Lumbar Revision Fusion Surgery

Understanding Why Prior Surgery May Fail — and What Can Be Done

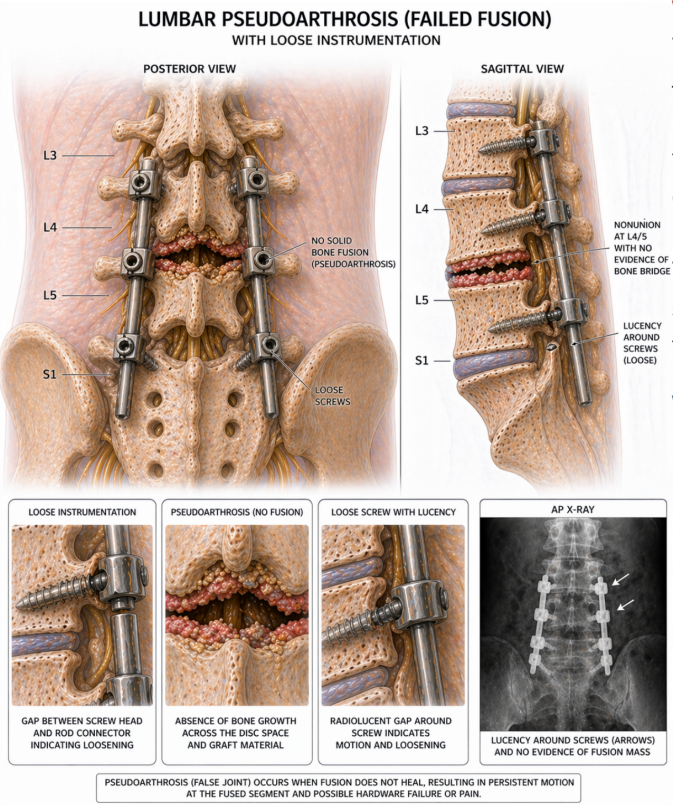
Dr. John M. Caridi, MD | Spinal Associates

1155 Park Avenue, Suite E | New York, NY | (212) 360-6500

Lumbar fusion surgery reliably helps the majority of carefully selected patients — but it is not infallible. A meaningful proportion of patients who undergo lumbar fusion will, over time, develop new or recurrent symptoms that require further evaluation and, in some cases, revision surgery. Understanding *why* prior surgery may fail is the first step toward effective treatment.

The three most common and clinically significant causes of failure after lumbar fusion are: **pseudoarthrosis and hardware failure**, **iatrogenic flat back deformity**, and **adjacent segment disease**. Each has a distinct mechanism, presentation, and surgical solution. Dr. Caridi specializes in the diagnosis and surgical correction of all three.

1. Pseudoarthrosis & Hardware Failure



Posterior and sagittal views showing failed fusion (pseudoarthrosis) with loose instrumentation, absent bone bridge, and screw lucency on AP X-ray (arrows).

What Is Pseudoarthrosis?

The word *pseudoarthrosis* literally means "false joint" — a condition in which the bone across a fusion site never fully heals, leaving a persistent fibrous non-union that moves under load like a pathological joint. Instead of the bone bridging solidly across the disc space or posterolateral gutters, fibrous scar tissue fills the gap. The result is continued abnormal motion at the fused segment, chronic pain, and progressive hardware fatigue.

Why Does Fusion Fail?

- **Smoking** — the single most potent modifiable risk factor. Nicotine directly impairs osteoblast function and reduces bone vascularity, dramatically increasing pseudoarthrosis rates
- **Osteoporosis** — poor bone quality means screws lack purchase and bone graft fails to incorporate adequately
- **Diabetes** — impairs bone healing biology and increases infection risk
- **Obesity** — increased mechanical loads overwhelm the fusion construct before solid bone has formed
- **Multilevel fusion** — longer constructs have more levels to heal and greater mechanical demands on each junction
- **Inadequate bone graft** — insufficient graft volume or poor graft biology (e.g., no BMP, no local autograft)
- **Infection** — even a low-grade infection disrupts fusion biology
- **Technical factors** — inadequate decompression of the endplates, improper cage positioning, or poor screw trajectory

Hardware Failure

When pseudoarthrosis is present, the spinal implants are subjected to cyclic loading across a mobile segment — the mechanical equivalent of bending a paper clip back and forth repeatedly until it snaps. Hardware failure is therefore almost always a *consequence* of failed fusion, not an independent primary event:

- **Rod fracture:** The connecting rod breaks — most commonly at the lumbosacral junction (L5-S1), where bending moments are greatest. A broken rod on X-ray is nearly pathognomonic of pseudoarthrosis.
- **Screw loosening:** Pedicle screws toggle in the pedicle over time, creating a radiolucent halo around the screw on CT — a hallmark of failed fixation. Loose screws may migrate and cause new neural injury.
- **Cage subsidence:** The interbody cage sinks into the softened vertebral endplate, losing height and lordosis correction — particularly common in osteoporotic bone.
- **Cage migration:** Rarely, an unfused cage can migrate posteriorly into the canal or anteriorly out of the disc space.

Symptoms of Pseudoarthrosis / Hardware Failure

Patients may present at any point from months to years after the original surgery. Classic features include:

- Return or persistence of axial back pain after a period of improvement
- New or worsening leg pain, numbness, or weakness — from motion-induced nerve irritation at the non-union site
- Pain that is mechanical in nature — worse with activity, better with rest
- A palpable or audible "click" with movement (rare, but pathognomonic)
- Visible hardware prominence under the skin in thin patients

Diagnosis

- **CT scan** — the gold standard; reveals absence of bridging bone across the fusion site, screw lucency, cage position
- **Flexion-extension X-rays** — demonstrate motion at the fusion site; broken rods, displaced screws
- **MRI** — evaluates nerve compression from hardware migration or recurrent disc herniation at the fusion level
- **SPECT-CT bone scan** — increased uptake at the non-union site indicates ongoing biological activity (healing attempt)

Surgical Treatment of Pseudoarthrosis / Hardware Failure:

- Removal of failed hardware (broken rods, loose screws) and thorough debridement of fibrous non-union tissue from the fusion bed
- Re-preparation of endplates and revision interbody fusion with a new cage and liberal bone grafting — autograft, allograft, and/or rhBMP-2
- Re-instrumentation with new pedicle screws (often augmented with cement — "cement augmentation" — in osteoporotic bone), new rods, and cross-connectors
- Extension of the fusion construct if adjacent levels have also failed or degenerated
- Optimization of fusion biology: smoking cessation, osteoporosis treatment, diabetes control, and external bone stimulator use post-operatively

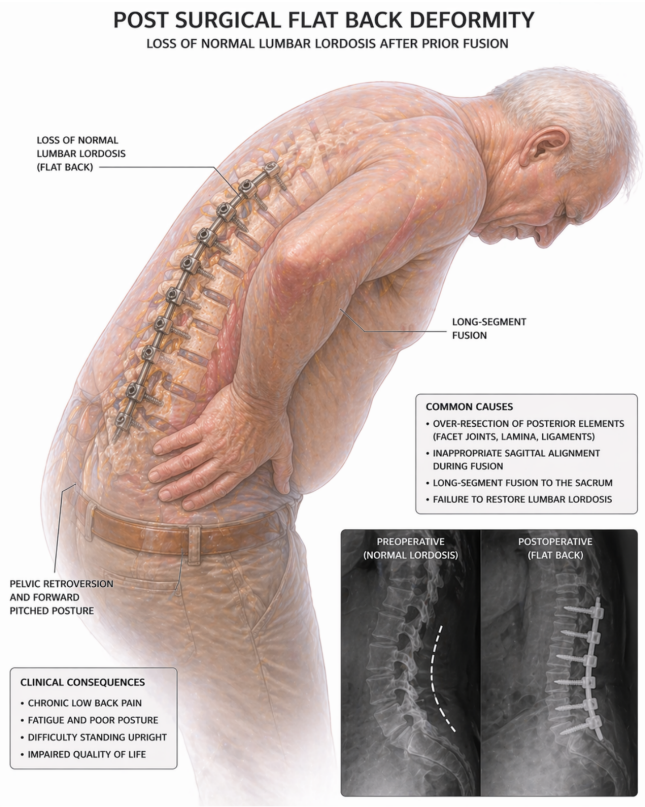
2. Iatrogenic Flat Back Deformity

What Is Iatrogenic Flat Back?

Iatrogenic means caused by medical treatment. Iatrogenic flat back deformity is a loss of normal lumbar lordosis — the inward curve of the lower back — that develops as a direct consequence of prior spinal fusion surgery. When the lumbar spine is fused in a straight or kyphotic position rather than in its natural lordotic curve, the result is a rigid deformity that the patient cannot correct voluntarily.

How Does Prior Surgery Cause Flat Back?

- **Straight rod contouring:** Rods that are not bent to reproduce lumbar lordosis lock the spine in a flattened position permanently
- **Flat or non-lordotic interbody cages:** Cages placed without appropriate lordotic angulation fail to restore disc height anteriorly, where it is needed to create curvature
- **Over-resection of posterior elements:** Aggressive removal of facet joints and laminae during decompression destabilizes the posterior tension band, allowing the spine to sag into kyphosis
- **Long-segment fusion to the sacrum:** Extending a fusion construct to S1 without adequate lordosis at L4-5 and L5-S1 — the levels that contribute most to lumbar curvature — produces a flat or reversed curve
- **Failure to account for pelvic incidence:** Each patient has a fixed anatomic parameter (pelvic incidence, or PI) that determines how much lumbar lordosis they need. Ignoring PI leads to a mismatch that manifests as sagittal imbalance
- **Historical Harrington rod instrumentation:** Older scoliosis hardware intentionally straightened the spine, producing predictable flat back decades later in many patients



Post-surgical flat back: loss of lumbar lordosis after long-segment fusion, causing forward-pitched posture and pelvic retroversion. Pre/post X-rays demonstrate the loss of lordosis that developed following surgery.

Symptoms

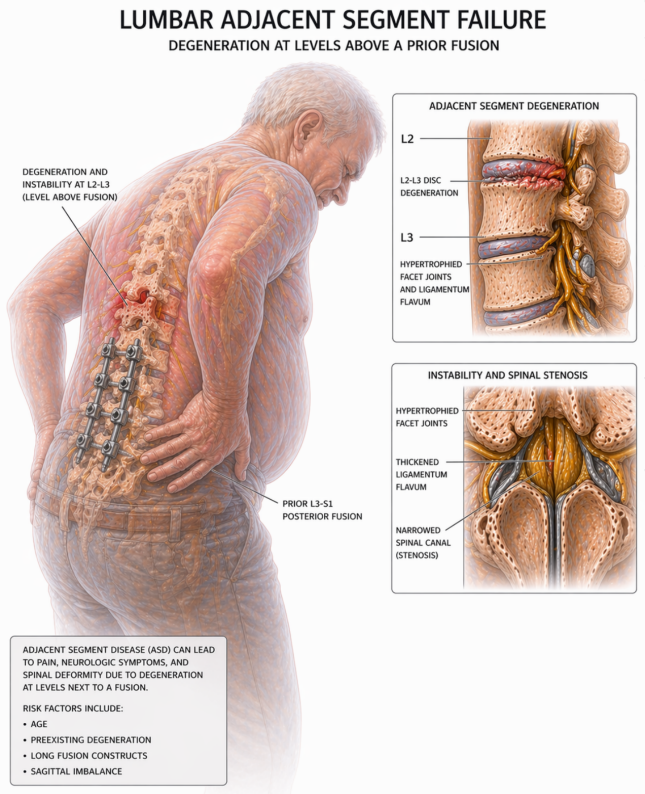
- Progressive forward-stooped posture that cannot be voluntarily corrected
- Chronic low back pain worse with prolonged standing and walking
- Severe fatigue — constant muscular effort required to remain upright
- Hip and knee flexion contractures from compensatory posturing
- Inability to stand for more than minutes without leaning on a support
- Neck pain from cervical hyperextension used to maintain horizontal gaze
- Leg pain from nerve compression in the deformed spinal canal

Surgical Correction

Restoring sagittal balance requires one or more **spinal osteotomies** — deliberate cuts through the posterior (and sometimes anterior) bony elements of the spine that allow the surgeon to re-open the spine and re-close it in a corrected, lordotic position:

- **Smith-Petersen Osteotomy (SPO/Ponte):** Removal of posterior elements at one or more levels; disc opens anteriorly as spine is extended. Achieves 10–15° correction per level.
- **Pedicle Subtraction Osteotomy (PSO):** A full wedge of bone including the pedicles and part of the vertebral body is removed. Up to 30–40° of lordosis can be restored at a single level — the workhorse of flat back correction.
- **Vertebral Column Resection (VCR):** Complete removal of one or more vertebrae for severe, rigid deformity. Highest correction potential; highest surgical risk.
- **Lordotic interbody cages (ALIF/TLIF):** Placed anteriorly or posterolaterally to restore disc-level lordosis. Most powerful at L4-5 and L5-S1 via anterior (ALIF) approach.
- **New rod contouring and fixation:** All prior hardware is removed and new, properly contoured rods are placed across the corrected spine.

3. Adjacent Segment Disease & Failure



Adjacent segment failure above a prior L3-S1 fusion. Degeneration and instability at L2-L3 have produced disc collapse, facet hypertrophy, and severe spinal stenosis at the level immediately above the fusion.

What Is Adjacent Segment Disease?

When the spine is fused at one or more levels, motion at those levels is eliminated. The spine must still move, however — and that motion is redistributed to the segments immediately above and below the fusion. These adjacent levels experience increased range of motion, increased intradiscal pressure, and altered load transfer. Over time, this accelerated mechanical stress drives premature degeneration at those levels — a process called **adjacent segment disease (ASD)** or, when it becomes clinically symptomatic, **adjacent segment failure**.

What Happens at the Adjacent Level?

- **Disc degeneration and herniation:** The disc above or below the fusion collapses and may herniate, compressing nerve roots
- **Facet joint hypertrophy:** The facet joints at the adjacent level become arthritic and enlarged, contributing to canal narrowing
- **Ligamentum flavum thickening:** The posterior ligament buckles inward, further compromising the canal
- **Spinal stenosis:** The combination of the above produces a new stenosis immediately above or below the prior fusion — often more rapidly than would occur in an unfused spine
- **Instability and spondylolisthesis:** The adjacent level may become unstable, with one vertebra slipping forward on the next, particularly if the facet joints are already damaged
- **Deformity:** Degeneration at the adjacent level can produce new sagittal or coronal malalignment, compounding any pre-existing flat back or scoliotic deformity

Symptoms of Adjacent Segment Failure

ASD typically develops gradually, months to years after the original fusion. The onset may be subtle — a gradual return of back pain or a new pattern of leg symptoms — or it may be sudden with an acute disc herniation. Common presentations include:

- New or recurrent back pain at a level above or below the prior fusion
- New leg pain, numbness, or weakness in a distribution different from the original symptoms — corresponding to the newly compressed nerve root
- Neurogenic claudication (leg pain with walking) if stenosis has developed
- Progressive postural change or worsening of pre-existing deformity
- Bladder or bowel dysfunction in severe cases — emergency evaluation required

Risk Factors for Adjacent Segment Disease

- **Age** — older patients have pre-existing degeneration that accelerates once the adjacent levels are stressed
- **Pre-existing degeneration** at adjacent levels at the time of the original surgery
- **Long fusion constructs** — the longer the fusion, the greater the concentration of force at the end-segments
- **Sagittal imbalance** — poor alignment increases loads on adjacent levels disproportionately
- **Fusion to L5 vs. S1** — stopping a fusion at L5 rather than going to S1 increases stress at the L5-S1 disc below

Surgical Treatment of Adjacent Segment Failure

The approach depends on what has failed at the adjacent level:

- **Decompression alone:** If the adjacent level is stable and only nerve compression is present, a targeted laminectomy may suffice
- **Extension of fusion:** If instability, spondylolisthesis, or deformity is present at the adjacent level, the fusion construct must be extended to include that level — with decompression and new interbody fusion
- **Deformity correction:** If the adjacent segment failure has worsened overall sagittal or coronal alignment, osteotomies may be required to re-establish balance in conjunction with construct extension

4. Diagnosing Failure After Prior Fusion

The evaluation of a patient who has had prior lumbar fusion and is now experiencing new or recurrent symptoms is a methodical process. Dr. Caridi performs a comprehensive assessment to determine the precise cause of failure before any revision plan is made:

History & Physical Examination

A detailed account of the original surgery, the nature and timing of symptom recurrence, and a thorough neurological examination are the starting point. Key questions: When did symptoms return? Are they the same as before, or different? Are they worse with activity or constant? Is there new weakness?

Standing Full-Length X-Rays

36-inch standing AP and lateral radiographs are mandatory. They reveal the overall sagittal and coronal alignment, hardware integrity (broken rods, loose screws, displaced cages), degree of any vertebral slip, and the condition of the disc spaces above and below the fusion.

Flexion-Extension X-Rays

Dynamic views demonstrate motion at the fusion site (pseudoarthrosis) or at adjacent segments (instability). More than 3–4 mm of translational motion or 10° of angular change indicates pathological instability.

CT Scan

The most important study for evaluating fusion integrity. CT clearly shows the presence or absence of bridging bone across the fusion, the degree of screw-bone contact versus lucency (loosening), cage position, and subsidence. It also defines bony anatomy for revision surgical planning.

MRI Lumbar Spine

Evaluates nerve compression — from hardware migration, adjacent segment disc herniation, new stenosis, or recurrent stenosis. Also assesses disc degeneration at adjacent levels and identifies any epidural fibrosis (scar tissue) around prior decompression sites.

SPECT-CT Bone Scan

Increased metabolic activity ("hot" uptake) at a fusion level on SPECT-CT suggests an actively failing non-union and helps confirm pseudoarthrosis when CT findings are equivocal.

Laboratory Studies

Inflammatory markers (ESR, CRP, WBC) are obtained when infection is suspected as a contributing cause of hardware loosening or non-union. Bone density (DEXA) is measured to guide implant selection and determine whether osteoporosis treatment is needed before revision.

5. Risks of Revision Surgery

Revision spine surgery carries higher risks than primary surgery. Scar tissue from prior operations obscures normal anatomy, increases the technical challenge of the dissection, and raises the risk of neural injury. Prior hardware may be difficult to remove. Blood loss is typically greater. Understanding these risks is essential to making an informed decision:

- **Nerve root injury:** The most significant risk. Scar tissue (epidural fibrosis) from prior surgery binds nerves to surrounding structures, making dissection hazardous. Neuromonitoring (MEPs, SSEPs) is used throughout revision procedures to protect neural function.
- **Dural tear / CSF leak:** The dura is frequently adherent to prior scar tissue. Inadvertent openings are repaired immediately but may prolong recovery.
- **Greater blood loss:** Revision dissection through scarred tissue is more vascular. Cell-saver autotransfusion and tranexamic acid are used routinely; blood transfusion may be required.
- **Re-pseudoarthrosis:** Fusion failure rates are higher at revision than primary surgery, particularly if the underlying risk factors (smoking, osteoporosis, diabetes) are not corrected.
- **Infection:** Revision cases have higher infection rates than primary surgery. Prophylactic antibiotics, meticulous technique, and vancomycin powder application to the wound are used to minimize this risk.
- **Hardware removal complications:** Prior screws may be difficult to extract if they are osteointegrated or broken. Specialized instruments (broken screw extractors, trephines) are used.
- **Proximal junctional kyphosis (PJK):** Extension of a long fusion construct places new stress at the upper instrumented vertebra, risking kyphotic collapse at that junction.
- **Longer operative time and anesthetic exposure:** Revision procedures are more complex and time-consuming, increasing overall physiological demands — particularly in elderly patients.

Optimizing Your Outcome Before Revision Surgery — What You Can Do:

- Stop smoking completely — this is non-negotiable for fusion success. Smoking doubles the pseudoarthrosis rate and dramatically increases infection risk
- Treat osteoporosis — a course of anabolic agents (teriparatide/Forteo) for 3–6 months before revision surgery significantly improves bone quality and screw purchase
- Optimize blood sugar control — target HbA1c below 7.5%
- Achieve a healthy weight — BMI above 35 substantially increases all complication rates
- Complete pre-operative cardiac, pulmonary, and medical clearance as directed
- Begin prehabilitation physical therapy to maximize strength and conditioning
- Discuss bone stimulator use with Dr. Caridi — an external stimulator worn post-operatively significantly improves fusion rates in high-risk patients

6. Recovery After Revision Fusion Surgery

Recovery from revision surgery is generally longer and more demanding than from a primary procedure. The timeline below applies to most revision cases; complex deformity corrections (PSO, VCR) may require longer hospital stays and extended recovery periods.

Hospital Stay 3–7 days	Walking begins on post-operative day 1 with physical therapy. A TLSO brace is fitted before discharge. Pain managed with IV and oral medications. ICU monitoring overnight after complex deformity cases.
Weeks 1–6 Home Recovery	Frequent short walks; wear brace when upright. No bending, lifting, or twisting. Wound check at 2 weeks. Outpatient PT at 2–4 weeks. Begin bone stimulator use as directed. Expect more fatigue than after primary surgery — this is normal.
Weeks 6–12 Rehabilitation	PT progresses to core strengthening and functional activities. X-rays at 6 weeks confirm hardware position. Return to desk work typically at 6–8 weeks. Brace may be discontinued per Dr. Caridi's assessment. Driving permitted when off narcotics.
Months 3–6 Fusion Assessment	CT scan at 3–6 months to evaluate fusion progress. Significant pain relief and functional improvement typically seen by this point. Activity gradually expanded as cleared by Dr. Caridi. Continue bone stimulator until fusion is confirmed.
Months 6–18 Full Recovery	Bone fusion matures over 12–18 months. Final X-rays at 12 months confirm solid union. Long-term outcomes for carefully selected and well-optimized revision patients are very good — the majority experience meaningful, lasting relief of their primary symptoms.

7. When to Seek Evaluation

Do not assume that pain or new symptoms after prior spine surgery are simply "normal" or permanent. Many patients suffer unnecessarily for years with a correctable problem. Please contact Spinal Associates if you experience any of the following:

Seek Evaluation With Dr. Caridi If You Experience:

- Return of back or leg pain after a period of improvement following prior fusion
- New or different pattern of leg pain, numbness, or weakness
- Progressive forward-stooped posture that is difficult or impossible to correct voluntarily
- Pain that is mechanical — clearly worse with activity and better with rest
- A palpable "click" or sense of instability in the spine with movement
- Any new neurological deficit — weakness, foot drop, or bladder/bowel dysfunction (seek urgent/emergency evaluation)
- Back pain at the level immediately above or below your prior fusion
- You were told at your last visit that your fusion may not have healed properly

Revision spine surgery is a field that demands both experience and meticulous planning. Dr. Caridi has extensive training in complex revision and deformity correction surgery and offers a comprehensive evaluation to determine whether revision surgery is appropriate, what procedure offers the best chance of lasting relief, and how to optimize your health to achieve the best possible outcome.