Complications of Spinal Instrumentation[1]

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ONLINE-ONLY CME

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LEARNING OBJECTIVES

After reading this article and taking the test, the reader will be able to:

- Explain the functional rationale behind spinal column reconstruction.
- Describe a basic approach for postoperative radiography after spinal column reconstruction.
- Recognize common complications of spine surgery that cause persistent postoperative pain.

TEACHING POINTS

See last page

Despite tremendous technical advances in spine surgery in recent decades, patients may experience residual or recurrent pain and other symptoms after such surgery. The standard history and physical examination have only limited utility for assessing the postoperative anatomy, and radiologists can play an important role in diagnosing complications and guiding postoperative care. To do so effectively, they must be familiar with the imaging features of successful and unsuccessful fusion, instrumentation fracture and loosening, complications due to faulty hardware placement, and postoperative infection. A basic knowledge of spinal biomechanics and common approaches to surgical instrumentation also may help radiologists anticipate and identify complications.

Introduction

Spinal fusion surgeries have increased markedly in frequency in recent decades. Since the first successful fusion procedures were described by Hibbs and Albee in 1911 for prevention of progressive deformity from Pott disease, an improved understanding of spinal biomechanics and a burgeoning armamentarium of surgical fixation devices have allowed tremendous advances in surgical technique (1,2). Despite these developments, the incidence of residual or recurrent postoperative back pain (so-called failed back syndrome) remains high because of the influence of a myriad of factors (3). Follow-up radiography is often performed to clarify the cause of postoperative pain. With the use of radiography and various other modalities, the radiologist can play a crucial role in determining the origins of persistent or recurrent symptoms, which may be frustratingly nonspecific.

RadioGraphics 2007; 27:775–789 • **Published online** 10.1148/rg.273065055 • **Content Code:** MK

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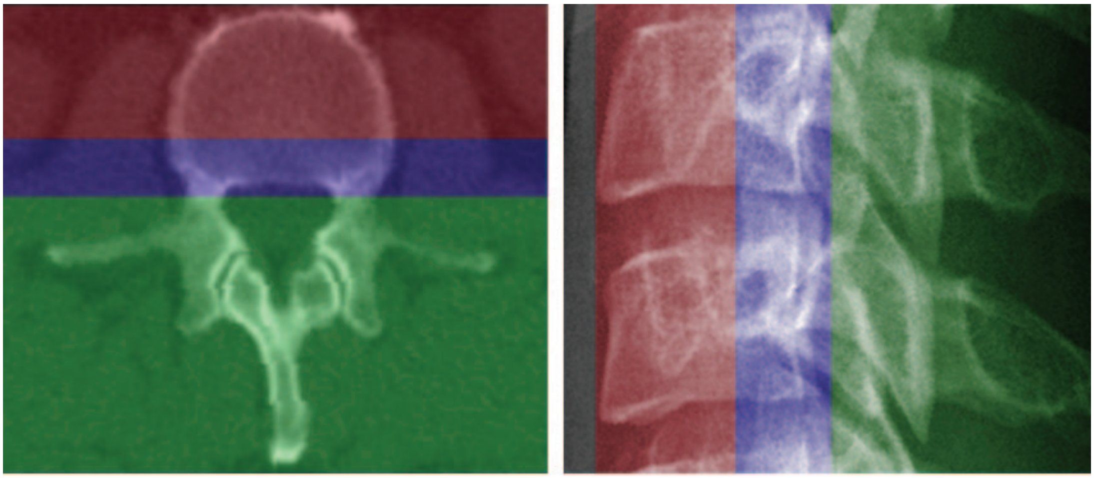


a. b.

Figure 1. The three columns of the spine. Axial CT image **(a)** and lateral radiograph **(b)** with color overlay show the anterior (red), middle (blue), and posterior (green) columns in a normal patient.

The article reviews the potential complications of spinal instrumentation, beginning with a description of biomechanics and an overview of surgical approaches and continuing with a discussion of various types of complications and their appropriate radiologic assessment. The imaging features of immediate and delayed complications—including instrumentation malpositioning and failure, graft nonincorporation and resorption, and infection and other nonmechanical complications—are described.

Biomechanics of the Three-Column Spine

The spinal column serves as the primary structural support of the human body. It transmits axial loads from most of the weight of the body and facilitates restrained motion during flexion, extension, rotation, and lateral bending. Each of these types of movement places a particular pattern of stress on the vertebral bodies, intervertebral disks, and ligamentous structures that form the spinal column. As observed by Francis Denis in 1983, the biomechanics of the spine may be better described by giving separate consideration to three anatomic divisions—the anterior, middle, and posterior columns (4). Although subsequent work has led to the development of a more sophisticated understanding of the mechanical functioning of the spinal column, the three-column construct provides a simple method for evaluating gross stability and is commonly employed by surgeons in preoperative planning.

The anterior column consists of the anterior longitudinal ligament and anterior two-thirds of the vertebral body and annulus fibrosus. Its primary functions are to bear the axial load and to resist extension. The middle column is comprised of the posterior one-third of the vertebral body, annulus fibrosus, and nucleus pulposus, as well as the posterior longitudinal ligament. The middle column functions primarily to resist flexion, and it also bears some of the axial load. The posterior column consists of the posterior elements—pedicles, facets, ligamentum flavum, interspinous ligament, and supraspinous ligament. In addition to resisting flexion, the posterior column provides important stability during rotational movement and lateral bending. The three columns are shown in Figure 1.

Surgical Procedures

Comprehensive discussions of surgical procedures and radiographic appearances of implants have been presented thoroughly elsewhere, and these topics are discussed only briefly here (5–7). Fusion surgeries are performed for a wide spectrum of indications, including correction of degenerative deformities, trauma, infection, tumor, and congenital anomalies such as scoliosis. The goal of spinal fusion is to restore anatomic alignment and functional biomechanics to as near normalcy as possible. Preference of surgical approach

Figure 2. Two-column instability. Anteroposterior radiograph shows instability above the level of successful fusion in a 61-year-old woman who underwent laminectomies at L1 through L5 and posterior lumbar interbody fusion at L4 through S1.

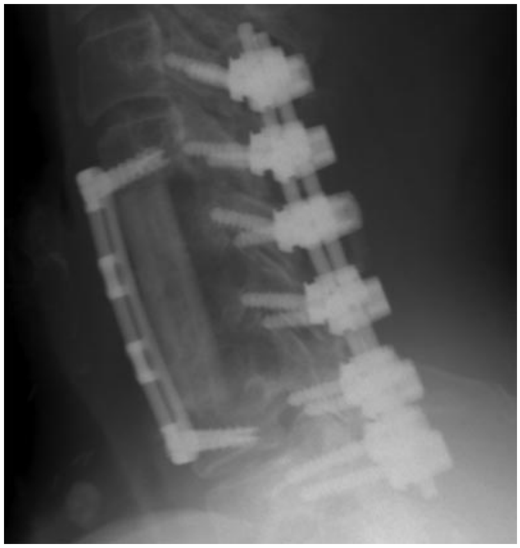


Figure 3. Combined anterior and posterior fusion of the cervical spine. Lateral radiograph demonstrates an anterior column reconstruction with a fibular allograft and an anterior plate and screws after vertebral body resection (corpectomy) at multiple levels, as well as a posterior column reconstruction with articular pillar screws and rods. The structural integrity of the anterior and posterior columns made reconstruction of the middle column unnecessary.

and instrumentation vary and are dictated by the underlying condition. Although a comprehensive knowledge of instrumentation and surgical technique is beyond the scope of most radiologists, familiarity with the favored procedures and implants used by the referring clinician will foster improved communication with the surgeon and may lead to an increased awareness of potential complications.

Whereas the early surgeries performed by Hibbs and Albee required a significant convalescence period and extended bracing, subsequent developments in orthopedic hardware have dramatically shortened the postoperative recovery period. Internal fixation devices can preserve alignment and prevent motion to optimize graft incorporation, while allowing early mobility.

Teaching Point

Generally, two of three columns must be anatomically intact for functional stability. Instrumentation is therefore often necessary if more than one column is disrupted by trauma, infection, tumor, degenerative change, or surgical approach. Complications may arise even years after single-column surgery if subsequent trauma or degenerative change affects the remaining columns (Fig 2).

Reconstruction of the posterior column has been performed for decades and may be accomplished with many types of instrumentation. Commonly used methods include long rods with sublaminar hooks or wires, such as Cotrel-Dubousset or Luque rods. This type of instrumentation is now used primarily for correction of scoliosis. Pedicle screw and rod or plate constructs have become the preferred method of instrumentation when multiple-column reconstruction is required.

The anterior and middle columns can be reconstructed from an anterior or posterior approach. The anterior approach is generally preferred in the cervical spine because of the risk of cord manipulation, which would be required for a posterior approach at this level. Autograft or allograft bone blocks may be used for reconstruction after diskectomy or corpectomy in the anterior and middle columns. Allograft struts or bone graft cages also may be employed if a corpectomy is performed. Posterior instrumentation, if required, then can be placed through a separate incision (Fig 3).

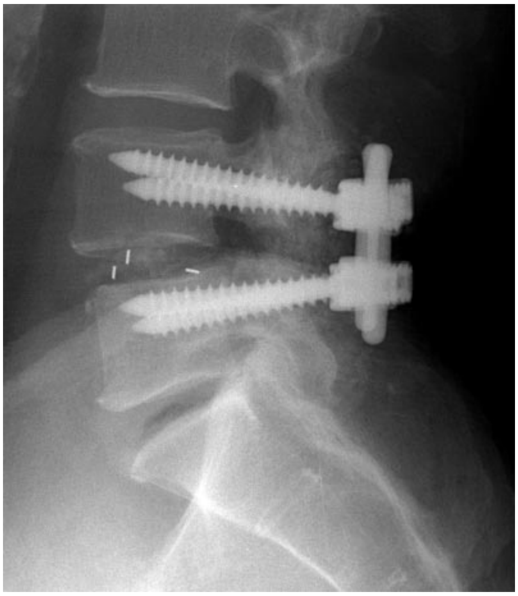


Figure 4. Posterior interbody fusion of L3 to L4 in a 51-year-old man. Lateral radiograph shows the pedicle screw and rod instrumentation used to reconstruct the posterior column. Radiopaque markers indicate the location of the radiolucent bone graft cage.

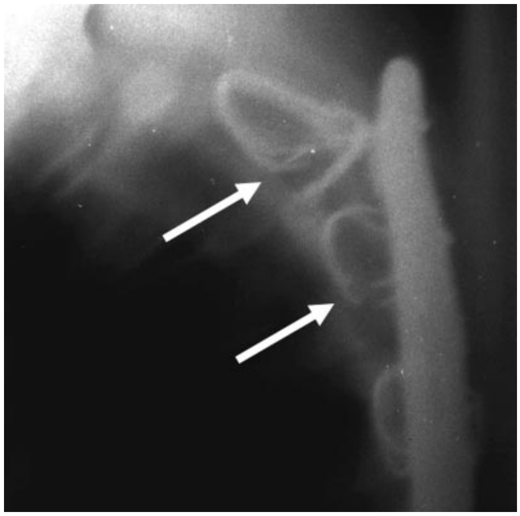


Figure 5. Fracture of sublaminar wires used in corrective surgery for scoliosis. Routine surveillance radiograph demonstrates the fracture of multiple wires (arrows) and recurrent kyphosis of the thoracic spine anterior to the instrumentation.

A posterior approach to anterior- and middle-column reconstruction is often preferred in the lumbar spine for two reasons. The first is that the morbidity associated with an anterior approach is significant and delays recovery. The second is that pedicle screws and rods or plates can be placed before dural retraction and dissection of the intervertebral disk. This instrumentation may be used to maximally distract the disk space, restoring normal disk height and decompressing the neural foramina. The evacuated disk space is then filled with allograft bone blocks or fusion cages that contain morselized autograft bone. The blocks and cages are preselected with specific dimensions to restore anatomic alignment. Cages may be metallic or radiolucent, with radiopaque markers outlining the margins of the latter (Fig 4). The posterior instrumentation is then locked into place to restore the normal lumbar lordosis and prevent posterior herniation of the graft material. Anterior interbody fusion is sometimes performed, frequently with the use of threaded cages that are "screwed" into the intervertebral disk space. Because the sharp screw threads penetrate

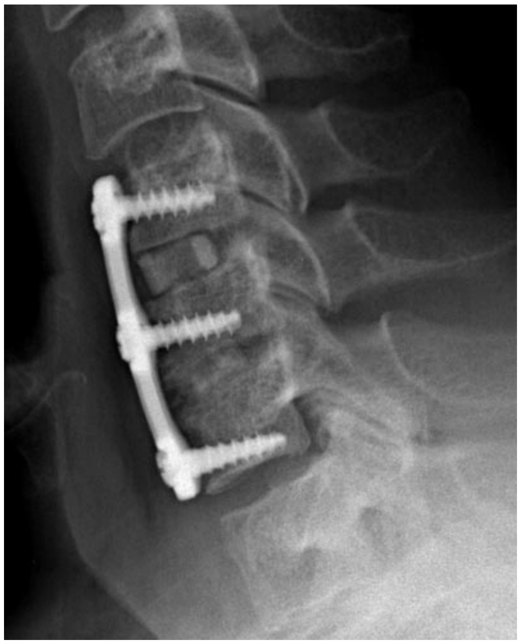
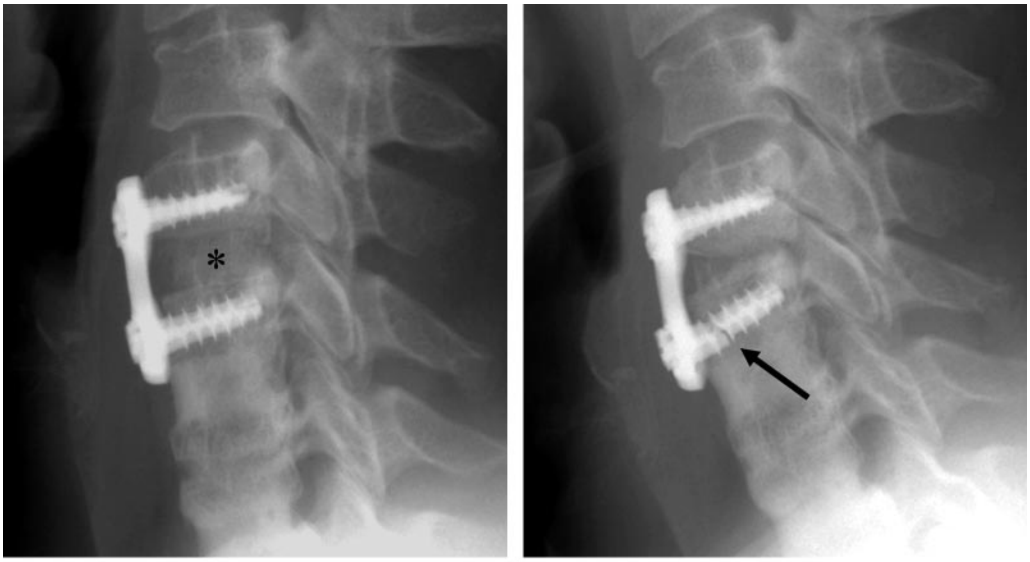


Figure 6. Nonincorporated bone graft material. Lateral radiograph demonstrates anterior plate and screw instrumentation at C4 through C6, with intervertebral bone blocks used to reconstruct the anterior column. The graft material at C5–6 shows evidence of fusion, with blurring of graft margins and new bone formation in the interspace. Visible at the C4–5 level are persistent graft margins, sclerosis of the adjacent endplates, and absence of new bone formation, features indicative of a lack of graft incorporation.



a. b.

Figure 7. Resorption of nonunited graft material and hardware fracture. **(a)** Initial postoperative lateral radiograph demonstrates anterior plate and screw fixation of C4 to C5 with an intervertebral bone graft (*). Note the excellent graft incorporation at the levels of previous anterior fusion (C5 to C6 and C6 to C7); hardware was removed from those levels during surgical fusion of C4 to C5. **(b)** Extension radiograph obtained at 13-month follow-up demonstrates resorption of the graft material and fracture of the inferior screw (arrow).

the dense cartilaginous endplates, there is a risk of vertebral collapse onto the instrumentation.

Complementary Roles of Instrumentation and Fusion

The development of an integrated osseous fusion complex is essential for long-term success, and the assessment of the integrity of the bone is of primary importance. Implanted hardware exists solely to provide short-term stability while fusion develops. Inadequate fixation and subsequent motion may cause the bone graft to resorb rather than to be incorporated. This in turn puts hardware at risk of fracture (Figs 5, 6).

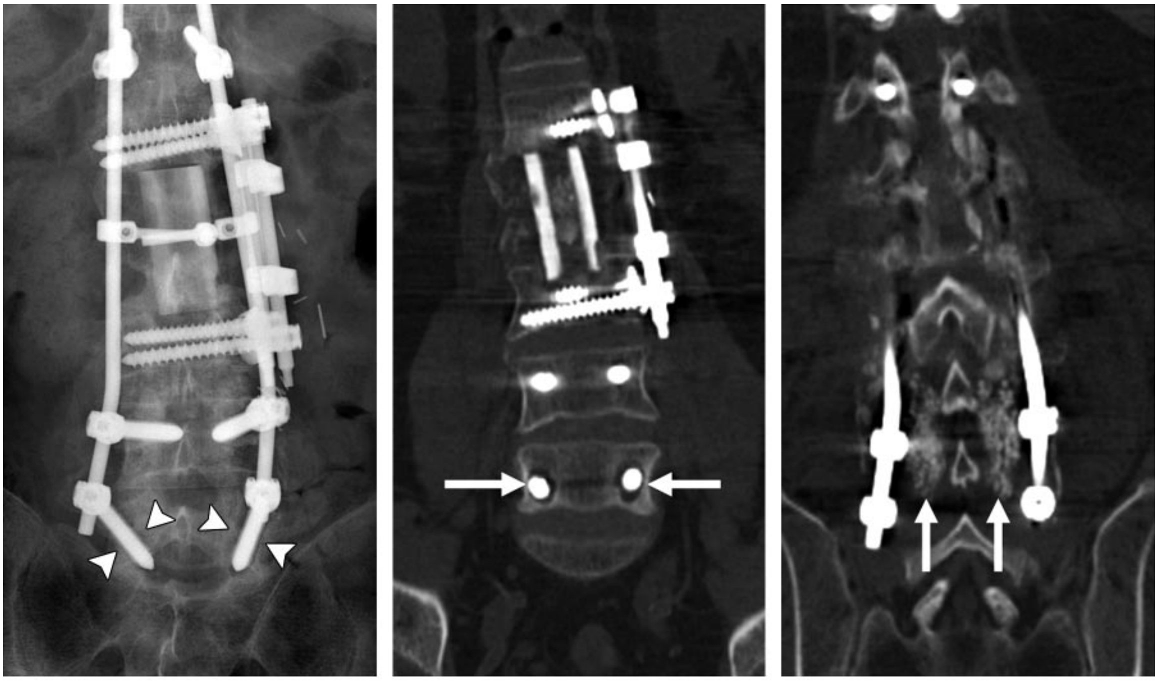
Radiography has long been the standard method for evaluation of the fusion construct (Figs 6, 7). The assessment of fusion may be difficult, but, typically, signs of bridging bone should occur by 6–9 months after surgery. Ray (8) defined six criteria for assessing the solidity of fusion at radiography (Table). These criteria have not been externally validated, but they have gained clinical acceptance and are useful for interpreting postoperative radiographs. In addition to postoperative radiography, multidetector CT with multiplanar reformatting of image data can be extremely useful for presurgical planning; it has

Teaching Point

Criteria for Radiographic Assessment of Bridging Osseous Fusion

1. Less than 3 degrees of intersegmental position change on lateral flexion and extension views.
2. No lucent area around the implant.
3. Minimal loss of disk height.
4. No fracture of the device, graft, or vertebra.
5. No sclerotic changes in the graft or adjacent vertebra.
6. Visible bone formation in or about the graft material.

Source.—Reference 8.



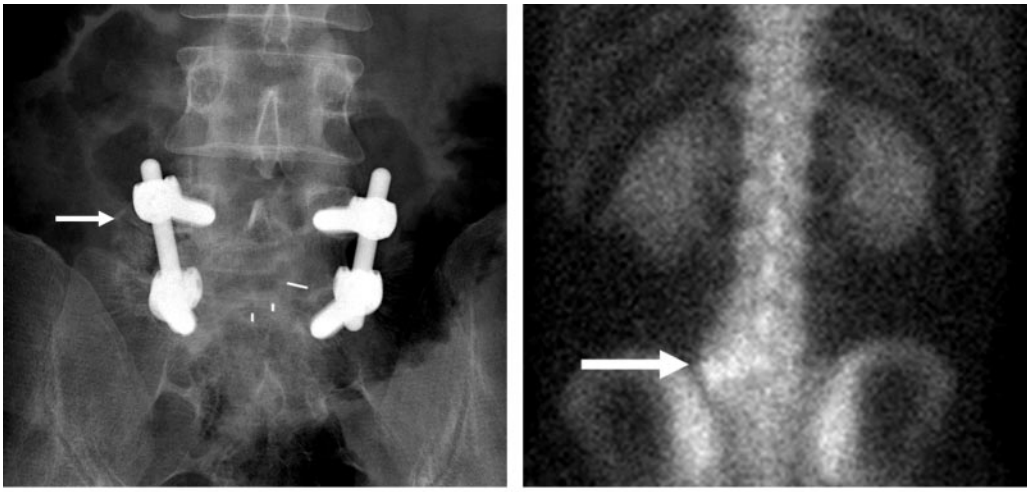
a. b. c.

Figure 8. Utility of multidetector CT in evaluation of nonunion. **(a)** Anteroposterior radiograph demonstrates multilevel pedicle screw and rod instrumentation with a corpectomy at L3 and reconstruction with a humeral strut graft and lateral sideplate and screws. Areas of lucency around the inferior pedicle screws are indicative of loosening (arrowheads). **(b)** Coronal CT image clearly shows areas of lucency around the inferior pedicle screws (arrows). **(c)** Coronal CT image in a more posterior plane than **b** demonstrates the dense, granular appearance of the graft material (arrows), a finding indicative of a lack of graft incorporation into a solid fusion construct at this inferior level. **(d)** Coronal CT image in a more posterior plane than **b** and **c** shows adequate formation of a posterolateral osseous fusion complex at higher levels (arrows).

d.

the capability to provide exquisitely detailed depiction of hardware and graft materials (Fig 8).

In the presence of chronic low-grade instability and motion, pseudarthrosis may develop. Pseudarthrosis represents fibrous rather than osseous union of the fusion complex. Without solid osseous fusion, loosening or fracture of instrumentation may occur. In addition, the pseudarthrosis itself may be a source of pain generation. Mature pseudarthrosis is typically seen as a clearly corticate linear lucency across the graft material (Fig 9). Early-stage pseudarthrosis may have a subtle appearance, but radionuclide bone scanning or CT may help confirm the diagnosis (Fig 10). Increased radiotracer uptake is expected at sites of motion, and CT may allow precise definition of cortical margins and residual graft material. Magnetic resonance (MR) imaging also is possible with most titanium and cobalt-chromium implants, and T2-weighted images may demonstrate focal high signal intensity in the region of pseudoarticulation. We have successfully performed diagnostic and therapeutic injections of pseudarthroses for surgical planning and symptom relief, respectively, and further study is needed regarding the effectiveness of pseudarthrosis injection.



a. b.

Figure 10. Early pseudarthrosis in a 43-year-old man. **(a)** Anteroposterior radiograph demonstrates a linear lucency in the posterolateral bone graft material on the right (arrow), a finding indicative of early pseudarthrosis. **(b)** Technetium 99m methylene diphosphonate bone scan (reversed to correspond to **a**) shows an area of markedly increased activity at this level (arrow), a feature that helps confirm the diagnosis.

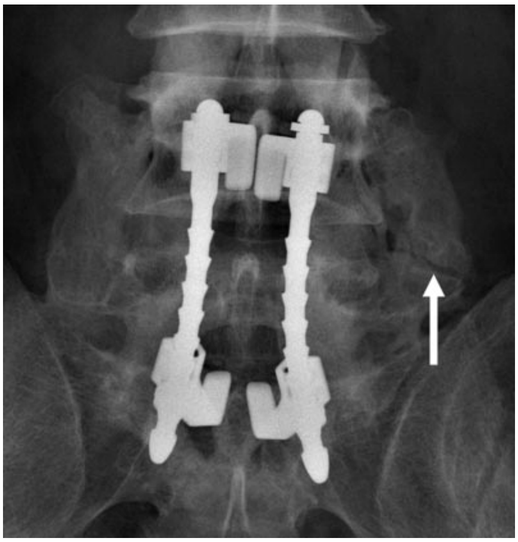


Figure 9. Mature pseudarthrosis in a symptomatic 54-year-old man who had undergone posterolateral fusion with Harrington rods from L4 through S1. Anteroposterior radiograph demonstrates a corticate linear defect in the posterolateral fusion complex on the left (arrow), a feature indicative of pseudarthrosis.

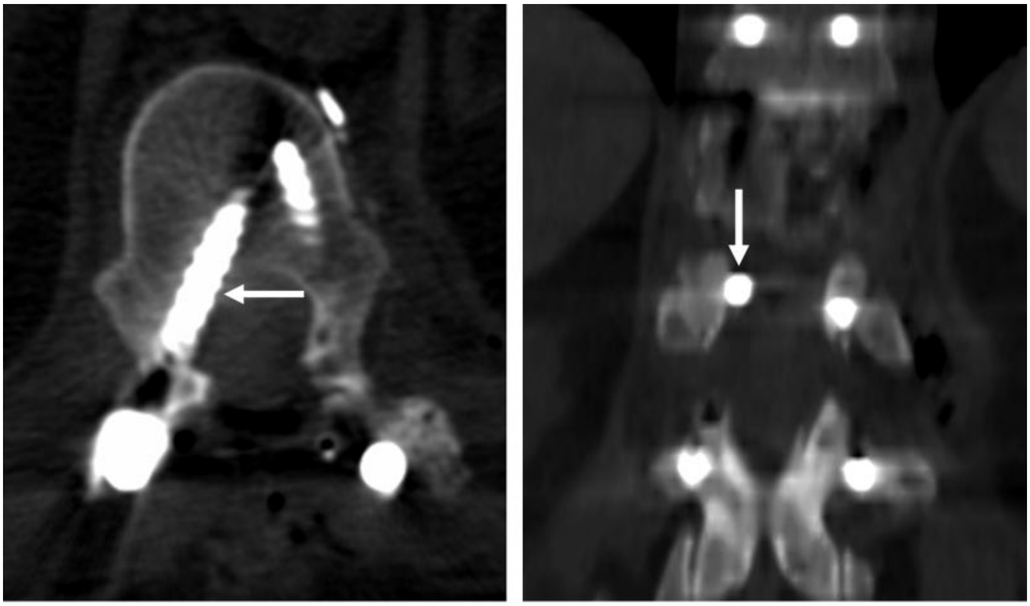
Instrumentation-related Complications

Given the technical difficulties of placing instrumentation in the spine, it is inevitable that complications sometimes arise from malpositioning of hardware. The radiologist should systematically assess the integrity of neural and vascular structures throughout the spine, including the neural foramina, thecal sac, central cord and cauda equina, and foramen transversarium, as well as adjacent structures such as the major abdominal vessels, psoas musculature, posterior mediastinum, and prevertebral soft tissues.

Teaching Point

Pedicle screws, in particular, deserve attention because of their frequent use and proximity to sensitive neural and vascular structures. Lonstein et al (9) reported an overall complication rate of 2.4% per screw in a retrospective review of clinical outcomes with placement of 4790 pedicle screws. The most common complication was nerve root irritation from medial angulation of the screw with resultant violation of the medial cortex of the pedicle.

Optimal screw placement is typically along the medial aspect of the pedicle. The instrumentation gains purchase from its proximity to cortical bone but should not disrupt it; the tip of the pedicle screw should approach but not breach the anterior cortex of the vertebral body. Loosening of pedicle screws often may be seen as a rim of lucency around the screw threads (Fig 8). Complications may arise from medial or lateral deviation of a screw or from its penetration of the anterior cortex of the vertebral body (Figs 11–13). Similar complications may arise from malpositioning of



a. b.

Figure 11. Medial deviation of a pedicle screw. Axial **(a)** and coronal **(b)** CT images show a screw that has traversed the medial cortex of the pedicle and penetrated the thecal sac (arrow), leading to a cerebrospinal fluid leak. The leak was repaired when the errant screw was removed, and a new screw was correctly positioned.

Figure 12. Lateral pedicle screw deviation in a 71-year-old man with neuropathy at L5. Axial CT image shows deviation of the right pedicle screw, which exits the lateral cortex and traverses the right neural foramen at the L5-S1 level (arrow). Neuropathy resolved after the screw was removed.

Figure 13. Penetration of the anterior sacral cortex in a 46-year-old man after lumbosacral fusion. Sagittal CT image shows that the inferior pedicle screw has exited the anterior cortex of the S1 segment and is impinging on the hypogastric vein (arrow).

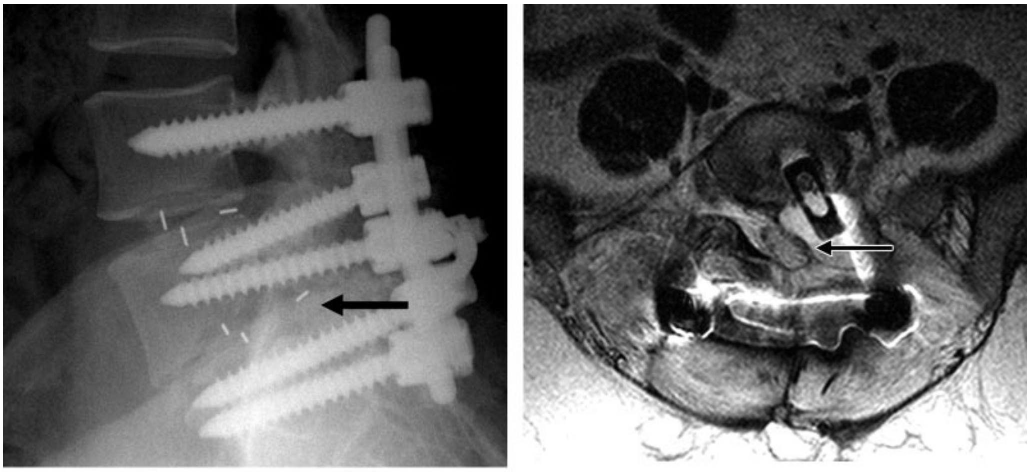


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Figure 15. Dorsal herniation of an intervertebral bone graft cage in a 41-year-old woman with acute neuropathy. **(a)** Lateral radiograph depicts posterior interbody fusion at L4–5 and L5-S1 and posterolateral displacement of the L5-S1 bone graft cage into the spinal canal (arrow). The patient was experiencing worsening low back pain and a left L5 radiculopathy. **(b)** T2-weighted MR image demonstrates ventral and lateral effacement of the thecal sac (arrow) by the cage.

Figure 14. Hardware malpositioning. Sagittal T2-weighted MR image demonstrates a magnetic susceptibility artifact produced by an anterior cervical screw that has exited the posterior cortex of the vertebral body and entered the spinal canal (arrow).

anterior cervical plates and screws, which may penetrate the adjacent disk space, foramen transversarium, spinal cord, or nerve roots (Fig 14). Graft material in either case also may herniate anteriorly or posteriorly (depending on the approach used for placement) and cause neurologic compromise (Fig 15).

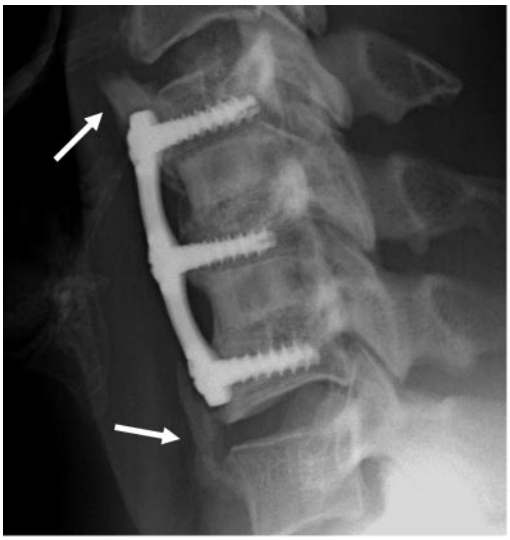
Although surgery at the wrong level is an uncommon occurrence, it may account for the persistence of clinical symptoms. The radiologist should consider potential surgical interventions and should provide surgically relevant information when reporting findings at preoperative imaging. In reporting cases of spinal stenosis, it is important to describe the structures that are causing canal compromise (Fig 16).

The acute onset of neurologic symptoms in the immediate postoperative setting should arouse clinical suspicion about the possible formation of

16.

17.

Figures 16, 17. **(16)** Wrong level of surgery. Sagittal T2-weighted MR image of an 80-year-old woman demonstrates an acute burst fracture of the L4 vertebra. The interpretation of the preoperative study (not shown) stated that posterior displacement of fracture fragments caused severe central canal stenosis at this level. However, the narrowest segment is that between the L4 fracture fragments and the posterior elements of L3 (arrow), particularly the thickened ligamentum flavum. Laminectomies were performed at L4 and L5 (*), but central canal stenosis persists between the L4 fracture fragments and the posterior elements of L3. **(17)** Acute neurologic compromise (cauda equina syndrome) in an 80-year-old woman after laminectomies at levels L3 through L5 for decompression. Sagittal T2-weighted MR image demonstrates a large hematoma (arrow) in the postoperative bed, with resultant compression of the thecal sac (arrowheads).



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Figures 18, 19. **(18)** Accelerated ligamentous ossification secondary to placement of anterior cervical plates within 5 mm of the adjacent intervertebral disk. Lateral radiograph demonstrates large osteophytes (arrows). **(19)** Ligamentous instability following multisegmental cervical fusion. Lateral flexion radiograph demonstrates cervical fusion at C4 through C6 with anterior and posterior instrumentation and marked ligamentous instability at C6–7.

a hematoma. Such occurrences require urgent surgical decompression (Fig 17).

Long-term Sequelae of Fusion

Teaching Point

The essential problem in fusion, despite its frequent success, is that the lost mobility of the fused segment places additional stresses on adjacent levels of the vertebral column. The consequence is an increased likelihood of degenerative changes, ligamentous instability, and even fracture at levels adjacent to a successful fusion construct (Figs 18–21). The long-term consequences of altered spinal biomechanics are probably underrecognized.

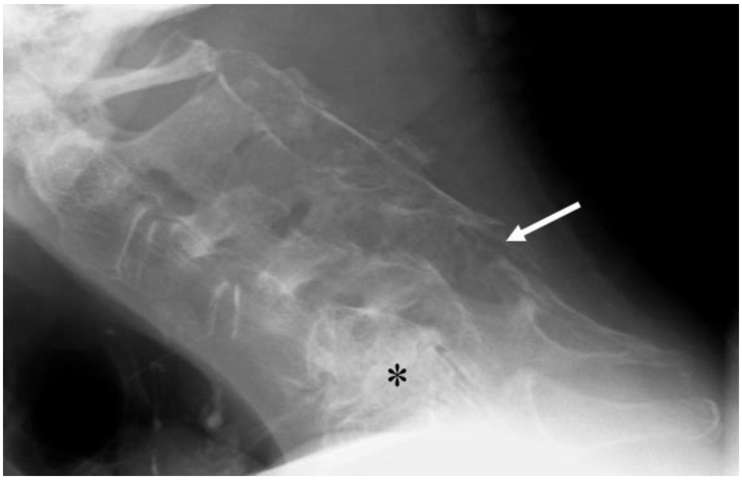
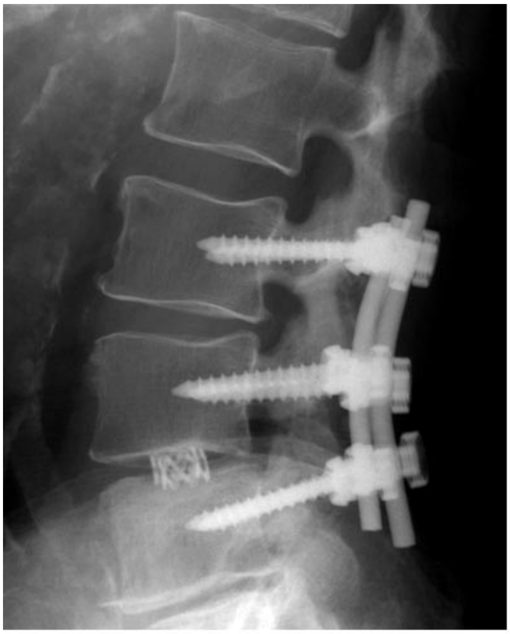


Figure 20. Acute fracture of the spine. Lateral radiograph of a patient who previously underwent a multilevel cervical fusion without instrumentation demonstrates an acute fracture that involves the anterior, middle (*), and posterior (arrow) columns at the C5 level. Underlying osteopenia and long-segment fusion created a predisposition to fracture.



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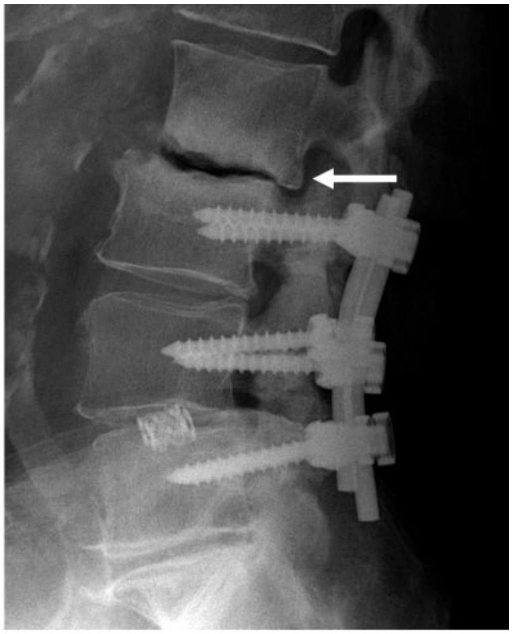

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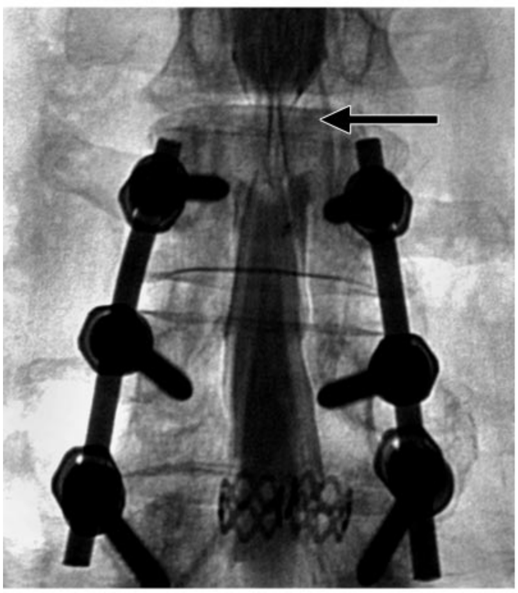


c.

Figure 21. Symptomatic disk herniation at a level adjacent to instrumentation. **(a)** Initial postoperative radiograph demonstrates posterior lumbar interbody fusion with pedicle screw and rod instrumentation at L3 through L5, with two titanium mesh cages in the L4–5 disk space. **(b)** Follow-up radiograph obtained 2½ years later demonstrates a severe loss of disk height with a vacuum phenomenon at L2–3, the level above the fusion (arrow). **(c)** Anteroposterior fluoroscopic image from myelography demonstrates a large extradural defect caused by compression of the cauda equina (arrow) with midline herniation of the L2–3 disk.

Figure 22. Osteopenia-related insufficiency fractures of the cartilaginous endplates adjacent to a humeral strut graft. Sagittal CT image after an L1 corpectomy and reconstruction with a humeral allograft depicts the collapse of the cartilaginous endplates onto the dense graft material (arrows), which shows no signs of incorporation. Construct failure and a thoracic compression fracture (*) are associated with underlying osteopenia.

Figure 23. Facet fracture-dislocation and partially dislodged C5–6 anterior plate and screws. Sagittal CT image demonstrates a dislodged inferior screw (arrow) and interbody bone graft material. Bilateral locked facets and a facet fracture also were found. The patient, who had dementia, had removed his cervical collar and attempted to ambulate shortly after surgery.

Even seemingly minor differences in instrumentation technique may affect outcome. Park et al (10) recently showed that placement of an anterior cervical plate with its margin within 5 mm of the adjacent disk space increased the incidence of osteophyte formation at that level (Fig 18).

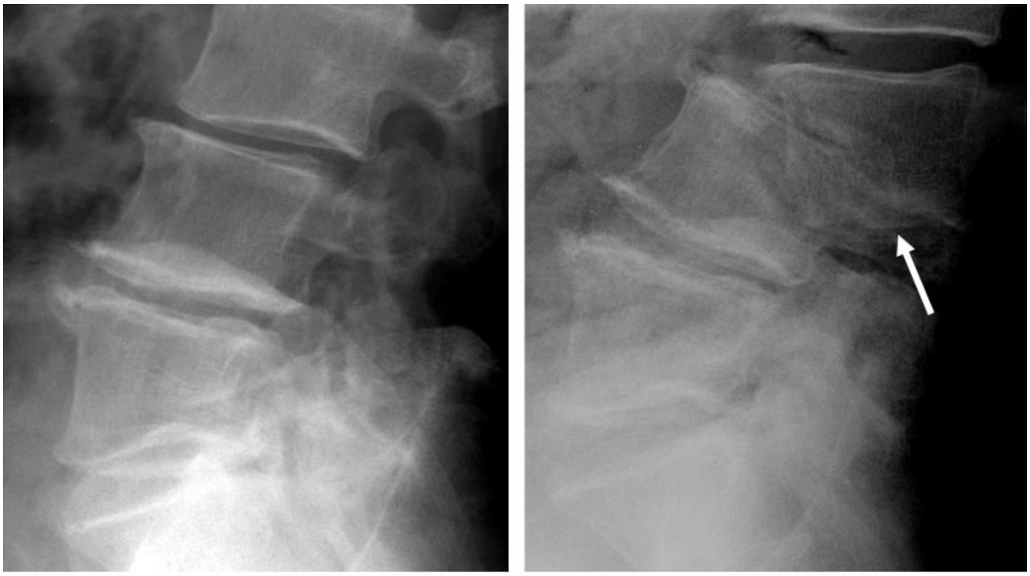
Even in the absence of morphologic changes, increased stress from fusion may cause microtrauma to the intervertebral disks at adjacent levels. The physiology of pain originating in a damaged disk is poorly understood, but it is well accepted that a disk that is radiographically normal may be the focus of extreme pain. Diskography may be performed and the results used to guide therapy. Frank herniation of a disk can be seen at myelography or MR imaging (Fig 21).

As discussed previously, decompressive laminectomy without instrumentation or fusion also may have long-term functional consequences. Such procedures typically disrupt only the posterior column and have excellent initial results. However, if degenerative changes subsequently occur in the anterior column, two-column instability may develop, necessitating further surgery.

Figure 24. Postoperative abscess and resultant dorsal effacement of the thecal sac. Sagittal T2-weighted fat-saturated MR image demonstrates a large abscess in the postoperative bed, with extensive abnormal T2 hyperintensity and mass effect on the thecal sac.

Patients also may be at risk for complications due to underlying medical conditions. Patients with osteoporosis, metabolic bone disease, Paget

RadioGraphics



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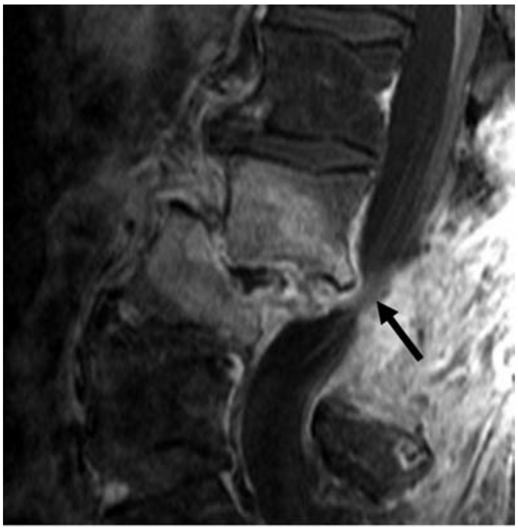


c.

Figure 25. Postoperative diskitis and osteomyelitis. **(a, b)** Lateral radiographs in a patient who underwent partial diskectomy, laminectomy, and lumbar fusion without instrumentation. Initial postoperative image **(a)** and 6-month follow-up image **(b)** show progressive endplate destruction, collapse of the disk space, and osteopenia in the adjacent vertebral bodies (arrow in **b**), findings indicative of diskitis and osteomyelitis. **(c)** Sagittal T1-weighted contrast-enhanced MR image demonstrates intense enhancement in the vertebral bodies and remaining disk—a finding that helped confirm the diagnosis—as well as ventral compression of the thecal sac (arrow).

disease, or a history of smoking may have poor underlying bone quality and be more susceptible to injury (Fig 22). Morbid obesity adds to the technical difficulty of spine surgery and exerts greater stresses on instrumentation. Patients with dementia or a movement disorder are prone to fall and therefore have a higher risk for damage to the construct (Fig 23). Parkinson disease, in particular, may be a significant risk factor for complications, as was recently suggested by Babat et al (11).

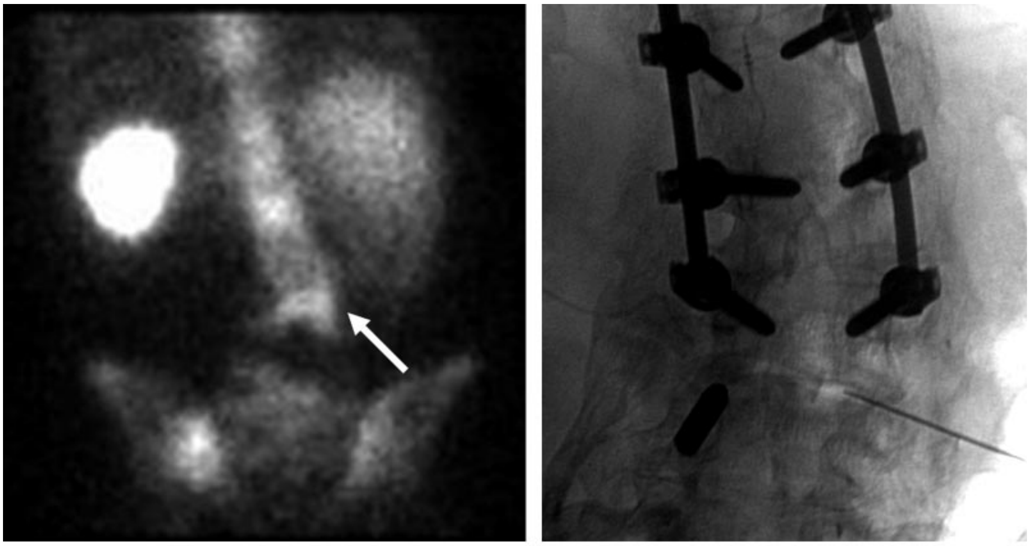
In summary, successful fusion permanently alters the mechanics of vertebral segments at adjacent levels. Such alterations may accelerate degenerative changes in the vertebrae, ligaments, and intervertebral disks. Awareness of this fact, as well as of any cormorbid medical conditions, may help the radiologist to anticipate complications and achieve an earlier diagnosis.

Nonmechanical Causes of Postoperative Symptoms

Teaching Point

Infection is a complication that may not be manifested until much later in the postoperative course—even more than 2 years after surgery (12). Infection may involve any tissue in the postoperative bed. Generally, superficial infections are manifested earlier than are deep-tissue and hardware-associated infections. Subcutaneous and soft-tissue infections, which may be signaled by redness, pain, edema, or a draining sinus tract, typically are easy to diagnose clinically. MR imaging may depict fluid collections and intense enhancement and often is useful for determining the extent of infection (Fig 24).

Deeper infections, including diskitis, may be difficult to diagnose. Radiographs of patients with diskitis classically show a collapse of the disk space, destruction of the adjacent endplates, and evidence of osteomyelitis in the adjacent vertebral bodies (Figs 25, 26). In the early stages, when



a. b.

Figure 26. Postoperative diskitis after posterior instrumentation. **(a)** Scintigram obtained with indium 111–labeled autologous leukocytes demonstrates increased radiotracer activity and acute angulation at the disk space (arrow), a finding suggestive of postoperative diskitis. **(b)** Anteroposterior fluoroscopic spot image shows a needle inserted in the disk space for aspiration biopsy. The presence of bacterial diskitis was confirmed.

diagnosis may be especially difficult, scintigraphy with radionuclide-labeled white blood cells and MR imaging may be useful for confirming the diagnosis. A disk biopsy also may be performed; this method has a high sensitivity for the detection of bacterial pathogens but a lower detection rate for fungal infections (13).

Pain and neurologic symptoms that arise over the long term may be due to arachnoiditis, an intradural scarring process that may manifest as traction with deformity of the nerve roots depicted at myelography or MR imaging (Fig 27).

Conclusions

Complications of spine surgery may be difficult to diagnose and manage, and it is frequently difficult to identify the causes of persistent or recurrent symptoms on clinical grounds alone. Radiography is the standard follow-up imaging method, and it provides a great deal of useful information. However, assessment of the fusion construct and of

Figure 27. Arachnoiditis after L4 and L5 laminectomies. Sagittal T2-weighted MR image demonstrates an abnormal configuration of the lumbar nerve roots (arrow), a finding indicative of arachnoiditis.

accelerated degenerative changes may be performed with multiple imaging modalities. Postoperative complications such as incomplete fusion, hardware failure, suboptimal positioning of instrumentation, infection, hematoma, and others may be detected at imaging. An assessment with any modality is facilitated by an understanding of spinal biomechanics. By accurately identifying complications of spinal instrumentation, the radiologist can play an important role in the care of patients with persistent postoperative pain.

Acknowledgment: Special thanks to Kathryn Waldeck for invaluable help in preparing the manuscript.

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Complications of Spinal Instrumentation

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RadioGraphics 2007; 27:775–789 • **Published online** 10.1148/rg.273065055 • **Content Code:** MK

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Generally, two of three columns must be anatomically intact for functional stability. Instrumentation is therefore often necessary if more than one column is disrupted by trauma, infection, tumor, degenerative change, or surgical approach.

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Ray (8) defined six criteria for assessing the solidity of fusion at radiography (Table). These criteria have not been externally validated, but they have gained clinical acceptance and are useful for interpreting postoperative radiographs.

Criteria for Radiographic Assessment of Bridging Osseous Fusion

1. Less than 3 degrees of intersegmental position change on lateral flexion and extension views.
2. No lucent area around the implant.
3. Minimal loss of disk height.
4. No fracture of the device, graft, or vertebra.
5. No sclerotic changes in the graft or adjacent vertebra.
6. Visible bone formation in or about the graft material.

Source.—Reference 8.

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The radiologist should systematically assess the integrity of neural and vascular structures throughout the spine, including the neural foramina, thecal sac, central cord and cauda equina, and foramen transversarium, as well as adjacent structures such as the major abdominal vessels, psoas musculature, posterior mediastinum, and prevertebral soft tissues.

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The essential problem in fusion, despite its frequent success, is that the lost mobility of the fused segment places additional stresses on adjacent levels of the vertebral column. The consequence is an increased likelihood of degenerative changes, ligamentous instability, and even fracture at levels adjacent to a successful fusion construct.

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Infection is a complication that may not be manifested until much later in the postoperative course—even more than 2 years after surgery.