig. 5B). The reduction of vertebra comes from the reduction of different screw depths to their final position on the rod. Finally the rod was locked, and after the position of the whole construct was checked by bi-planar fluoroscopy, the wound was closed.

Discussion

In this article, the authors successfully reduced a Meyerding grade III lumbosacral spondylolisthesis by minimally invasive TLIF approach. The patient recovered well without complications. Patients with high-grade spondylolisthesis may suffer from chronic back pain, radicular pain, and claudication. Indications for surgical management include unresponsiveness to medical treatments, neurological deficits, or severe lumbosacral kyphosis with sagittal imbalance. The choice of surgical procedure is the subject of debate, and the main controversy exists between performing fusion in situ and fusion after reduction of the deformity [11–14]. Fusion in situ has potential risks, including instability, pseudoarthrosis, slip progression, and uncorrected deformity. There is also a concern for the need to extend the fusion construct for improved stability [12]. However, the attempt to reduce this high grade spondylolisthesis is not always achievable and sometimes risky. Usually, the reduction requires open procedures and specialized techniques, including cast reduction [7], Harrington rod distraction [15], and gradual reduction using Magerl's external fixator followed by circumferential fusion [16]. Minimally invasive TLIF has been used to treat low-grade spondylolisthesis with good clinical results [17–19]. Nevertheless, there is a scarcity of reports addressing the ability of reduction with minimally invasive techniques.

Minimally invasive TLIF can achieve similar clinical results than conventional open procedures for fusion in spondylolisthesis. Using multiple but smaller skin incisions, less muscle destruction and little neural retraction, minimally invasive TLIF allows good fusion outcomes [20–24]. Minimally invasive spine surgery is intended to reduce approach-related morbidity inherent in conventional open surgery, including blood loss during the operation, paraspinous muscle injury, and iatrogenic muscle denervation causing atrophy and decreased trunk extensor strength. The successful reduction of Meyerding grade III spondylolisthesis through a minimally invasive procedure relies on several key steps. Bilateral facetectomy, adequate

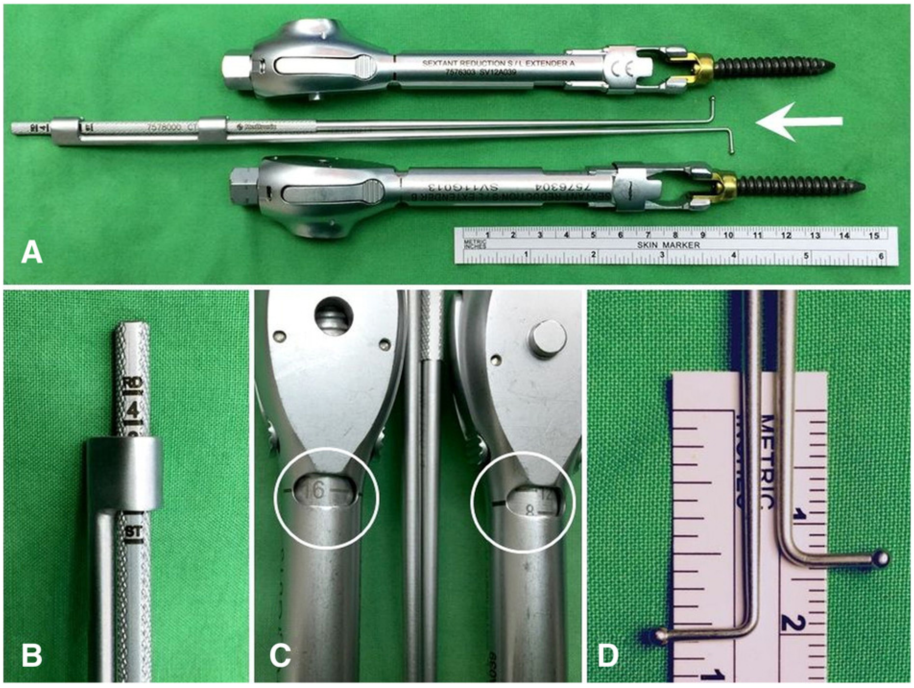

Fig. 4. The estimation of the amount of reduction. (A) A depth gauge (arrow) could be deployed in the measurement of the amount of listhesis. (B) When the depth gauge is inserted against the neutral vertebral body and the listhesed vertebral body, the depth difference could be shown on the top of the instrument. (C) The screw extender laxity could be adjusted accordingly (circles). (D) The depth difference is 6 mm in this illustration.

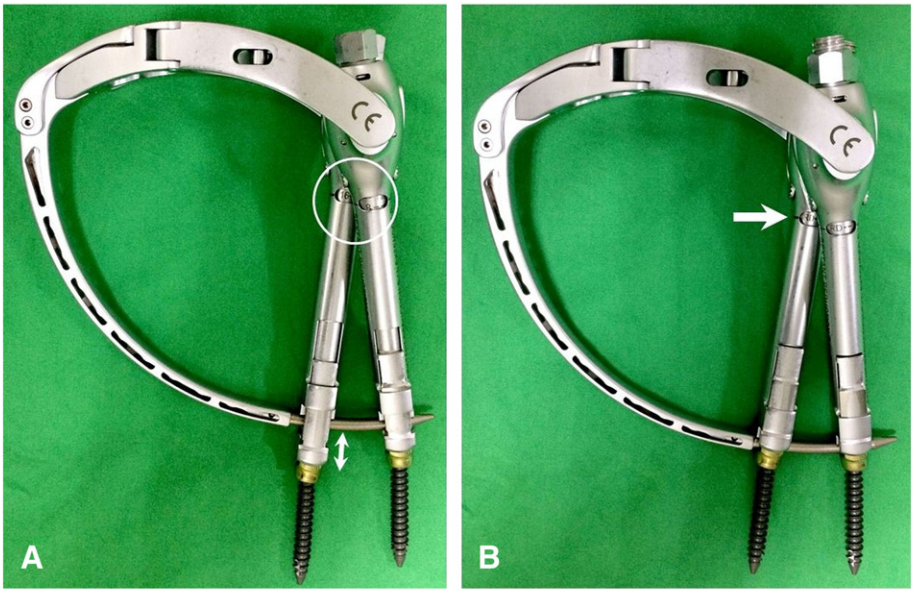

Fig. 5. Illustration demonstrating how the reduction was made. (A) When the rod is inserted, it passes through the space created by the extenders, the laxity. The extender on the listhesed vertebra is supposed to have more space than the one on the neutral level (circle, 16 and 8 respectively, in this illustration), and the difference (double arrow) can be measured with the depth gauge. (B) When the rod is in proper position, the extender on the listhesed vertebra was reduced to the same depth as the one on the neutral vertebra. Both extenders are then evenly reduced to the final position, which is RD in the system (arrow), hence the reduction is made.

discectomy, and good purchase of pedicle screws are the cornerstones for correction. The well-designed screw-rod reduction system can generate enough power to restore the lumbosacral alignment. However, a larger series of patients is required to corroborate the ability of reduction by this minimally invasive TLIF approach. Moreover, the long-term durability and fusion rates of this procedure in high grade spondylolisthesis need further evaluation.

Conclusion

Reduction of high-grade lumbosacral spondylolisthesis can be achieved by minimally invasive TLIF.

Disclosure

Conflicts of Interest and Source of Funding:

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