

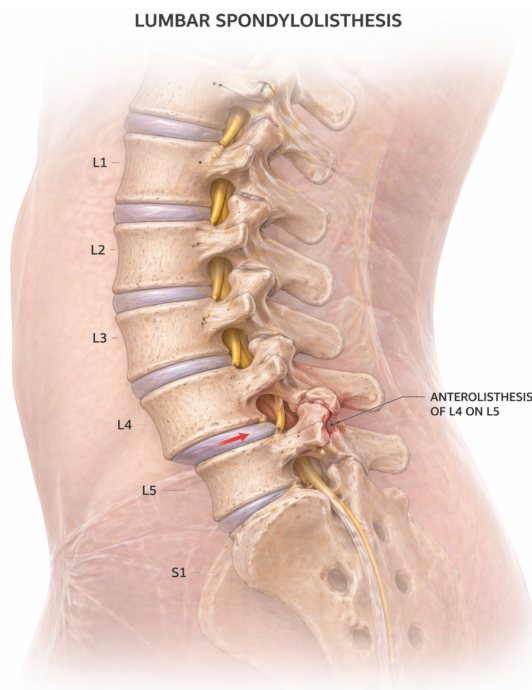
Lumbar Spondylolisthesis

Understanding Vertebral Slippage — Causes, Symptoms & Surgical Correction

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1. What Is Lumbar Spondylolisthesis?



Lateral view: L4 has slipped forward (anterolisthesis) onto L5, compressing the nerve root at that level.

Spondylolisthesis (pronounced *spou-dee-lo-lis-THEE-sis*) is a condition in which one vertebra slips forward out of position over the vertebra below it. The word comes from the Greek *spondylos* (vertebra) and *olisthesis* (to slip or slide). The most commonly affected level in the lumbar spine is **L4 slipping forward on L5**, though L5 on S1 is also frequent.

This forward shift of the upper vertebra stretches and compresses the nerves passing through that spinal level, narrows the spinal canal (causing stenosis), and destabilizes the disc and facet joints at the affected segment. The result is a characteristic combination of back pain and leg symptoms that can range from mild and intermittent to severe and disabling.

Grading — How Much Has It Slipped?

The Meyerding classification grades the degree of slip as a percentage of the vertebral body width:

Grade I	Grade II	Grade III	Grade IV	Grade V (Spondyloptosis)
0–25% slip	26–50% slip	51–75% slip	76–100% slip	>100% (complete)
Most common; often managed conservatively	Moderate; may need surgery	Significant instability; generally surgical	Severe; surgical correction	Complete dislocation; complex surgery

2. Causes & Types of Spondylolisthesis

Several distinct types of spondylolisthesis exist, each with a different underlying cause. The two most common types seen in adult patients are degenerative and isthmic:

Degenerative Spondylolisthesis

By far the most common type in adults over 50. As the intervertebral disc degenerates and loses height, it can no longer maintain the proper position of the vertebra above. Simultaneously, the facet joints — which act as the "locks" preventing forward shift — become arthritic and lose their ability to restrain motion. The vertebra gradually creeps forward. **L4-5 is the most commonly affected level**, and women are more frequently affected than men. This type almost always accompanies lumbar stenosis, as the forward slip further narrows the already-compromised spinal canal.

Isthmic Spondylolisthesis

Caused by a defect or stress fracture in the pars interarticularis — the narrow bridge of bone between the upper and lower facet joints. This fracture (called **spondylolysis**) is often acquired in adolescence from repetitive hyperextension activities (gymnastics, football linemen, dancers). Once the bony restraint is broken, the vertebra may slip forward. **L5-S1 is the most commonly affected level**. Many patients are asymptomatic in youth but develop pain as adults when disc degeneration accelerates the slip.

Other Types

- **Congenital (Dysplastic):** Abnormal development of the sacrum or L5 vertebra at birth that predisposes to early slippage. Often presents in childhood or adolescence.
- **Traumatic:** Caused by an acute fracture of the posterior elements (other than the pars) following significant trauma. Immediate instability may require urgent surgical stabilization.
- **Pathologic:** A fracture at the posterior elements caused by tumor, infection, or metabolic bone disease (e.g., osteoporosis, Paget's disease) that destroys bony integrity.
- **Post-surgical (Iatrogenic):** Slippage that develops or worsens following a prior spinal decompression — particularly after extensive laminectomy or facetectomy that removes the stabilizing posterior elements. This underscores the importance of adding fusion when instability is anticipated at the time of decompression.

Risk Factors for Progression

- Female sex (degenerative type)
- High-grade slip at presentation (Grade II or above)
- Significant disc degeneration at the affected level
- Hypermobility facet joint orientation (more sagittal facets)
- Obesity — increased axial and shear loading on the disc
- Smoking — accelerates disc degeneration

3. Symptoms & Diagnosis

Symptoms

Symptoms depend on the degree of slip, the degree of nerve compression, and whether instability is present. Some patients with low-grade slips have no symptoms at all and are diagnosed incidentally on imaging. Common presentations include:

- **Low back pain** — aching, worse with prolonged standing, walking, or extension activities; often relieved by sitting and flexing forward
- **Buttock and leg pain (sciatica)** — pain radiating down one or both legs, caused by nerve root compression at the level of the slip
- **Neurogenic claudication** — cramping or heaviness in the legs with walking that is relieved by sitting, particularly when stenosis coexists with the slip
- **Leg weakness or numbness** — weakness of foot or ankle muscles, or sensory loss in the leg or foot corresponding to the compressed nerve root
- **Hamstring tightness** — a characteristic finding in younger patients with isthmic spondylolisthesis; results from nerve root irritation and compensatory postural changes
- **Visible postural change** — in high-grade slips, a step-off may be visible or palpable in the lumbar spine, and the patient may have a "waddling" gait or hyperlordotic posture
- **Bladder or bowel dysfunction** — rare but urgent; indicates severe cauda equina compression requiring emergency surgery

Diagnosis

Spondylolisthesis is primarily a radiographic diagnosis, confirmed by clinical correlation:

- **Standing X-rays (flexion/extension views):** The most important initial study. Lateral radiographs demonstrate the degree of slip and allow Meyerding grading. Dynamic flexion-extension views reveal whether the slip is *stable* (fixed) or *unstable* (motion at the segment), which critically influences surgical planning.
- **MRI of the lumbar spine:** Defines nerve root and cauda equina compression, disc degeneration, canal and foraminal stenosis, and the condition of adjacent levels. Essential for surgical planning.
- **CT scan:** Best for assessing bony anatomy — particularly the pars interarticularis defect in isthmic type, the quality of facet joints, and pedicle size for screw placement planning.
- **CT myelogram:** Used when MRI is contraindicated to provide detailed imaging of nerve root compression.
- **DEXA bone density scan:** Obtained before surgical planning to assess osteoporosis and guide implant selection.

Instability Is Key

The distinction between a **stable** and **unstable** slip is critical. Instability — defined as >4 mm of motion between flexion and extension X-rays — is one of the strongest indications for surgical fusion, as it means the spinal segment cannot adequately support the body under normal daily loads.

4. Conservative Treatment

Low-grade spondylolisthesis (Grade I–II) with manageable symptoms is appropriately treated non-operatively as a first step. The goals are pain control, neurological protection, and functional improvement:

Physical Therapy

A structured PT program is the cornerstone of conservative management. Treatment focuses on core strengthening (to compensate for the unstable segment), lumbar stabilization exercises, hip flexor and hamstring stretching, and postural retraining. Flexion-based exercises are generally better tolerated than extension exercises, which may worsen symptoms.

Activity Modification

Avoid high-impact activities, heavy lifting, and hyperextension exercises (back extensions, gymnastics, heavy deadlifts) that increase shear forces at the unstable level. Low-impact activities — swimming, cycling, walking — are encouraged.

Medications

NSAIDs reduce pain and inflammation. Neuropathic agents (gabapentin, pregabalin) address radicular symptoms. Muscle relaxants reduce associated spasm. Short oral steroid courses may provide temporary relief during flares.

Epidural Steroid Injections

Fluoroscopy-guided epidural or selective nerve root block injections deliver corticosteroid directly to the compressed nerve, reducing inflammation and providing significant short- to medium-term relief. Injections can be repeated and allow patients to engage in PT; they do not address underlying structural instability.

Bracing

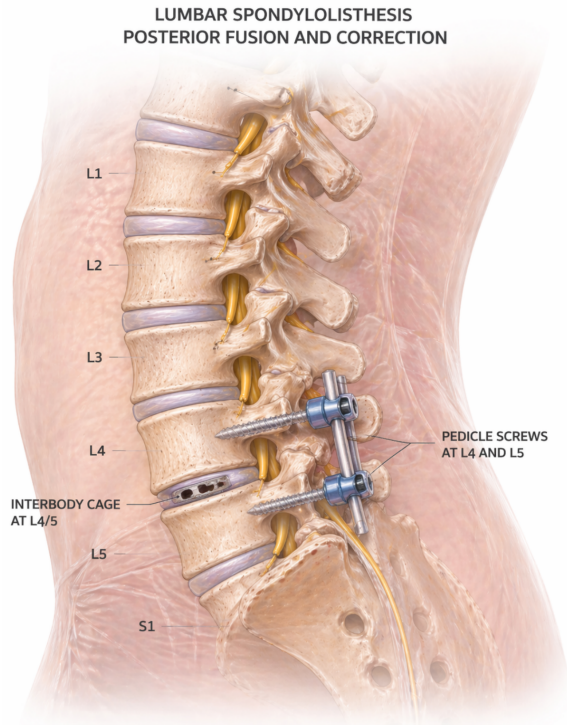
A rigid lumbar orthosis (brace) can reduce motion at the unstable segment and provide symptomatic relief — particularly useful during a pain flare or as a bridge to surgery. Long-term continuous bracing weakens paraspinal muscles and is not recommended.

When Surgery Becomes Necessary

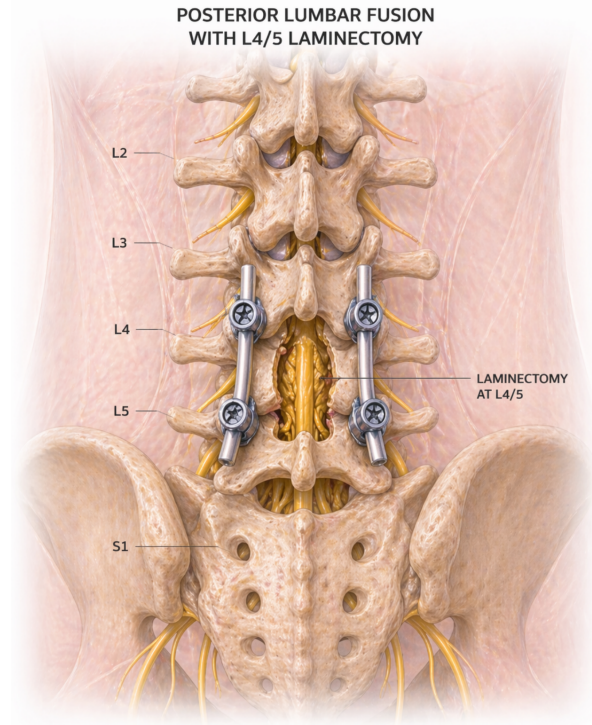
Surgery is indicated when: symptoms fail to improve after 3–6 months of structured conservative care; neurological deficits (weakness, progressive numbness) are present; the slip is high-grade (Grade III–IV); radiographic instability is documented; or cauda equina syndrome develops — which requires **emergency surgery**.

5. Surgical Treatment — Decompression & Fusion

Surgery for spondylolisthesis has two primary goals: **decompressing the compressed nerve roots** and **stabilizing the unstable spinal segment** with fusion. Both are typically performed together. Decompression alone — without fusion — is insufficient when instability is present, as the unrestrained segment will continue to move and symptoms will recur.



Lateral view: interbody cage at L4/5 restoring disc height and lordosis; pedicle screws at L4 and L5 with connecting rod provide rigid fixation.



Posterior view: bilateral pedicle screws and rods with laminectomy at L4/5 — nerves are decompressed and the segment is locked in corrected alignment.

Laminectomy — Nerve Decompression

The lamina and ligamentum flavum are removed at the level of the slip, directly opening the spinal canal and relieving pressure on the cauda equina. Individual nerve roots are carefully freed from the lateral recesses and foramina where they are compressed by the forward-shifted vertebra and degenerated disc. Undercutting of the facet joints further enlarges the nerve root tunnels without destabilizing the segment — since the pedicle screws provide that stability.

Interbody Fusion — Restoring Height and Lordosis

A lordotic interbody cage packed with bone graft is placed in the disc space at L4-5 (or L5-S1). This accomplishes three goals simultaneously: it restores the collapsed disc space height, re-opens the foramina through which the nerve roots exit, and reestablishes proper lordosis at the fused level. The cage provides a scaffold across which bone grows to achieve a solid fusion over the following 3–12 months.

Approaches for Interbody Fusion

- **TLIF (Transforaminal Lumbar Interbody Fusion):** Cage placed through a posterolateral approach via the foramen — the most common technique for L4-5 and L5-S1 spondylolisthesis.
- **PLIF (Posterior Lumbar Interbody Fusion):** Two smaller cages placed directly from behind through the central canal. Greater nerve retraction required.
- **ALIF (Anterior Lumbar Interbody Fusion):** Cage placed from the front via an abdominal approach. Allows the largest cage and maximum lordosis correction — particularly effective at L5-S1.
- **LLIF (Lateral Lumbar Interbody Fusion):** Cage placed from the side through the psoas muscle. Highly effective at L2-5 but technically limited at L5-S1 due to the iliac crest.

Pedicle Screw Fixation

Titanium pedicle screws are placed bilaterally into the vertebral bodies of L4 and L5 (or the affected levels), connected by rigid rods. This construct eliminates motion at the unstable segment, holds the correction obtained by the interbody cage, and provides the mechanical environment needed for bone fusion to occur. Screws are placed using fluoroscopic X-ray guidance or robotic navigation for precision.

Slip Reduction

In most Grade I–II degenerative cases, the goal is stabilization in situ (in place) rather than complete anatomic reduction. In high-grade or isthmic slips, partial or complete reduction may be performed to restore sagittal alignment — though aggressive reduction carries a higher risk of nerve stretch injury and must be done carefully.

Bone Graft & Fusion Biology

Solid bone fusion is the ultimate goal. Bone graft options include:

- **Autograft** (patient's own bone from the iliac crest or local decompression bone) — the gold standard for fusion.
- **Allograft** (donor bone) — used to supplement or replace autograft to avoid harvest site complications.
- **rhBMP-2** (recombinant bone morphogenetic protein) — a biologic agent that stimulates bone growth, used in select cases.

Minimally Invasive Surgery (MIS)

MIS-TLIF uses tubular retractors and percutaneous screw placement through smaller incisions, significantly reducing muscle damage, blood loss, and recovery time — while achieving equivalent decompression and fusion rates compared to open surgery.

6. Risks & Complications

Lumbar decompression and fusion for spondylolisthesis is a well-established procedure with excellent long-term outcomes. As with all surgery, risks exist and should be understood prior to proceeding:

- **Nerve root injury:** The compressed nerves are carefully mobilized during surgery. Temporary postoperative worsening of numbness or weakness can occur as the nerve recovers from chronic compression. Permanent neurological injury is rare but possible.
- **Dural tear (CSF leak):** The outer covering of the spinal cord may be inadvertently opened, causing cerebrospinal fluid leakage. Most are repaired at the time of surgery and heal without long-term consequences.
- **Pseudarthrosis (failed fusion):** Bone fails to bridge across the fusion — more common in smokers, diabetics, and osteoporotic patients. May cause hardware failure and loss of correction, requiring revision.
- **Hardware failure:** Screw loosening, rod fracture, or cage subsidence (sinking into the vertebral body) can occur, particularly in patients with poor bone quality.
- **Adjacent segment degeneration:** Fusion increases stress on the discs above and below the fused levels, potentially accelerating degeneration at those levels over time.
- **Infection:** Surgical site infections occur in 1–3% of cases. Deep infections may require return to the operating room for irrigation and debridement.
- **Blood loss:** Managed with cell-saver autotransfusion, controlled hypotension, and tranexamic acid. Blood transfusion is occasionally needed.
- **Thromboembolic events (DVT/PE):** Prevented with early mobilization, compression stockings, and anticoagulation as appropriate.
- **Retrograde ejaculation:** A specific risk of anterior (ALIF) approaches at L5-S1 due to proximity of the superior hypogastric plexus; occurs in approximately 1–2% of cases.

7. Recovery After Spondylolisthesis Surgery

Hospital Stay 2–4 days	Walking begins day 1 with physical therapy assistance. Pain managed with IV and oral medications. Discharge when safely mobile and pain controlled. A lumbar brace (TLSO) is often fitted before discharge.
Weeks 1–6 Home Recovery	Short frequent walks, increasing daily. No bending, lifting >5–10 lbs, or twisting. Brace worn for support as instructed. Wound check at 10–14 days. Many patients notice improvement in leg pain within the first few weeks.
Weeks 6–12 Rehabilitation	Outpatient PT begins at 4–6 weeks — core stabilization, flexibility, and gradual return to activity. X-rays at 6 weeks confirm hardware position and early fusion progress. Return to desk work typically 4–8 weeks.
Months 3–6 Intermediate Recovery	Significant improvement in pain and function expected. CT scan may be obtained at 3–6 months to assess fusion progress. Brace discontinued. Gradually return to light recreational activity.
Months 6–18 Full Fusion & Return to Activity	Bone fusion matures over 12–18 months. Full return to activity permitted as cleared by Dr. Caridi. Long-term studies show 85–90% of patients experience meaningful, lasting improvement in pain and function.

8. Post-Operative Instructions

Activity

- Walk multiple short distances each day and increase gradually
- Wear your brace as instructed when upright and active
- No bending, twisting, or lifting >10 lbs for 6 weeks
- No driving while taking narcotic pain medications
- No swimming or soaking in a bath until the wound is fully closed (4–6 weeks)
- Sleep on your side with a pillow between your knees, or on your back with pillows under your knees

Wound Care

- Keep incision clean and dry for the first 48–72 hours
- Shower after 48–72 hours — pat incision dry, do not scrub
- Do not apply lotions or ointments unless instructed by Dr. Caridi
- Sutures/staples removed at 2-week follow-up visit

Medications

- Take pain medications as prescribed; do not exceed recommended doses
- Take a stool softener while on narcotic pain medications
- Resume blood thinners and anti-inflammatory medications only as directed
- **Do not smoke** — nicotine is the single most important modifiable risk factor for fusion failure

Bone Stimulator

Some patients — particularly smokers, diabetics, or those with prior failed fusion — may be prescribed an external bone growth stimulator (worn daily over the fusion site). This device uses pulsed electromagnetic fields or ultrasound to enhance bone healing and is highly recommended when prescribed.

Follow-Up Schedule

- 2 weeks: wound check and staple/suture removal
- 6 weeks: X-rays, brace assessment, PT clearance
- 3–6 months: CT scan to assess fusion; activity progression
- 12 months: final fusion X-rays

Call Dr. Caridi's Office or Go to the Emergency Room Immediately If You Develop:

- New or worsening weakness or numbness in either leg
- Loss of bladder or bowel control — this is a surgical emergency
- Fever above 101.5°F, or redness, warmth, swelling, or discharge at the incision
- Severe headache worse when upright and relieved by lying flat (possible CSF leak)
- Sudden severe increase in back pain or leg pain beyond your baseline
- Calf swelling, tenderness, or redness (possible deep vein thrombosis)
- Chest pain, shortness of breath, or rapid heart rate (possible pulmonary embolism)