

# Return of motor evoked potentials after knee flexion in the setting of high-grade spondylolisthesis

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## Abstract



**Purpose** To present a case of loss of motor-evoked potentials (MEPs) to the left foot in the supine position after a partial reduction and instrumented fusion from L4 to pelvis which was managed successfully without revision or removal of implants.

**Methods** We report a patient with high-grade spondylolisthesis who demonstrated loss of motor-evoked potentials after posterior spinal fusion and transfer to supine

position. The patient's knees were flexed to 90° and signals were immediately restored. Systemic steroids were administered and circumferential fusion was delayed 21 days. Anterior-interbody cage was placed without complication.

**Results** She was discharged on post-operative day 2. At 7 months, she is pain free and doing well with plans to return to gymnastics completely.

**Conclusions** Knee flexion can be instituted when encountering a neuromonitoring signal change following posterior spinal fusion for spondylolisthesis as a means to alleviate acute nerve stretch injury and may in some cases prevent the need to lessen the correction.

**Level of evidence** IV.

**Keywords** Spondylolisthesis · Neurologic deficit · Neuromonitoring change · Knee flexion

## Case presentation

A 9 year-old otherwise healthy female with a Meyerding Grade 3 spondylolisthesis at the level of L5/S1 presented with symptoms of radicular left leg pain and intermittent toe walking bilaterally (Fig. 1). On physical exam she displayed hamstring spasticity and positive left straight leg test and MRI of the lumbar spine confirmed foraminal and canal stenosis (Fig. 2).

## Review of condition

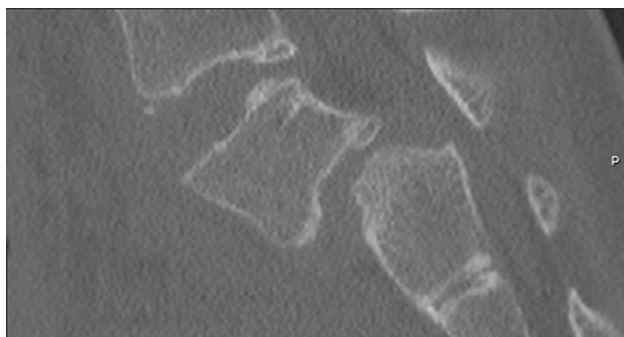
In children and adolescents, spondylolisthesis is a common cause of low back pain. In considering in situ fusion versus reduction and fusion, a recent meta-analysis showed

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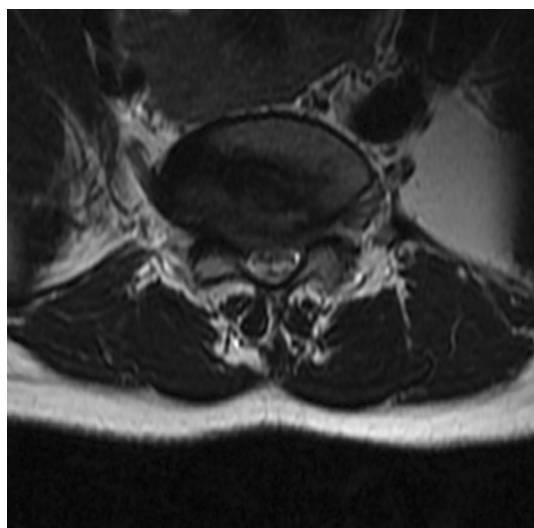
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**Fig. 1** Sagittal CT imaging demonstrating Grade 3 Spondylolisthesis. Reproduced with permission from the Children's Orthopaedic Center, Los Angeles



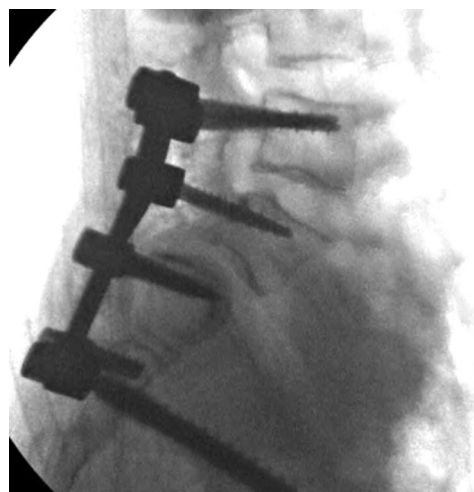
**Fig. 2** MRI T2-weighted Fast-Recovery Fast Spin-Echo (FRFSE) axial image of L5-S1 junction highlighting foraminal and canal stenosis. Reproduced with permission from the Children's Orthopaedic Center, Los Angeles

increased fusion rates with reduction without a significant overall incidence of neurologic injury, but could not provide definitive treatment guidelines [1]. The advantages of surgical reduction of a high-grade spondylolisthesis include improved fusion rate and sagittal alignment [2–5]. The addition of anterior column support with posterior instrumentation has been shown to help maintain reduction [6]. However, a retrospective comparative study reported a neurologic complication frequency of 21% [5]. While mostly transient, serious permanent injuries have also been reported. [5] We present a case of loss of motor-evoked potentials (MEPs) to the left foot in the supine position after a partial reduction and instrumented fusion from L4 to pelvis which was managed successfully without revision or removal of implants. Informed consent was obtained for presentation of this case.

## Procedure

Given the patient's activity level as a gymnast, we proposed a single-stage circumferential fusion. Intraoperative monitoring included Somatosensory Evoked Potentials (SSEP), Motor Evoked Potentials (MEPs), and electromyography (EMG). First an instrumented fusion from L4 to sacrum, wide L5 nerve root decompression, and partial reduction was performed with the patient in prone positioning with flexion of the hips and knees. Following partial reduction, the L5 nerve roots appeared subjectively taut, and so further reduction was not performed. The posterior procedure was carried out without changes in neuromonitoring (Fig. 3).

The patient was positioned for the anterior lumbar interbody fusion (ALIF) in a supine position with hips and knees straight on a flat table. After prepping and draping, but just prior to incision MEPs were noted to be decreased to the left tibialis anterior and abductor hallucis, which persisted despite adequate blood pressure, hemoglobin and technical troubleshooting. To minimize stretch of the L5 nerve roots her knees were flexed to 90°. Within minutes the left foot MEPs normalized, and all neuromonitoring was at baseline. To minimize the risk of nerve injury, as well as the fact that it would be technically difficult to perform an ALIF with the knees flexed at 90°, the ALIF was aborted. A wake-up test demonstrated full strength and sensation of distal extremities. In consultation with Neurosurgery, we instituted methylprednisolone intravenously for 24 h. Post-operatively her knees were flexed while in bed, but no restrictions were implemented while working with physical therapy or when out of bed. She was discharged on post-operative day two with unchanged serial



**Fig. 3** Fluoroscopic lateral imaging demonstrating L4-pelvis posterolateral spinal fusion. Reproduced with permission from the Children's Orthopaedic Center, Los Angeles

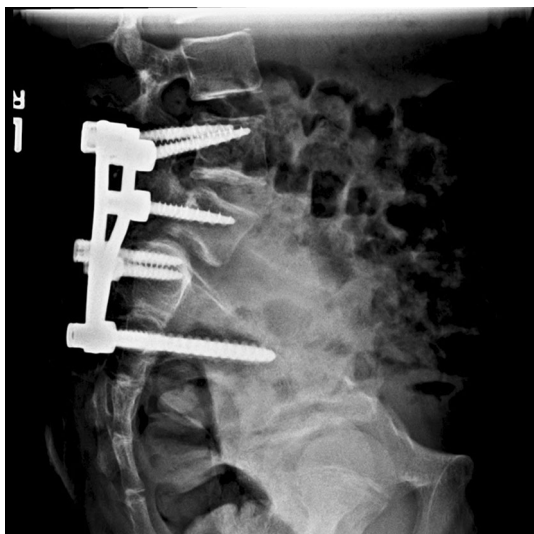
examinations which included while standing upright and ambulating (Fig. 4a, b).

At post-operative day six we hoped to complete circumferential fusion. However, the patient was toe walking and reported a “stretching” sensation through the back of both legs. With her knees extended, she could not dorsiflex her ankles beyond neutral. The patient was admitted, systemic steroids were given for 24 h with the knees flexed and her exam returned to normal by hospital day two and she was discharged. Twenty-one days from index procedure her exam had again returned to normal which was symmetric bilaterally and she underwent ALIF at L5-S1 (Fig. 5) without complications or neuromonitoring changes.

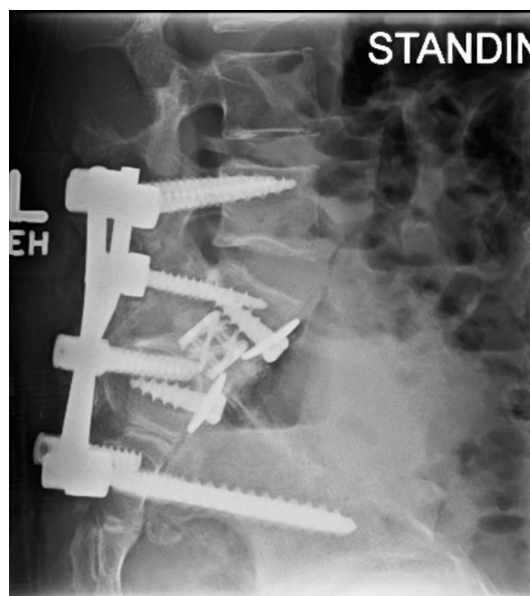
### Rationale for intervention

We describe loss of MEPs presumably due to an acute L5 nerve stretch injury in a patient with high-grade spondylolisthesis following partial reduction and instrumentation, and subsequent supine positioning with extension of the hips and knees. By flexing the knees to 90°, the MEPs quickly returned to normal. While it is impossible to state that knee flexion caused return of MEPs, the immediate return of signals, and the anatomy of the nerves suggest that is the probable cause. As the L5 contribution to the sciatic nerve lies posterior to the knee joint, knee flexion minimizes stretch on the nerve.

There is evidence that reduction with anterior column support can restore sagittal alignment and improve fusion



**Fig. 4** Lateral radiograph after index procedure. Reproduced with permission from the Children’s Orthopaedic Center, Los Angeles



**Fig. 5** Lateral radiograph after placement of anterior interbody cage at L5-S1. Reproduced with permission from the Children’s Orthopaedic Center, Los Angeles

rates, which is why we elected to use this technique for a 9 year old active in gymnastics [2–4]. However, sagittal plane deformity correction is associated with a higher incidence of intraoperative signal changes [7, 8]. Additionally, a retrospective study found that 12.5% of patients who underwent reduction had suffered a neurological deficit [9]. While L2, L3, and L4 nerve injuries have all been described after a reduction, L5 remains the most common in high-grade spondylolisthesis [10]. Consequently, assessment and monitoring of the L5 nerve root function preoperatively, intraoperatively using neuromonitoring and postoperatively is of the utmost importance.

As was true for our case, the most common nerve injury in spondylolisthesis is the L5 nerve root. Our patient likely had irritation of this nerve in part due to tension from the partial reduction that was aggravated by the extension of the knees when supine. We opted for a limited reduction based on our intraoperative visual assessment of the nerve roots. Petraco et al. showed in their biomechanical study that L5 nerve strain increases non-linearly the closer one proceeds to complete reduction, as 71% of the total strain occurs during the last 50% of a complete reduction [11].

We cannot determine the effect, if any, that systemic steroids had in the acute setting of this patient’s likely nerve stretch injury. Applying the guidelines from research on spinal cord injury we do not recommend it as a standard for every patient who presents with acute nerve stretch injury in the setting of spondylolisthesis [12, 13]. However, there is a deficiency of evidence for its efficacy in the pediatric population and we carefully weighed the risks and

benefits of its short term use. In our case, the patient exhibited toe-walking, a “stretching” sensation in the back of the legs, and decreased left foot dorsiflexion with the knee straight on post-operative day 6 suggesting a recurrence of nerve root stretch or irritation. Fortunately this resolved with further knee flexion. We believe that the decision to stage after recovering from a loss of MEPs was sound considering the viable option of posterolateral fusion alone as a treatment with reasonable clinical outcome [14, 15]. We also recommend that in many cases routine flexion of the knees postoperatively following reduction of spondylolisthesis may be beneficial to minimize subsequent stretch on the L5 nerve root both for prevention and management of L5 symptoms.

This case report presents an additional tool in the surgeon’s armamentarium when encountering abnormal intraoperative neuromonitoring changes or clinical symptoms following the reduction of spondylolisthesis. Knee flexion should relieve L5 nerve root stretch given the position of the nerve relative to the knee joint and in some cases may prevent the need for revision or removal of implants, as was the case with this patient.

## Follow-up

She was discharged on post-operative day 2. At 12 months, she is pain free and doing well with plans to return to gymnastics.

## Compliance with ethical standards

**Conflict of interest** None of the authors received financial support for this study.

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