Spino-pelvic balance and surgical treatment of L5–S1 isthmic spondylolisthesis

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Learning objectives

• To explain the principles of spino-pelvic balance;
• To show the clinical appearance, physical examination and indication for surgery in high-grade L5–S1 isthmic spondylolisthesis;
• To learn anatomy and technique related to severe high dysplastic isthmic spondylolisthesis;
• To explain technical tricks when performing a surgical reduction and fusion of a high-grade and high dysplastic isthmic spondylolisthesis.

Introduction

Spondylolisthesis is defined as the forward slippage of a vertebra over the underlying one, which typically occurs in the lumbosacral region. Despite segmental involvement, this pathology affects the whole biomechanical balance of the spine. Thus, a better definition could be that spondylolisthesis is the forward slippage of a portion of the spine on the underlying portion [1]. Isthmic spondylolisthesis is the younger form of slippage which occurs due to pars interarticularis defect and L5–S1 level is the most frequently affected site due to an L5 pars defect. Slippage severity can be easily assessed measuring the percentage of slipping. Consequently, spondylolisthesis can be classified as low-grade when the slippage is below 50% or high-grade when it exceeds half of the underlying vertebra. Surgery is indicated only in rare cases like:

• Demonstrated progression of the slippage;
• High slippage degree of spondylolisthesis due to the improved risk of evolution;
• Pelvic unbalance;
• Low back pain and/or sciatica unresponsive to conservative treatment;
• Associated neurological deficits.

The role of reduction of the slipped vertebra has been extensively studied and can be evaluated through the analysis of the spinopelvic alignment.

Aim of these paper and video is to show the surgical procedure and technical tricks for the surgical reduction and fusion of a high-grade and high dysplastic isthmic spondylolisthesis by a comprehensive analysis of the spino-pelvic balance.

Case description

We present the case of a 36-year-old male patient who is suffering of chronic low back pain and non-responsive L5 bilateral radiculopathy. He has been previously subjected to conservative treatment for 6 months without acceptable clinical results. X-rays show a severe unbalanced isthmic spondylolisthesis of L5 that can be classified as 3rd degree according to Meyerding [1].

Watch surgery online
Surgical strategy

The patient is placed on a spine frame in the prone position. The lumbar lordosis is slightly reduced to help the reduction of the vertebral slippage during surgery. Proper patient positioning has great importance because the abdomen should be allowed to hang free to reduce the intraabdominal pressure, which decreases the venous engorgement and intraoperative bleeding. To obtain correct intra-operative anteroposterior view, the C-arm should be tilted in line with the L5–S1 space to visualize the pedicles of L5 that are oblique due to the high-grade vertebral slippage. A standard midline approach is used to approach the L5–S1 level. Sharp dissection by electrocautery is carried through the subcutaneous tissue. The lumbar fascia is identified and incised just lateral to the supraspinous ligament. Paraspinal muscles are elevated subperiosteally just lateral to the spinous processes, and the laminae and facet joints are exposed up to the transverse processes with a Cobb elevator and electrocautery. To improve the visualization of the S1 pedicle we place a Hohmann retractor on the iliac crest. This manoeuvre allows us to visualize the S1 facet. The entry point for the pedicle is just lateral to it. The pedicle of L5 is just proximal to the facet joint, but it is deeper, since the vertebra is slipped anteriorly. To begin the screw insertion at S1, the lateral aspect of the facet of S1 is identified, and an awl is placed just lateral to the base of the S1 facet and the superficial cortex is opened. It should be oriented about 45° inward and caudal, thus staying in line to the pedicle in the lateral view; then the pedicle is gently drilled with a 2.7 mm drill bit. The anterior cortex of the vertebral body is identified and gently drilled in order to provide bicortical fixation with a monoaxial screw.

For L5 pedicle screw entry point the mammillary process of L5 is identified at the confluence of a horizontal line passing through the midline of the transverse process and the vertical line parallel to the lateral aspect of the L5 facet. The awl is placed on the entry point and properly orientated, about 30° inward, and aligned to the pedicle in the lateral view. The hole is tapered and the length of the screw is chosen in order to obtain monocortical fixation of the L5 body. Then a polyaxial monocortical reduction screw is placed in the L5 pedicle. The same procedure is performed on the contralateral side [2].

The rods are shaped in slightly lordosis and cut 1 cm longer than normally used to allow for disc space distraction. Rods and locking plugs are inserted into the screws head, gentle distraction is applied and the screws are locked. The spinous process of L5 is carefully isolated and removed with a rongeur. The posterior arch of L5 appears detached from the vertebral body because of the lysis of the pedicle; therefore, it can be mobilized and fully removed. Then, the dural sac and the spinal roots are visualized. The posterior annulus of the disc is incised with the blade oriented in line with the L5 body. Using a rod persuader, the locking plugs of L5 are tightened, while a gentle distraction is applied, to obtain reduction of the slippage and increasing of the disc space. Then, discectomy is completed and the endplates are prepared for the interbody fusion using two PEEK cages filled with autologous bone. Compression is applied across the L5–S1 space in order to improve arthrodesis and restore correct segmental lordosis [3].

Postoperative information

A lumbar brace can be used after surgery to restrict lumbar spinal movements. The patient is able to leave the hospital 4 days after the surgery. As the spine heals, the bone graft creates a solid fusion.

Discussion and conclusion

High-grade isthmic spondylolisthesis compromises the balance of the entire spine, due to the severe slippage of a lumbar vertebra on the one below [4]. Spondylolistheses reduction may help to re-establish a correct balance of the column by correcting the lumbosacral kyphosis and improving the altered biomechanics of the spine. Moreover, the reduction manoeuvre may improve the healing process, placing bony segment in a more anatomical position. Indeed, reducing the lumbosacral kyphosis by decreasing the slip angle, may improve the biomechanical environment for a fusion converting the shear forces to compressive forces [3, 5].

The spinal sagittal balance has been used as a guide in order to better understand effects of the reduction manoeuvre on a high degree spondylolisthesis.

Mac-Thiong et al. found that a proper posture is maintained in high-grade spondylolisthesis with balanced pelvis, whereas it is altered in high-grade spondylolisthesis with unbalanced pelvis [6, 7].

Hresko et al. proposed a classification of high-grade spondylolisthesis based on the spinopelvic balance; they distinguish between balanced and unbalanced forms, suggesting that balanced forms could benefit from the decompression and in situ fixation alone, while only the unbalanced forms would require reduction [8].

The classification of the Spinal Deformity Study Group is now considered the gold standard. This classification relies on the following parameters: (1) the grade of slippage; (2) the pelvic incidence; and (3) the spino-pelvic balance. Hence, three group of patients with high degree spondylolisthesis can be differentiated: Type 4, HGDS, balanced pelvis; Type 5, HGDS, unbalanced pelvis (retroverted), balanced spine; Type 6, HGDS, unbalanced pelvis (retroverted), unbalanced spine [9].