Biopsy for Spine Infection

9

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Learning

1. To review the clinical evaluation of suspected spine infection
2. To learn the role of image-guided percutaneous spine biopsy during clinical management
3. To introduce specific biopsy techniques and tools for the proper performance of image-guided percutaneous spine biopsy

Infectious spondylitis	Infection of one or more of the spine compartments
Diskitis	Infection confined to the intervertebral disk
Osteomyelitis	Infection confined to the bone (vertebral body)
Spondylodiskitis	Infection of the disk and adjacent vertebral bodies
Septic arthritis	Infection within a facet joint
Epidural abscess	Epidural space infection with focal purulent collection
Meningitis	Infection involving the meninges

9.1 Introduction

The timely diagnosis and management of patients with spine infection are crucial as delays in diagnosis can cause neurologic impairment and mortality. Infectious spondylitis, or spine infection, is defined as infection of one or more spine structures. The structure or structures of the spine that might become infected include the intervertebral disk, the vertebral body including the vertebral endplate, the posterior elements including the facet joint, the epidural space with possible extension to the subarachnoid space, the spinal cord, and the paraspinal soft tissues (Fig. 9.1).

Although a relatively less common clinical entity, spine infections are increasing in incidence. Recent studies have reported an estimated increase in the incidence of spine infection from 5.3/100,000 population per year in 2007 to 7.4/100,000 population per year in 2010 (Akiyama et al. 2013). While an improved accuracy in diagnostic capabilities is hypothesized as an etiology for the increased incidence of spine infection, iatrogenic causes also play a significant role. Up to one-third of new cases of vertebral osteomyelitis are healthcare related, and one-third of those cases are secondary to catheter-related infections (Pigrau et al. 2015). Spine surgery is a major risk factor for spine infection (Fig. 9.2). Despite pre-procedure antibiotic prophylaxis, improved

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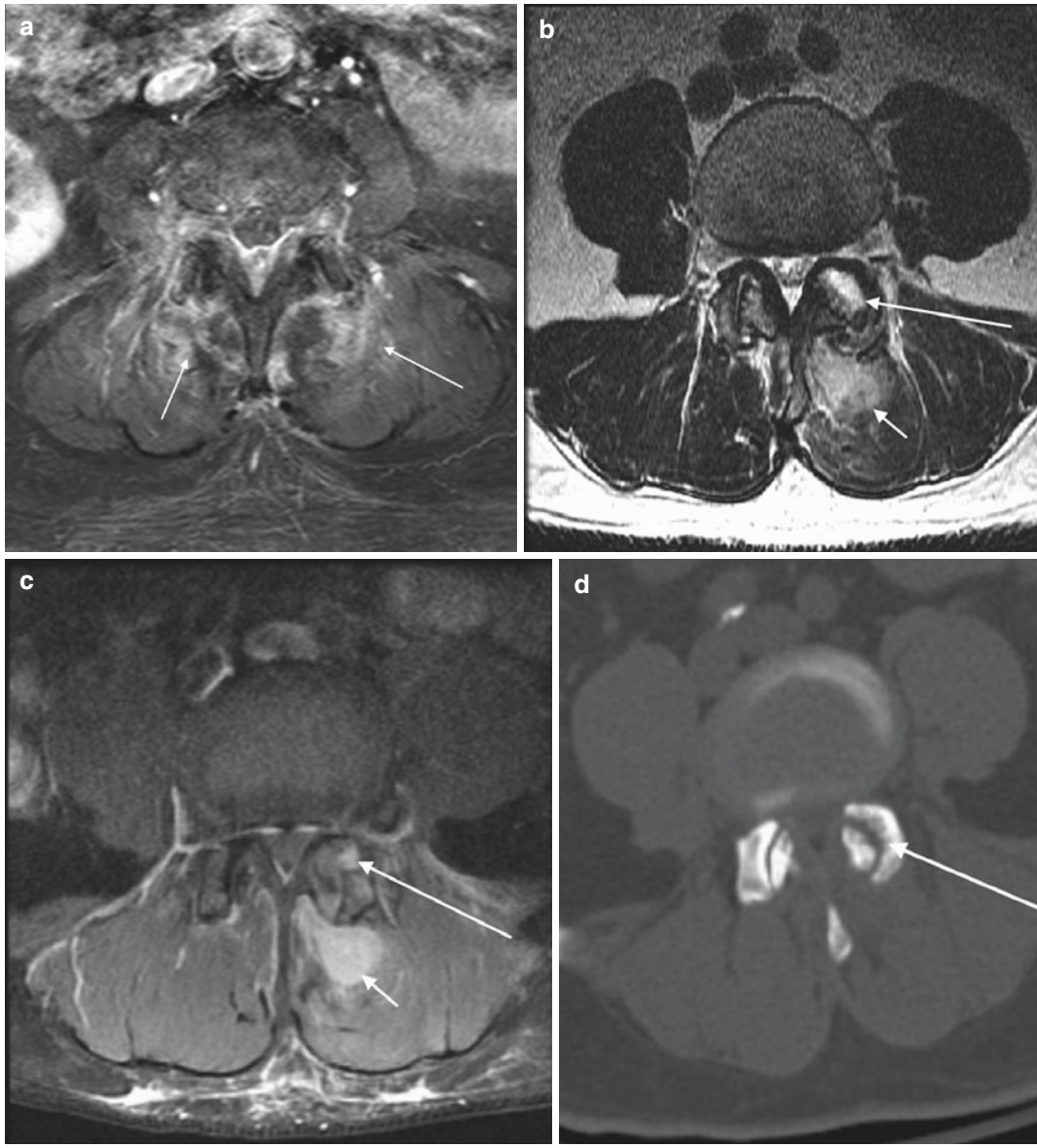
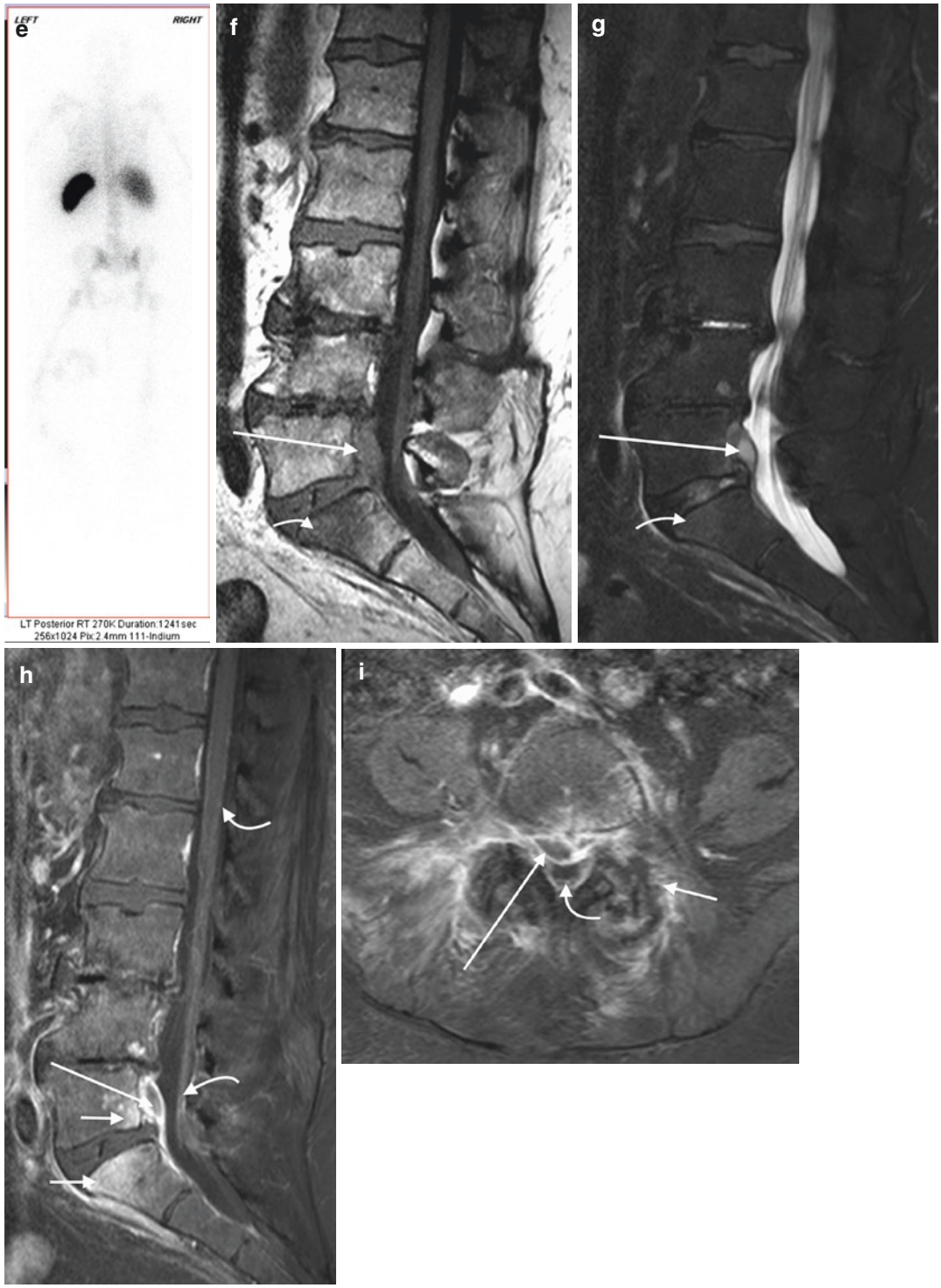


Fig. 9.1 Spectrum of spine infection. (**a**) Deep paraspinal muscle infection in an 84-year-old with low back pain and elevated ESR (90) and CRP (200) as shown on fat-suppressed contrast-enhanced T1-weighted axial image. A 56-year-old male with low back pain and fever due to septic left lumbar facet joint (*large arrow*) with edema in adjacent erector spinae and multifidus muscles (*small arrow*) as shown on T2-weighted axial image (**b**), fat-suppressed contrast-enhanced T1-weighted axial image (**c**), and axial CT image in bone window algorithm (**d**). Note the juxta-articular erosion within the infected joint (*arrow in* **d**). In this 76-year-old female with low back pain and fever, the indium-111 white blood cell study is normal (**e**), but the T1 sagittal image (**f**) shows intermediate signal soft tissue (*arrow)* posterior to the L5 vertebral body and low signal (*curved arrow*) within the sacral promontory, within hyperintense signal seen within these areas on the T2 sagittal image (**g**). The fat-suppressed contrast-enhanced T1-weighted sagittal image (**h**) shows a peripherally enhancing abscess (*large arrow*) and focal endplate enhancement (*small arrows*) as well as subtle leptomeningeal enhancement (*curved arrows*); the epidural abscess (*large arrow*) is again seen on the fat-suppressed contrast-enhanced T1-weighted axial image (**i**) as is the leptomeningeal enhancement (*curved arrow*) consistent with meningitis; deep soft tissue enhancement (*small arrow*) is also noted



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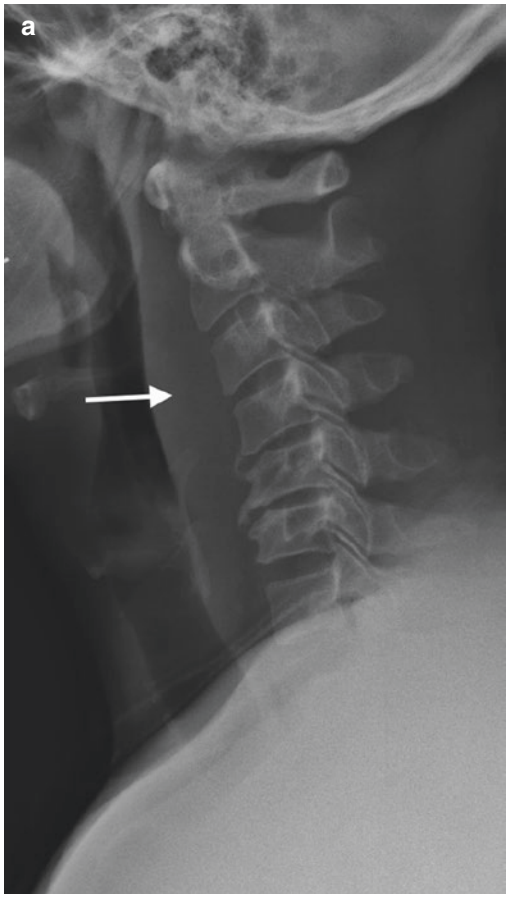
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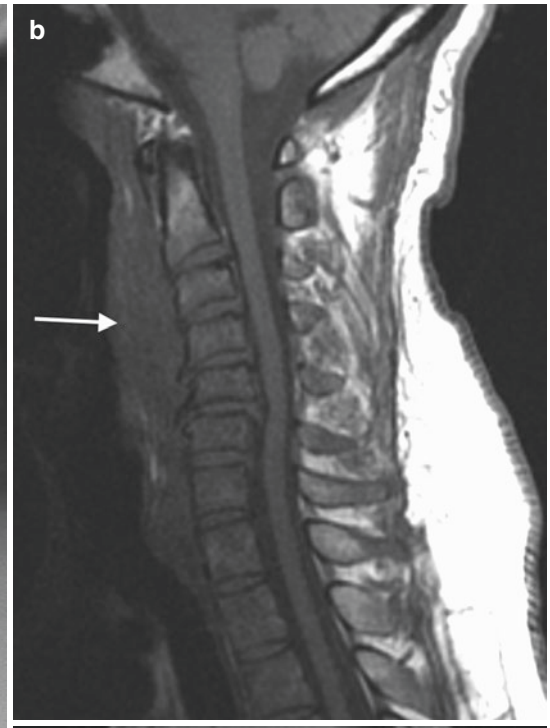
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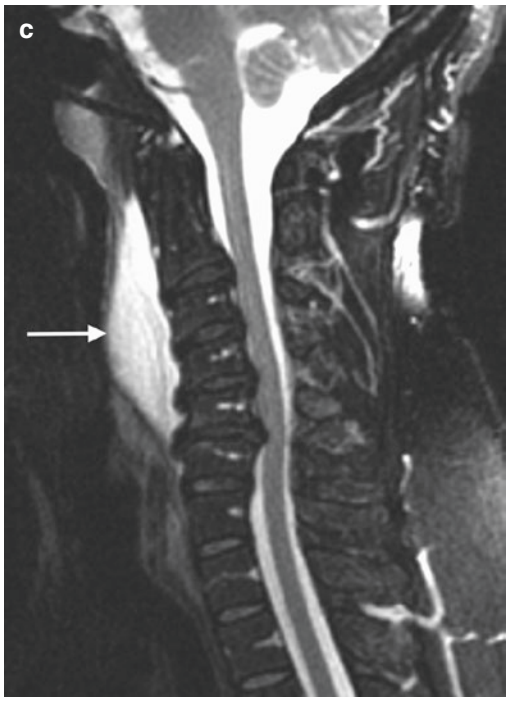
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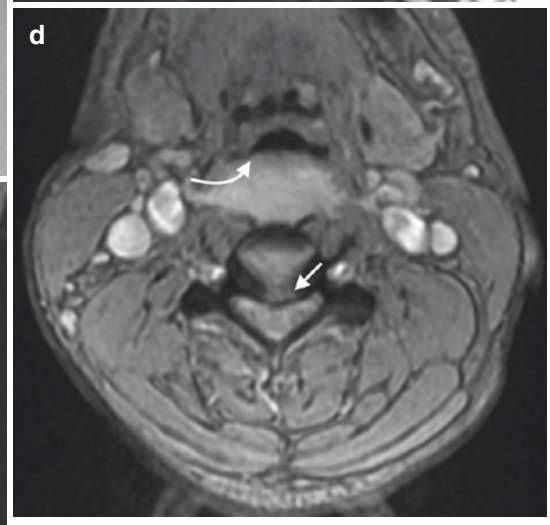
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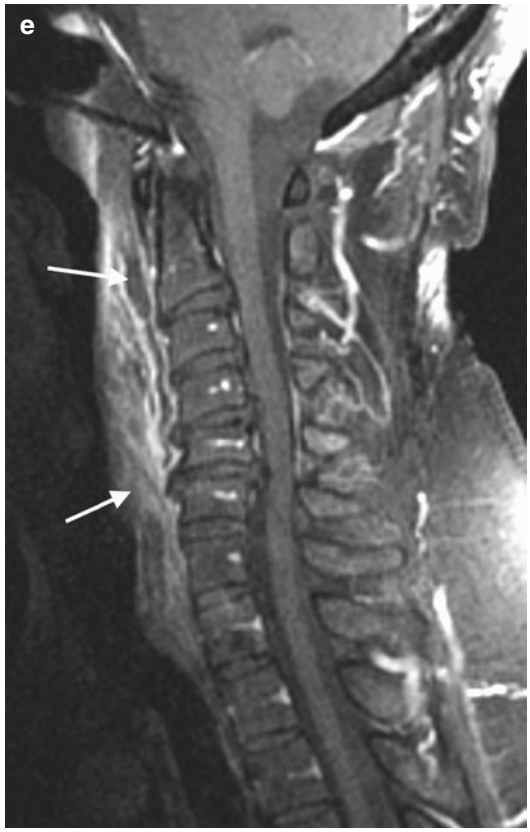

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surgical techniques, and postoperative care, postprocedural diskitis represents up to 30% of all cases of pyogenic spondylodiskitis (Jiminez-Mejias et al. 1999). Other factors that might account for the increased incidence of spine infection include the increasing age of the overall population, advancements in medicine leading to an increased life expectancy of patients with chronic diseases, and the increased prevalence of patients on immunosuppressive medications (Bhavan et al. 2010; Duarte and Vaccaro 2013; Kim et al. 2015; Pigrau et al. 2015).

9.2 Efficacy of Image-Guided Spine Biopsy for Infection

Image-guided percutaneous spine biopsy is a safe and effective procedure with a reported overall accuracy ranging from 88 to 95% (Gupta et al. 2002; Heyer et al. 2008; Rimondi et al. 2008; Tehranzadeh et al. 2007). Although, theoretically, an adequate sample is often obtained with biopsies in patients with suspected spine infection, there is an associated lower overall success rate in identifying the causative organism (Table 9.1). The accuracy for image-guided percutaneous disk space biopsy, in patients with surgically proven spondylodiskitis, has been reported to be as low as 36–57% (Kim et al. 2012; Kim et al. 2015; Marschall et al. 2011; Michel et al. 2006). A negative spine biopsy for spine infection is operationally defined as no evidence of microbial agent growth or identification in the submitted specimen(s) and no histopathologic evidence of diskitis or osteomyelitis in the submitted specimen(s).

Operational definition of a negative biopsy for spine infection:

1. No evidence of microbial identification or growth in the submitted specimen(s)
2. No evidence of disk or vertebral endplate inflammatory change in the submitted specimens

Fig. 9.2 A 40-year-old male with difficulty swallowing after attempted cervical disk procedure. Lateral radiograph (**a**) of the neck shows extensive prevertebral soft tissue swelling (*arrow*) with slightly hypointense signal intensity (*arrow*) on the T1-weighted sagittal image (**b**) and hyperintensity (*arrow*) on the T2-weighted sagittal image (**c**). The fat-suppressed axial image (**d**) shows mass effect (*large arrow*) upon the hypopharynx at C4-C5 with a disk herniation that impinges upon the spinal cord (*small arrow*). The fat-suppressed contrast-enhanced T1-weighted sagittal image (**e**) shows a heterogeneously enhancing (*arrows*) retropharyngeal fluid collection which was emergently drained and shown to be an infected hematoma

Table 9.1 Reasons for a negative biopsy result in patients with suspected spine infection

1. Patient
Patient is on concurrent antibiotic therapy
Incomplete patient work-up in imaging study that mimics spine infection
Incomplete imaging work-up and analysis prior to performing the biopsy procedure
2. Procedure
Unable to access the site of infection
Wrong level or wrong side is biopsied
Presence of transitional vertebra
Abnormality on MRI not well visualized with imaging guidance
Use of instruments that fail to collect an adequate amount of tissue and fluid
3. Specimen
Improper specimen handling
Insufficient specimen
Specimen not sent for both microbiologic *and* pathologic analysis

The length of pre-biopsy antibiotic therapy is inversely related to the likelihood of identifying a causative organism and is the most common reason for a false negative biopsy result (Enoch et al. 2008; Kim et al. 2012; Kim et al. 2015; Marschall et al. 2011; Mazzie et al. 2014; Wu et al. 2007). Ideally, a biopsy should be performed before the initiation of antibiotic therapy in order to maximize the probability of obtaining a positive culture result. Alternatively, if the clinical circumstances dictate, then the biopsy should be performed within 48 h of antibiotic administration. A patient who has been placed on antibiotic therapy for a period of time longer than this should have their antibiotic regimen stopped for a minimum of 2 days prior to attempting a biopsy procedure. Other common causes of a false negative biopsy in patients with suspected spine infection include insufficient specimen, improper specimen handling and processing, and obtaining disk material without adjacent subchondral bone (Michel et al. 2006). A repeat spine biopsy in patients with a negative first biopsy and negative blood cultures may yield a positive culture result, and this option, in the appropriate clinical setting, might be considered in patients who are not on antibiotic therapy (Terreaux et al. 2016).

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9.3 Spine Infection: Mechanisms of Spread

Understanding the pathophysiologic basis of spine infection is integral to perform image-guided percutaneous spine biopsy in patients with suspected spine infection. There are three possible routes of spread that may result in spine infection: (1) hematogenous spread, (2) direct inoculation, and (3) contiguous spread from adjacent structures. Hematogenous spread from a distant site, frequently the genitourinary tract or skin, is the most common cause of spine infection (Bhavan et al. 2010; Diehn 2012; Govender 2005). In adults, hematogenous seeding of vertebral body infection occurs at the level of the end-arterioles adjacent to the subchondral endplates. End-vessel occlusion results in ischemic and necrotic bone; the formation of a bony sequestrum in turn serves as a nidus for progression of infection. Pyogenic infection subsequently spreads from the infected vertebral endplate into the adjacent intervertebral disk (Bhavan et al. 2010; Duarte and Vaccaro 2013; Govender 2005; Jimenez-Mejias et al. 1999). In children, the end-arterioles extend into the intervertebral disk; hence, spine infections in children originate within the disk proper. In adults, therefore, in the setting of suspected vertebral osteomyelitis, disk aspiration and core needle biopsy of the subjacent subchondral vertebral body endplate should both be attempted (Mazzie et al. 2014; Michel et al. 2006). Direct inoculation is frequently due to an iatrogenic etiology. It occurs secondary to spine instrumentation, including spine surgery,

lumbar puncture, and percutaneous epidural or facet joint injections. A penetrating injury into or near the spine may also result in direct inoculation. Contiguous spread from an adjacent focus of infection is the least common of the three mechanisms responsible for spine infection. Skin infection (including decubitus ulcers), pulmonary infection, and kidney infection are examples of conditions that can be associated with direct contiguous spread to the adjacent segment of the spine.

9.4 Clinical Presentation

The clinical presentation depends upon two major factors, the virulence of the infectious agent and host resistance factors (Table 9.2). Potential infectious agents include bacterial, mycobacterial, fungal, or parasitic organisms depending on the clinical scenario. Clinically, spine infections are generally challenging to diagnose as patients may present with subtle and non-specific symptoms, which range in acuity. Therefore, a significant delay in clinical diagnosis may occur. A strong clinical suspicion of spine infection should be supported by correlation with pertinent imaging studies and laboratory analysis. On initial presentation, the most common reported symptom is unremitting back pain, which worsens at night and does not dissipate with rest. The lumbar spine is the spinal segment that is most frequently involved. Fever is an unreliable sign of spine infection as up to 54% of patients are afebrile at initial presentation (Bhavan et al. 2010). Neurologic deficits including lower extremity weakness, radiculopathy, and urinary incontinence have been reported in up to one-third of patients and are often associated with delays in diagnosis (Duarte and Vaccaro 2013). Spine infections are more common in males, and the incidence increases with age, most commonly affecting adults who are 50 years of age or older. Predisposing risk factors include intravenous drug abuse, chronic disease such as renal failure or diabetes, previous spinal surgery, or HIV infection or other immunocompromised state (Bhavan et al. 2010; Diehn 2012; Duarte and Vaccaro 2013; Govender 2005).

Table 9.2 Risk factors for spine infection

1. Age greater than 50 years
2. Intravenous drug use
3. Pre-existing source of infection
4. Diabetes
5. HIV infection or other immunocompromised state
6. Previous spine surgery
7. Chronic steroid use
8. Chronic medical condition (renal failure, cirrhosis)

A key initial step in diagnosing spine infection is to suspect it!

9.5 Laboratory Findings

There are several serum laboratory markers, which may be helpful in diagnosing and managing spine infection. The erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are inflammatory markers that are commonly elevated at initial presentation. ESR is a sensitive but non-specific measure of inflammation. It is the rate at which red blood cells layer, or sediment, in 1 h (Singh 2014). ESR directly correlates with the amount of fibrinogen in the blood, increasing with any condition that elevates fibrinogen. Other causes of an increased ESR include pregnancy, anemia, autoimmune disorders, multiple myeloma, and lymphoma. CRP is an acute phase protein of hepatic origin, which rises in response to the release of interleukin-6 by macrophages and T-cells (Go et al. 2012; Singh 2014). Infections and inflammatory diseases are common causes of an increase in serum CRP levels (Heyer et al. 2012). Pregnancy, obstructive sleep apnea, and malignancy can also cause an elevated CRP. Typically in spine infection, both ESR and CRP are elevated at initial presentation. However, bone pathology, specifically in diabetics, is reported as a common factor in causing an elevated ESR with a normal CRP level (Singh 2014). ESR is the most useful marker of inflammation, with elevation reported in 70–100% of infections at presentation (Go et al. 2012). Inflammatory markers are often followed to assess the patient's response to treat-

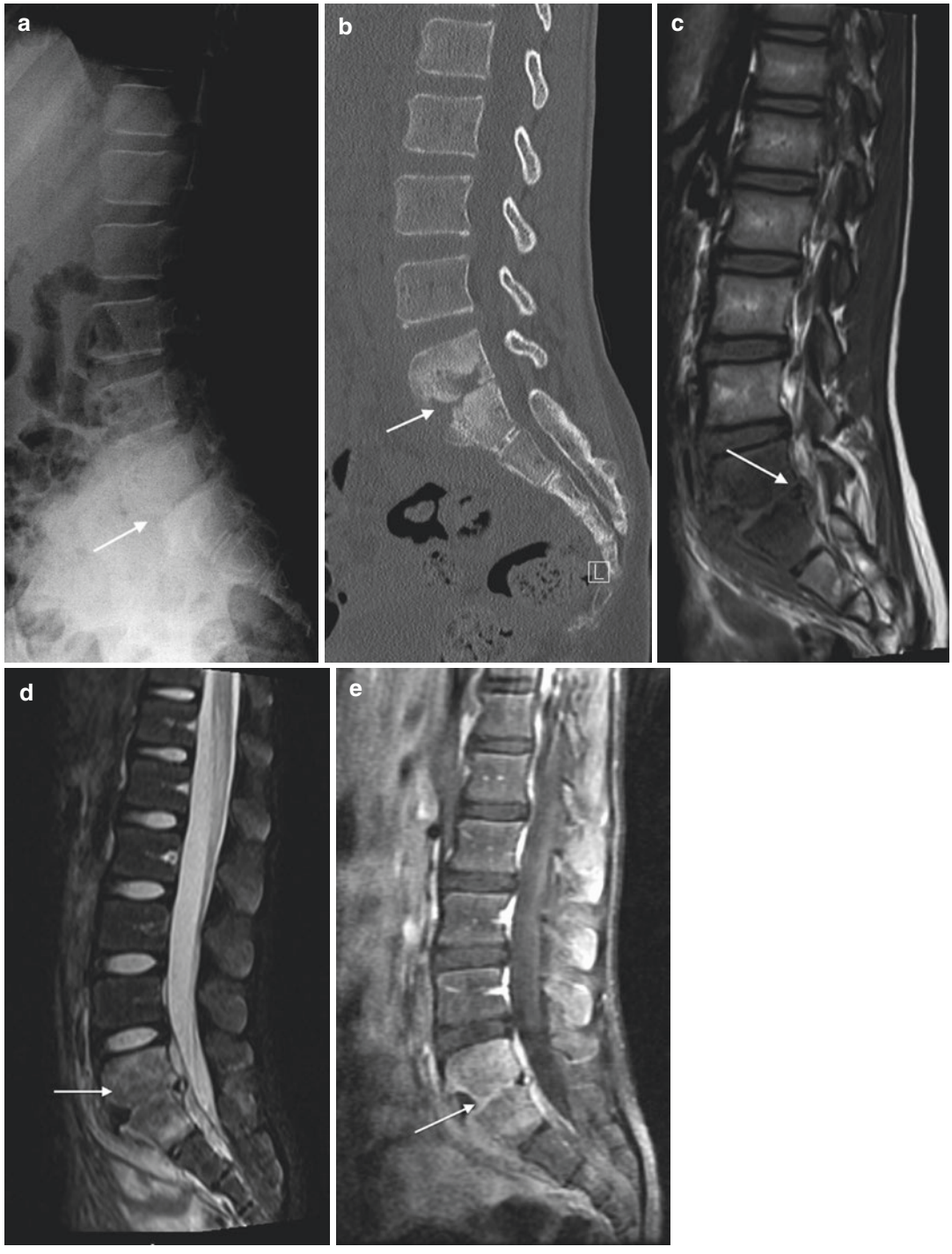
ment. Serum CRP returns to normal with treatment faster than ESR and is therefore a better marker for therapeutic response in patients with infection (Brigden 1999; Duarte and Vaccaro 2013; Singh 2014). The white blood cell count (WBC) is the least useful of the inflammatory markers due to its low sensitivity. In a large 2-year retrospective cohort study, 40% of patients who presented with or developed hematogenous vertebral osteomyelitis had a normal initial WBC (Bhavan et al. 2010). Positive blood cultures may be seen in approximately 24% of patients with suspected spine infection and may assist in identifying the offending microorganism and guiding subsequent treatment. In specific situations, when a coagulase-positive *Staphylococcus* infection is suspected, the use of counterimmunoelectrophoresis to detect serum anti-teichoic acid antibodies may be helpful in confirming the presence of staphylococcal infectious spondylitis (Dhale et al. 2003). Ribitol teichoic acid, found within the cell wall of *Staphylococcus aureus* species, is antigenic and a high serum titer (> 4) of anti-teichoic acid antibodies which may be detected in patients with staphylococcal spine infection.

9.6 Imaging

Due to the insidious and non-specific clinical presentation of infectious spondylitis, radiologists have an integral role in facilitating this diagnosis. Radiographs are often the initial imaging examination performed; however, plain films have an extremely low sensitivity for detection of early infection and may remain normal for several weeks (Diehn 2012; Govender 2005). Despite the low sensitivity for acute spine infection, radiographs often demonstrate findings of spine infection due to the delayed presentation that is associated with this condition. Loss of cortical definition with irregularity of the vertebral endplate is the earliest radiographic finding in spondylodiskitis (Diehn 2012; Go et al. 2012; Govender 2005). Radiographic detection of bone loss requires a 30–40% loss of the bony matrix typically occurring 2 weeks after initial symptoms (Go et al. 2012). Prevertebral or paraspinal soft tissue swelling, fullness, or bulging with loss of fat planes can also be identified on radiographs in early cases of spine infection (Diehn 2012; Go et al. 2012; Govender 2005). As the infection progresses, there is subsequent involvement of the intervertebral disk space, with loss of disk height and erosive changes of the vertebral endplates (Fig. 9.3). Radiographic findings of chronic infection include sclerosis of the vertebral endplates with variable collapse of the infected vertebral body, obliteration, and fusion across the affected disk space, leading to spinal deformities such as kyphosis and/or scoliosis (Diehn 2012; Go et al. 2012). In chronic spine infection, especially tuberculous spondylitis, calcification may be observed within the paraspinal soft tissues or within the epidural space.

Computed tomography (CT) has a higher sensitivity than plain radiography for the detection of early bony changes in spine infection due to the increased anatomic resolution. CT findings of spine infection are similar to those seen on radiographs; however, subtle endplate irregularity and erosions are better depicted (Fig. 9.4). Loss of the normal architecture of the trabecular bone is one

Fig. 9.3 An 11-year-old male with *S. aureus* proven septic spondylodiskitis. Lateral radiograph (**a**) of the lumbar spine shows L5-S1 disk space narrowing (*arrow*) with vertebral endplate erosions and subchondral sclerosis. Reformatted sagittal CT image (**b**) in bone window algorithm shows irregularity, sclerosis, and erosion of the subchondral bone (*arrow*) along the L5-S1 endplates. Sagittal T1-weighted image (**c**) shows obliteration of the disk space with loss of the cortical margins (*arrow*), while the sagittal T2-weighted image (**d**) shows hyperintense T2 signal within the disk space, as well as extensive vertebral bone marrow edema (*arrow*). Sagittal (**e**) and axial (**f**) T1-weighted fat-suppressed contrast-enhanced images show intradiskal enhancement with intradiskal abscess (*arrows*). Axial CT image acquired during biopsy at the level of the L5-S1 disk space (**g**) shows coaxial advancement of the biopsy needle through the guiding cannula (*arrow*) via a right S1 transpedicular approach utilizing cranial angulation through the pedicle (*P*) for successful sampling of the vertebral endplate and the adjacent disk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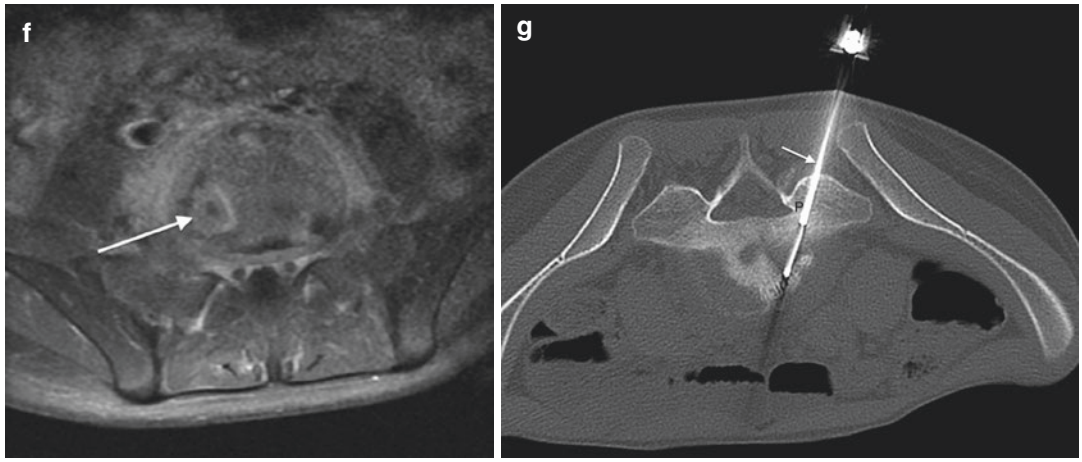

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of the early CT findings of pyogenic vertebral osteomyelitis, which is rarely appreciated on radiographs (Go et al. 2012). CT is commonly utilized in patients with contraindications to magnetic resonance imaging (MRI) and for differentiating mimickers of spondylodiskitis, such as reactive vertebral endplate changes. CT is useful for the depiction of the spread of infection and helps to characterize prevertebral and paraspinal soft tissue involvement. Mass effect from infected paraspinal collections can compromise the neural foramen and may cause nerve root impingement. Posterior extension of infection can involve the epidural space and, in the cervical or thoracic spine, may result in spinal cord compression. In patients that cannot undergo an MRI examination, this study may need to be performed with an intravenous contrast agent or, less commonly, with an intrathecal contrast agent.

Magnetic resonance imaging is the study of choice for diagnosing spine infection, with a reported sensitivity of 96%, specificity of 92%, and accuracy of 94%. Endplate irregularity, with loss of cortical definition, and erosions are common and may later progress to vertebral body destruction. The earliest MRI finding in spine infection is altered bone marrow signal manifested as hypointense T1- and hyperintense T2-weighted signal with contrast enhancement, most prominent along the vertebral endplates (Fig. 9.4). Involvement of the adjacent intervertebral disk space may manifest with loss of intervertebral disk height, alteration of normal disk morphology including loss of the intranuclear cleft, focal T2 hyperintensity, and variable contrast enhancement patterns (Fig. 9.5). Infection may also spread posteriorly into the epidural space and laterally into the paravertebral soft tissues. Because of the initial involvement of the vertebral endplate, loss of the normal disk-endplate margin may be a helpful sign in suspecting possible infection. Psoas musculature T2 hyperintensity shows a high sensitivity and specificity (92% at a 95% confidence interval) with a high positive likelihood ratio for spondylodiskitis; this may be a helpful imaging finding especially when an unenhanced MRI study is performed and may raise a concern for possible spine infection (Ledbetter et al. 2016). A contrast-enhanced MRI examination is the study of choice to evaluate a patient with a suspected spine infection and/or epidural abscess with possible spinal cord compression (Fig. 9.6). Initially, irregular, thick paraspinal, or epidural soft tissue enhancement is seen compatible with phlegmon. Paraspinal abscesses are readily identified on MRI as T1-hypointense and T2-hyperintense fluid collections with peripheral enhancement. Spine infections however can have a variable appearance on MRI, with atypical imaging characteristics and

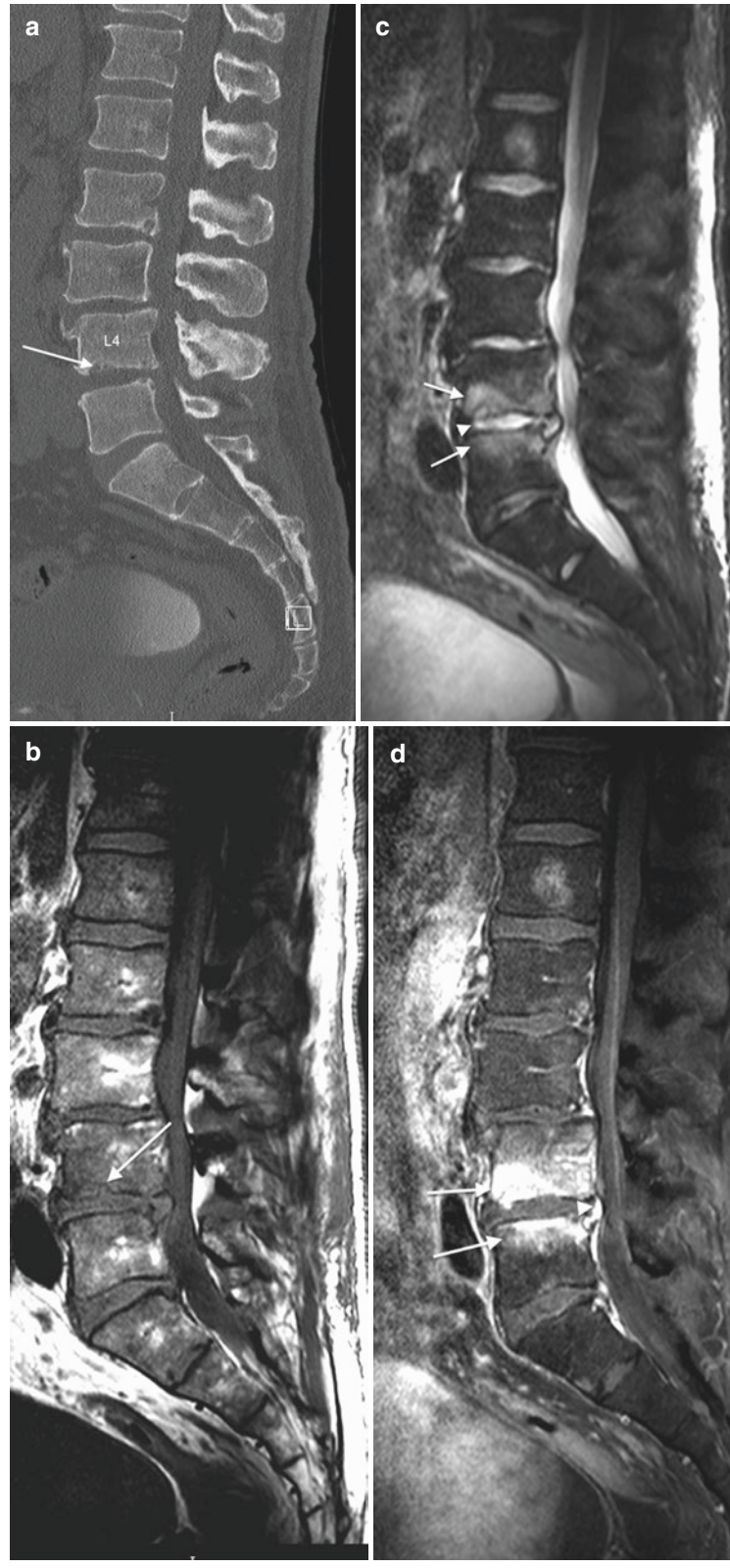
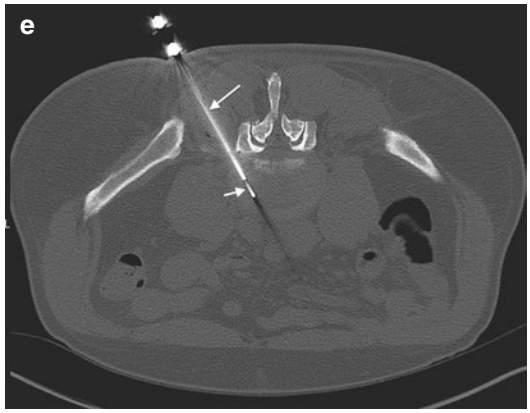


Fig. 9.4 A 53-year-old male with pathological analysis showing acute inflammation and purulent exudates and culture-positive gram-positive cocci in pairs. Reformatted sagittal CT image (**a**) in bone window algorithm shows irregularity of the inferior endplate of L4 with loss of cortical bone (*arrow*) and increased intervertebral disk height anteriorly. Sagittal T1-weighted image (**b**) also shows loss of the normal hypointense line along the inferior endplate of L4 (*arrow*) as well as hypointense T1 signal adjacent to the vertebral endplates of L4 and L5. Sagittal T2-weighted image (**c**) shows corresponding bone marrow edema (*arrows*) and hyperintense signal within the disk (*arrowhead*). Sagittal T1-weighted fat-suppressed contrast-enhanced image (**d**) shows prominent endplate enhancement (*arrows*) and focal epidural enhancement (*arrowhead*). Axial CT image (**e**) acquired during biopsy shows the biopsy needle (*small arrow*) advanced coaxially through a guide cannula (*large arrow*) via a posterolateral paravertebral approach directly into the L4-L5 disk space



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variable vertebral involvement with sparing of the intervening disk spaces. MRI findings with the reported highest sensitivity for the diagnosis of spine infection are vertebral body T1-hypointense signal, intervertebral disk space T2-hyperintense signal, and disk space enhancement (Diehn 2012) (Fig. 9.7). Epidural abscess formation may be associated with spondylodiskitis or, depending on the etiology (e.g., a spinal procedure), may be seen in isolation (Fig. 9.8). MRI will show a heterogeneous T1-hypointense and T2-hyperintense variable-length fluid collection within the epidural space that is associated with prominent peripheral and epidural contrast enhancement. It should be noted that, at the cervical and/or thoracic spine level, a patient's myelopathic presentation may be disproportionately greater than the severity of spinal cord compression because the associated spinal cord ischemia also reflects the presence of epidural venous plexus vascular congestion. Untreated epidural abscesses can progress rapidly and cause significant morbidity and mortality. The detection of a suspected epidural abscess should prompt immediate spine surgical consultation for consideration of emergent drainage and decompression of the epidural abscess.

The MRI detection of a suspected spinal epidural abscess should prompt immediate spine surgical evaluation.

In patients with lumbar spondylosis and advanced degenerative disk disease, diffusion-weighted MR images (DWI) may distinguish between reactive fibrovascular vertebral endplate changes and spondylodiskitis (Patel et al. 2014). With respect to reactive endplate change, DWI will show a focal diffusion pattern referred to as the "claw" sign, whereas in infection, a diffuse DWI pattern or absent "claw" sign is noted. The abnormal MRI findings that are seen with spine infection may persist for a variable period of time despite successful treatment of the spine infection.

Nuclear medicine imaging can sometimes be useful in diagnosing spine infection. The radionuclide imaging method of choice is a combined triple phase ^{99m}technicium-methylene diphosphonate bone and ^{67}gallium-citrate scan. This dual radionuclide study has a high sensitivity and high specificity for spine infection (Diehn 2012; Duarte and Vaccaro 2013; Go et al. 2012; Mazzie et al. 2014). Discordant or increased radionuclide uptake on the gallium scan, in comparison to the technetium bone scan, is the most common finding in spondylodiskitis. Radionuclide imaging for spine infection, however, is typically reserved for certain clinical situations due to limited spatial resolution, a long examination time, and the greater availability and sensitivity of MRI (Fig. 9.9). The combined bone and gallium scan is most useful in patients with contraindications for MRI or with equivocal CT and MRI results.

9.7 Spine Infection in the Immunocompromised Patient

Due to a blunted immune response, the diagnosis of spine infection is often further delayed in immunocompromised patients. These patients often do not manifest the typical signs and symptoms of spine infection and can even be asymptomatic. The causative microorganisms also differ in immunocompromised patients, who are prone to atypical bacterial, fungal, and parasitic infections. HIV/AIDS predisposes patients to fungal infections due to neutrophil and leukocyte

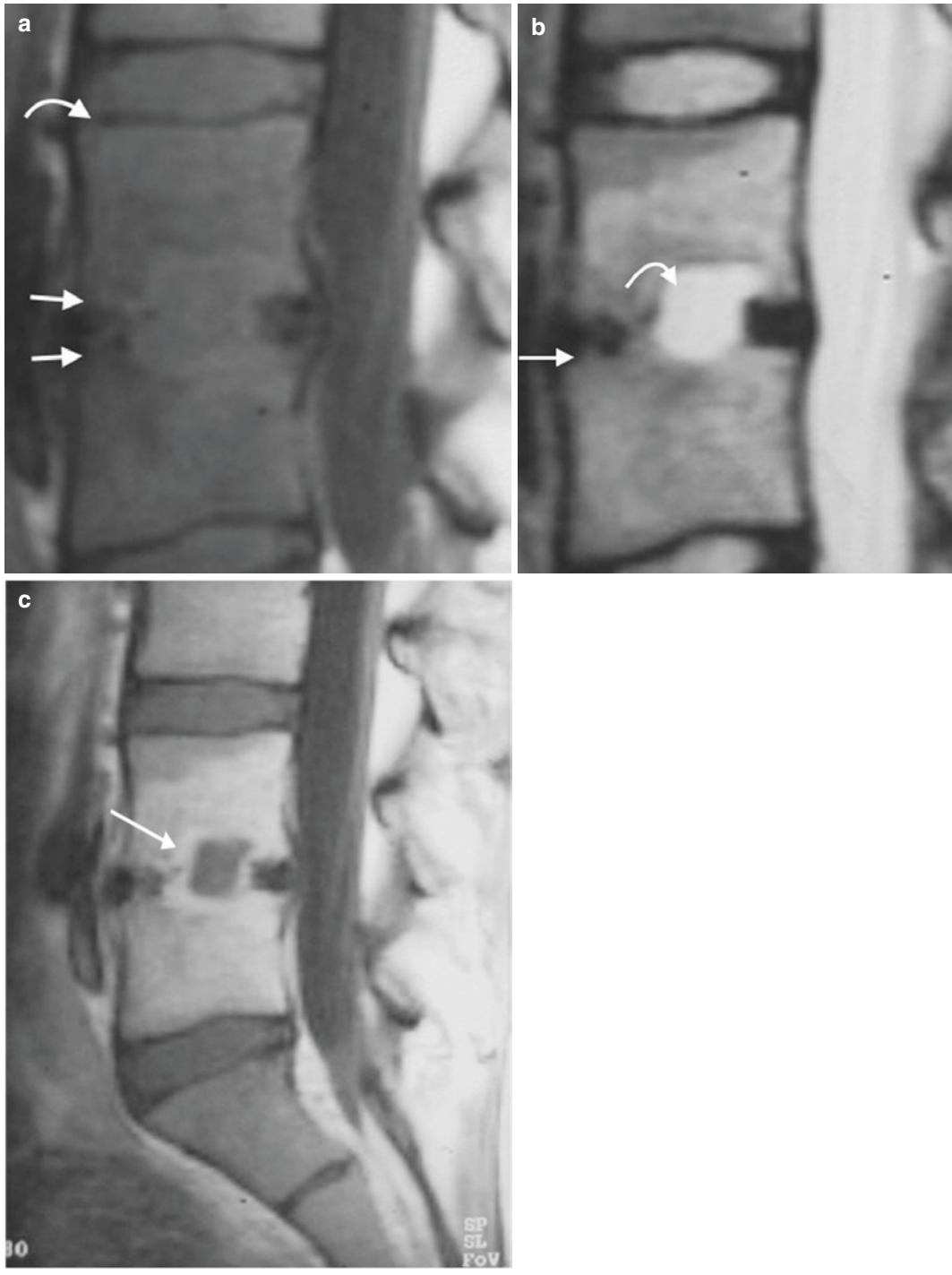


Fig. 9.5 MRI signs of early disk space infection. T1-weighted sagittal image (**a**) shows loss of the hypointense lines (*arrows*) that correspond to the vertebral endplate; compare to the normal vertebral endplate at the level above (*curved arrow*). T2-weighted sagittal image again shows vertebral endplate irregularity/erosion (*arrow*) and loss of the normal intranuclear cleft (*curved arrow*). Contrast-enhanced T1-weighted sagittal image (**c**) shows prominent marrow enhancement and ring enhancement surrounding an intradiskal abscess (*arrow*)

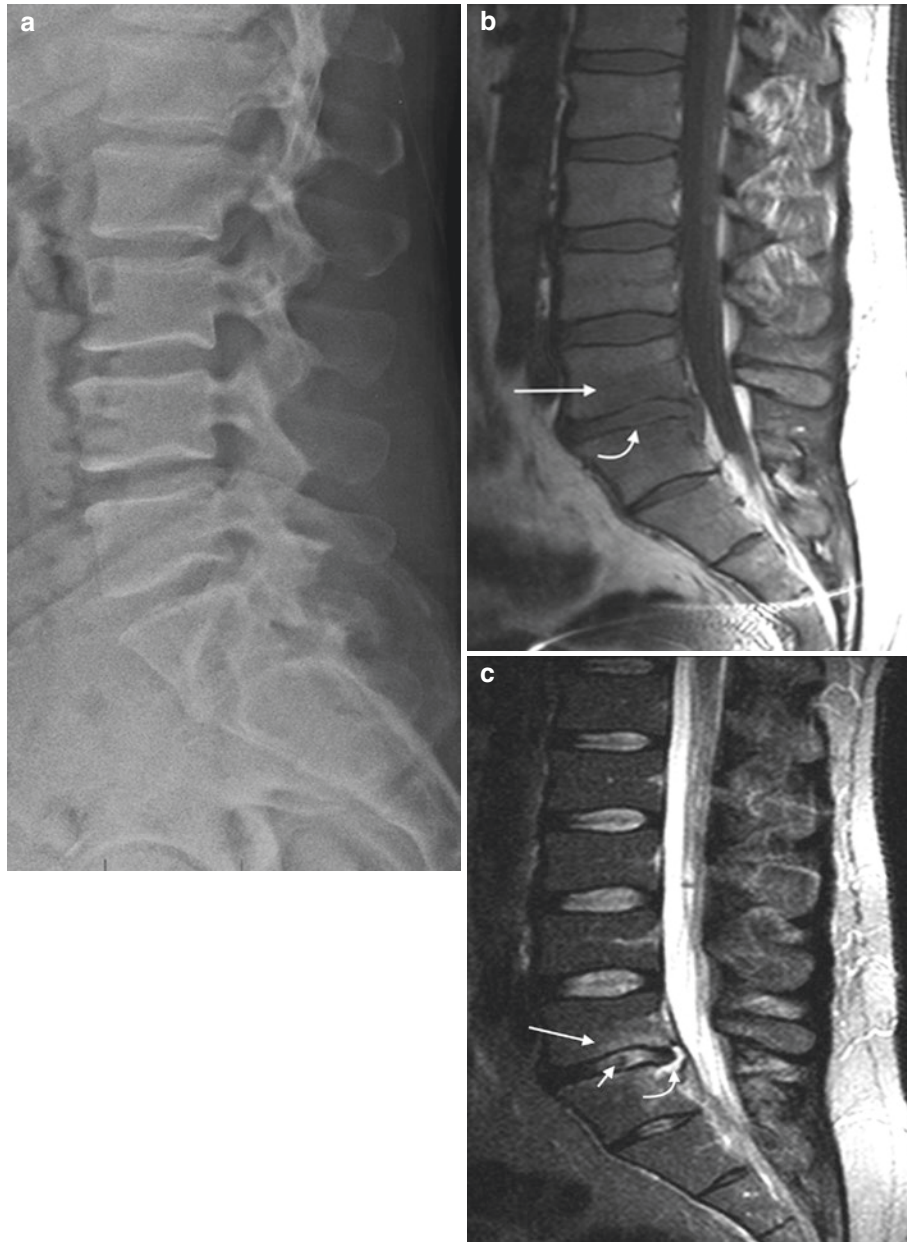
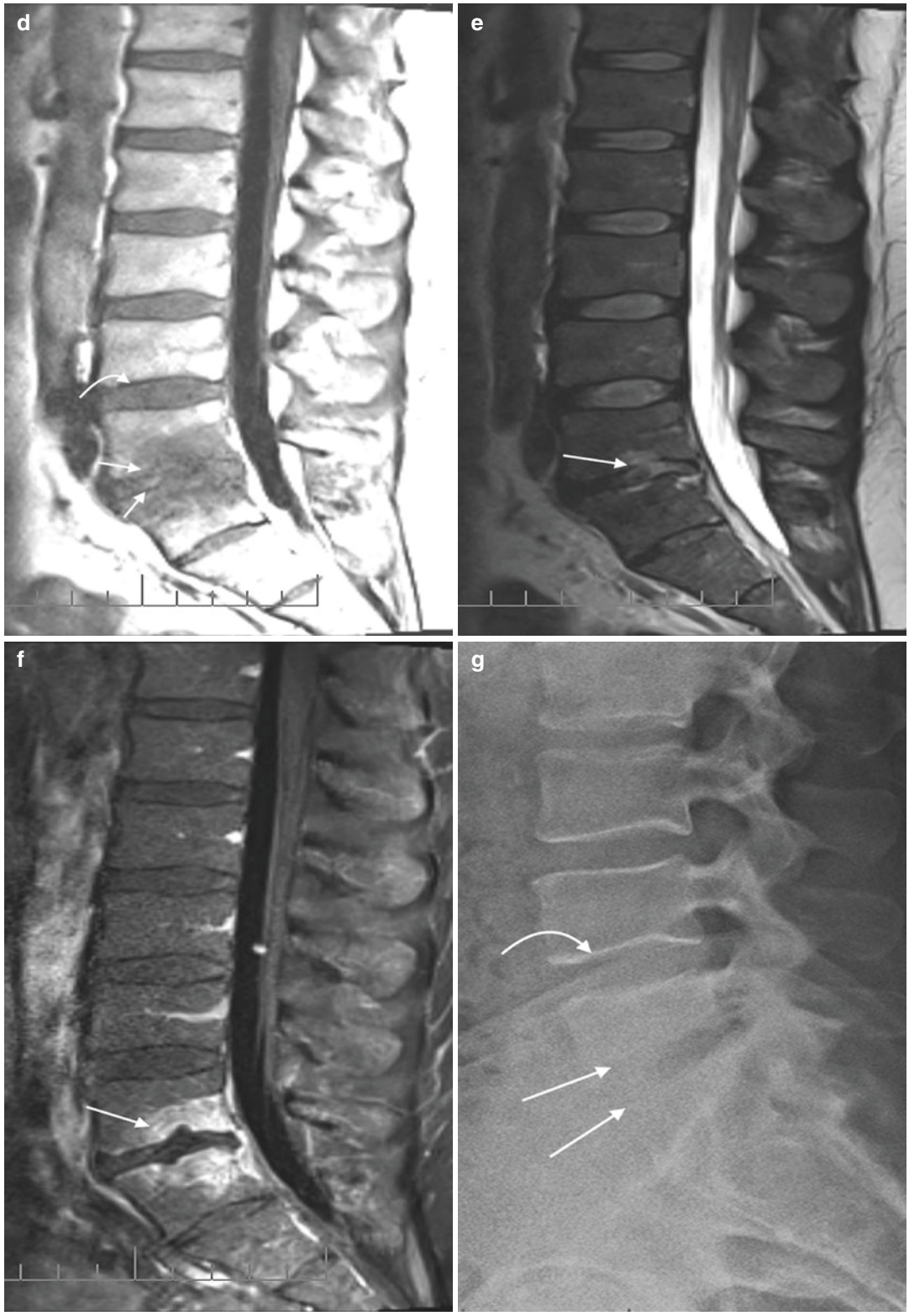


Fig. 9.6 Chronology of a case of spine infection. Lateral radiograph of the lumbar spine (**a**) in a patient with acute low back pain is normal. T1-weighted sagittal image (**b**) obtained on the same day shows hypointense endplate signal (*arrow*) which was attributed to degenerative endplate change at L5-S1; note the subtle cortical erosion of the endplate (*curved arrow*). The T2 sagittal image (**c**) shows reactive endplate edema (*large arrow*), loss of the intranuclear cleft (*small arrow*), and thick hyperintense signal (*curved arrow*) adjacent to the posterior annulus. Three weeks later, a repeat MR examination shows further loss of the normal T1 hypointense endplate signal (**d**) as compared to the level above (*curved arrow*) and prominent marrow edema. The T2-weighted sagittal image (**e**) shows progression of intradiskal signal increase (*arrow*) with contrast enhancement confined to the endplates and adjacent marrow as shown on the fat-suppressed contrast-enhanced T1-weighted image (**f**). The findings were attributed to degenerative disk disease with reactive endplate change at L5-S1, and conservative medical management was continued. The patient's back pain symptoms persisted, and lateral radiograph (**g**) obtained 10 weeks after the initial onset of the patient's symptoms shows complete loss of the cortical endplates at L5-S1 (*arrows*); compare to the normal level above (*curved arrow*). A third MRI study obtained 12 weeks from the onset of symptoms now shows extensive marrow edema and disk space height loss with disorganization and signal abnormality with extensive vertebral body and intradiskal enhancement at L5-S1 as shown on the sagittal T1(**h**), T2 (**i**), and fat-suppressed contrast-enhanced T1-weighted (**j**) images



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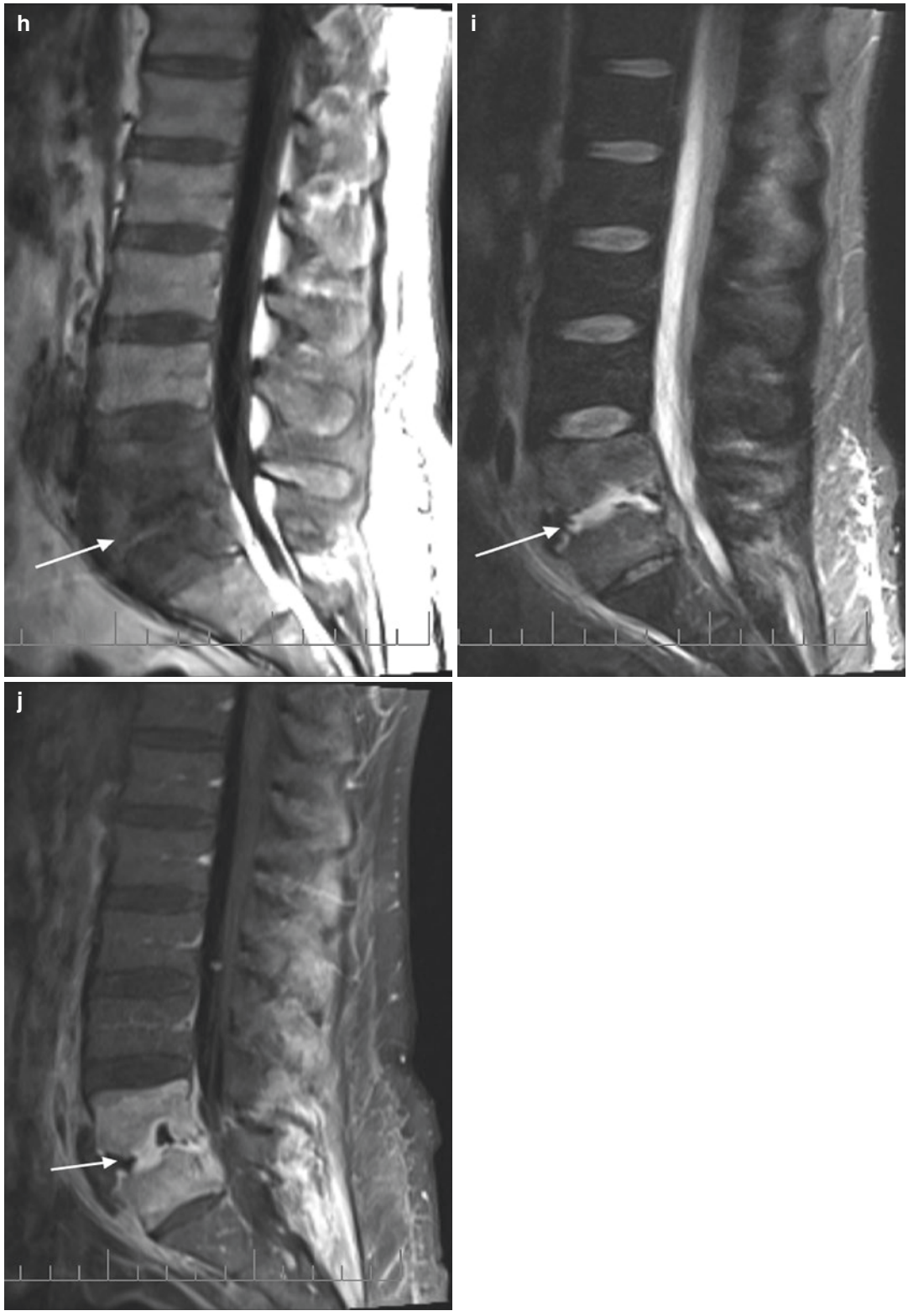

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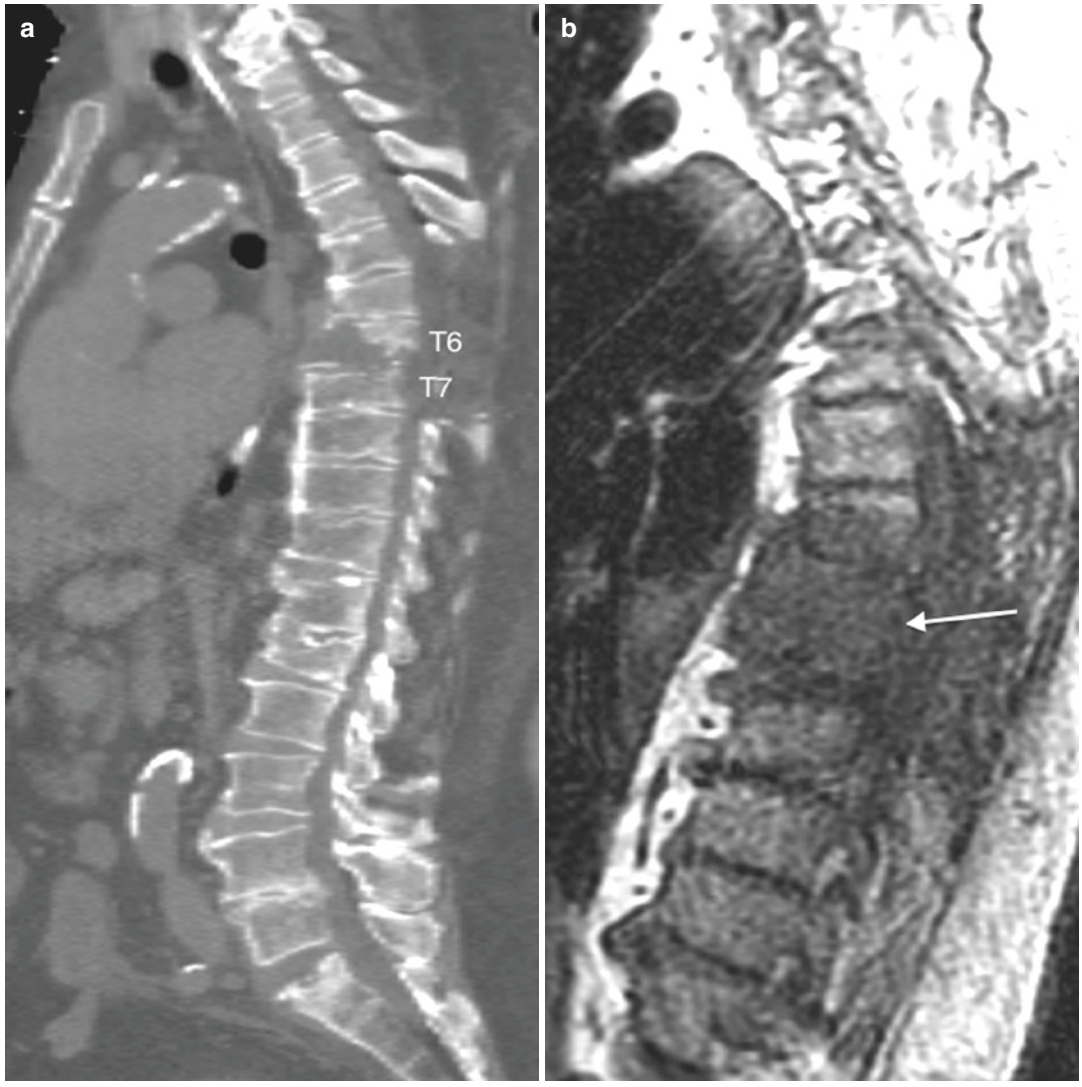
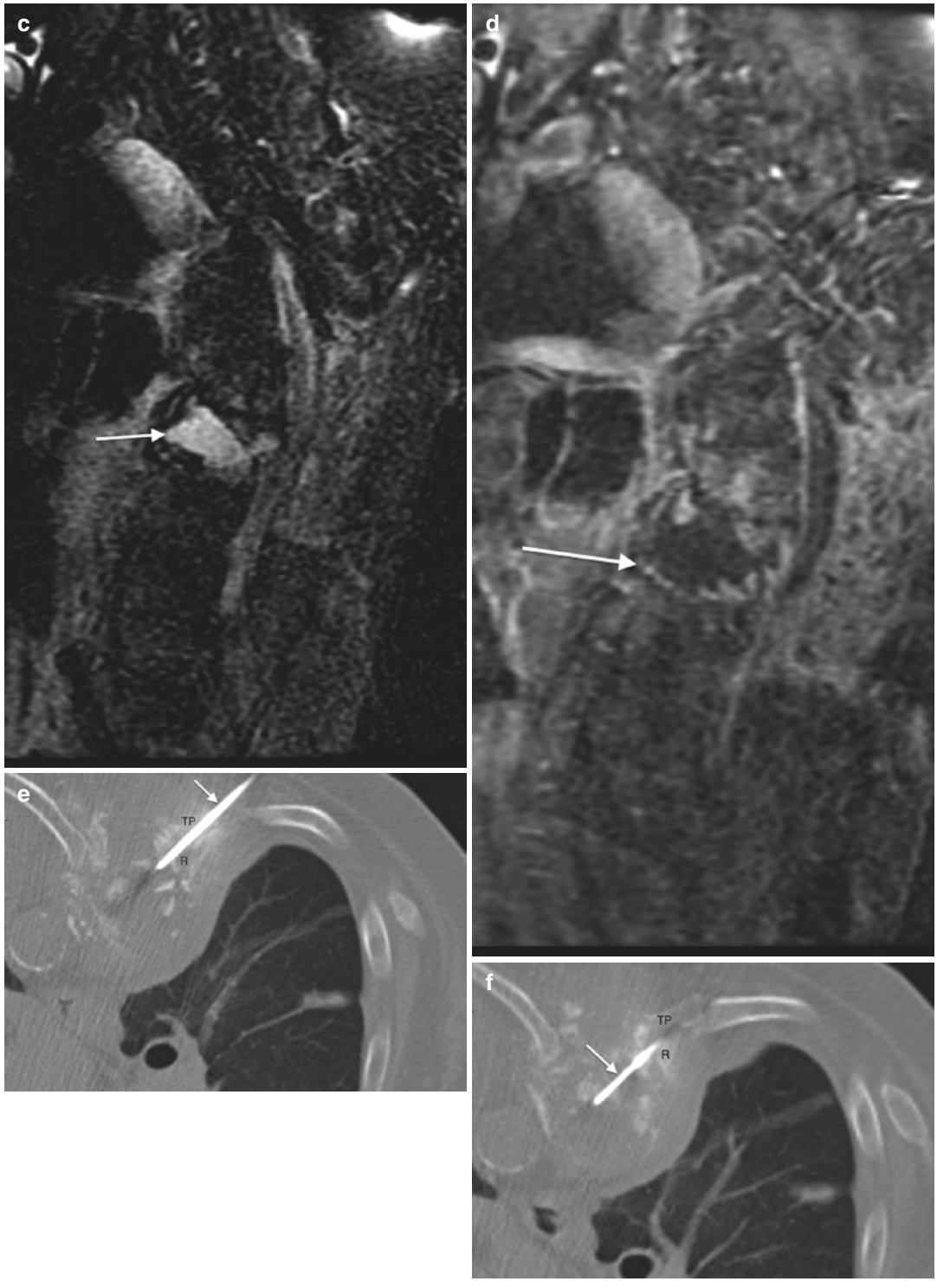


Fig. 9.7 A 65-year-old male with methicillin-resistant *Staphylococcus aureus* (*MRSA*) proven T6-T7 septic spondylodiskitis. Reformatted sagittal CT image in bone window algorithm (**a**) shows irregularity of the T6 and T7 endplates with advanced erosion and destruction of the T6 vertebral body. Sagittal T1-weighted image (**b**) shows diffuse hypointense signal (*arrow*) from T6 to T7 with loss of the normal endplate cortical margins. Sagittal T2-weighted image (**c**) shows hyperintense fluid signal within the T6-T7 disk space and T6 vertebral body (*arrow*). Sagittal T1-weighted fat-suppressed contrast-enhanced image (**d**) shows peripheral enhancement around the fluid collection (*arrow*) indicative of a large intradiskal and vertebral body abscess. Axial CT images (**e**, **f**) acquired during a spine biopsy show the biopsy needle (*arrow*) advanced between the right seventh rib (*R*) and transverse process (*TP*) (a costotransverse approach), in order to access the T6-T7 disk space



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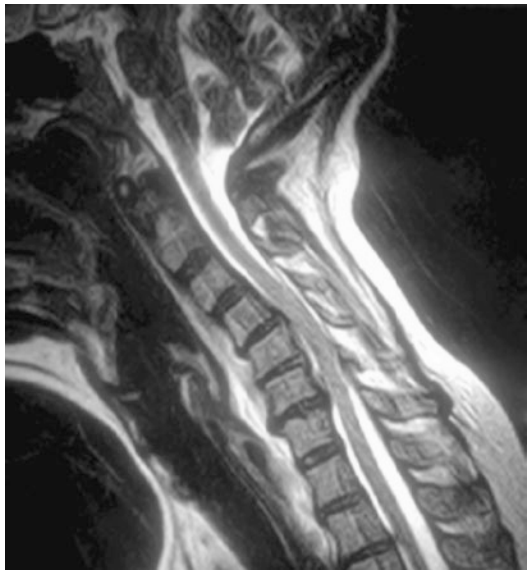


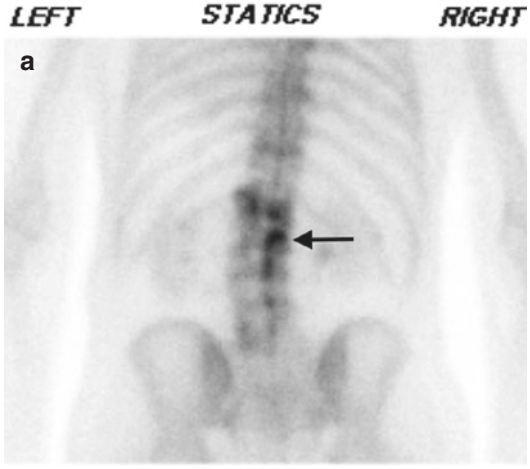
Fig. 9.8 Epidural abscess in patient with severe neck pain. T2-weighted sagittal image shows a small focal hyperintense ventral epidural fluid collection at C5-C6 that is associated with mass effect upon the spinal cord

dysfunction (Govender 2005). *Mycobacterium tuberculosis* is a particularly common cause of spine infection in HIV-positive patients, reported in up to 60% of identified pathogens (Duarte and Vaccaro 2013). On imaging, involvement of the vertebral pedicle, lamina, and spinous process is uncommon for pyogenic infection and should raise the suspicion for *Mycobacterium tuberculosis* (Duarte and Vaccaro 2013). The duration of treatment for tuberculous spondylodiskitis is also longer with recommendations of at least 12 months, to prevent multidrug resistance in the immunocompromised patient.

9.8 Spine Infection in the Postoperative Spine Patient

The diagnosis of spine infection in the postoperative spine patient is a challenging situation that requires correlation with the surgical procedure, clinical presentation, laboratory, and imaging findings. Clinically, the signs and symptoms of pain and elevated temperature are unreliable and may occur with the healing response in the postoperative patient. A persistently elevated CRP for greater than 2 weeks following spine surgery is an early indication of postoperative infection (Mazzie et al. 2014). Postsurgical change following a spine intervention and developing infection are difficult to differentiate on diagnostic imaging examinations. For example, hyperintense T2 signal is seen within the intervertebral disk space and subchondral endplates after diskectomy, with varying contrast disk enhancement (Mazzie et al. 2014). Asymptomatic post-diskectomy patients often have contrast-enhanced MR studies that show focal enhancement at the diskectomy site, linear enhancement within the intervertebral disk, and, less often, vertebral endplate enhancement (Ross et al. 1996). While initially these "normal" postsurgical changes are confined to the surgical tract and site, subsequent spread of signal change and contrast enhancement beyond the surgical bed, a so-called triad of vertebral bone marrow, and intradiskal and posterior annulus fibrosis enhancement may herald infection (Boden et al. 1992). Due to the overlap between expected inflammatory changes and infection on diagnostic imaging of the postoperative spine, image-guided percutaneous biopsy is sometimes requested in order to evaluate for possible postoperative spine infection (Fig. 9.10). When identified either via biopsy or blood culture, the most common pathogens that are encountered for postoperative spine infections are *Staphylococcus* species.

Postoperative spine paraspinal fluid collections are common and may be incidental or require further intervention, based upon the patient's clinical presentation (Fig. 9.11). These paraspinal fluid collections can be classified as seromas, hematomas, pseudomeningoceles, or abscesses. Differentiating a non-infected fluid collection from an infected collection may be difficult but is critical for appropriate patient care. Paraspinal seromas are collections of lymphatic-type fluid, which may be encapsulated. Seromas follow the imaging characteristics of fluid on CT and MRI; however, a small hematocrit level may be evident (Jain et al. 2014). Encapsulated seromas may demonstrate homogenous wall enhancement on contrast-enhanced MRI. Treatment options range



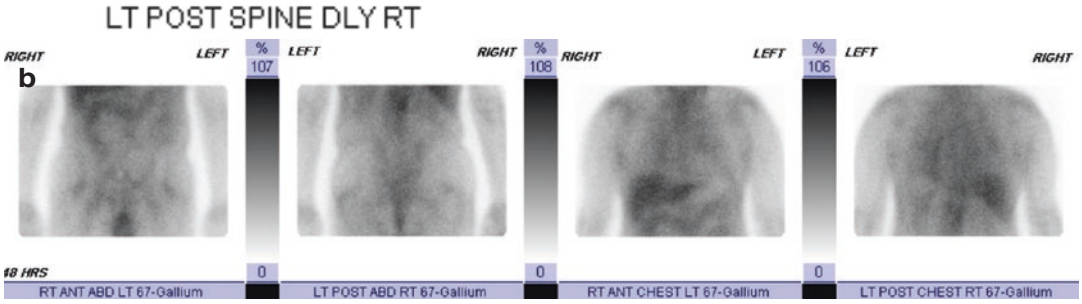
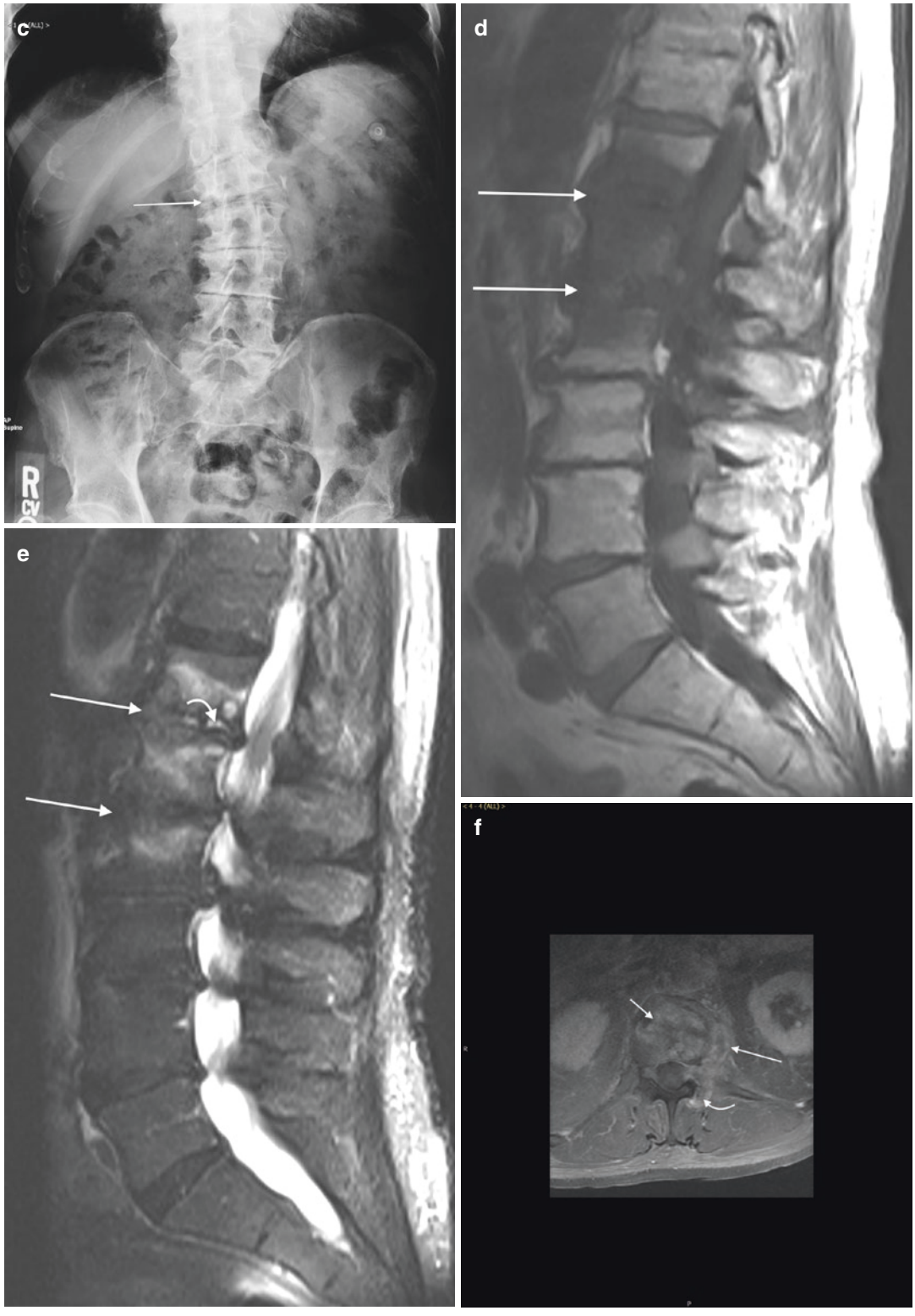


Fig. 9.9 An 85-year-old male with intermittent low back pain and abnormal gait. Static posterior image from bone scan (**a**) shows asymmetric focal radionuclide uptake (*arrow*) within the upper lumbar spine; this was attributed to osteoarthritis. Multiple static images from a negative gallium scan (**b**). Frontal radiograph (**c**) of the lumbar spine shows degenerative changes of the spine; there is focal erosive change on the right at L1-L2 (*arrow*). T1-weighted sagittal image (**d**) shows extensive hypointense signal extending from T12 to L2 (*arrows*) with loss of the vertebral endplate margins. T2-weighted sagittal image (**e**) shows patchy hyperintense signal in the same distribution (*arrows*) and focal increased signal (curved arrow) within the T12-L1 disk space. Fat-suppressed contrast-enhanced T1-weighted axial image (**f**) shows prominent patchy enhancement throughout the T12-L1 disk (*small arrow*), left peri-diskal soft tissue enhancement (*large arrow*), and left peri-facet soft tissue enhancement (*curved arrow*). Due to the relatively asymptomatic nature of the patient's clinical presentation, this was initially thought to be related to aggressive degenerative changes of the spine, and the patient was referred for spine injections. However, the MR imaging findings and their location within the upper lumbar spine suggested the possibility of an indolent spine infection; the high degree of radiologic suspicion prompted a consideration for an image-guided percutaneous biopsy



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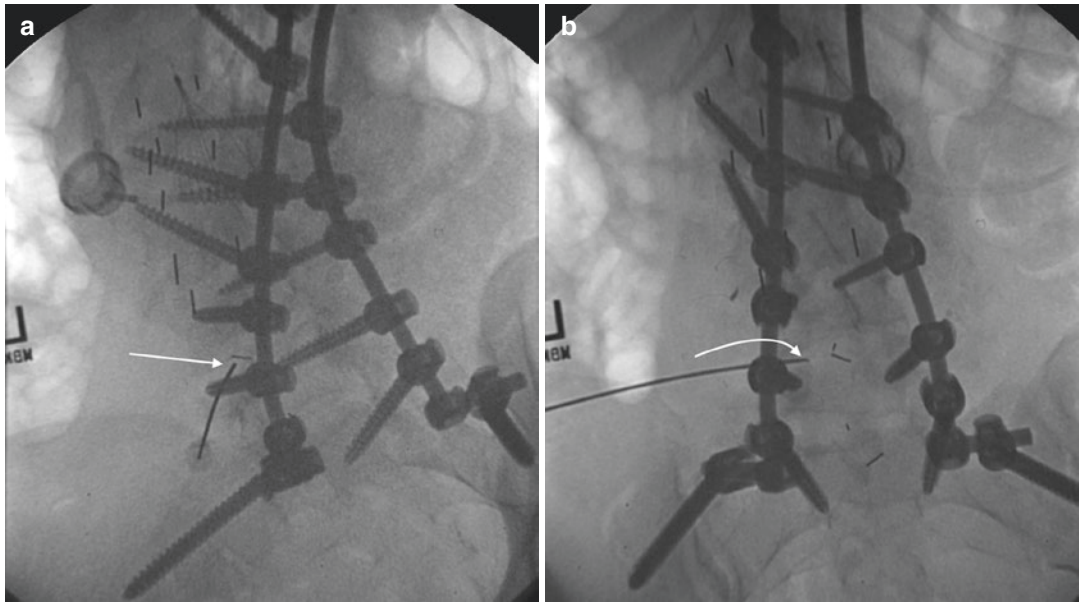
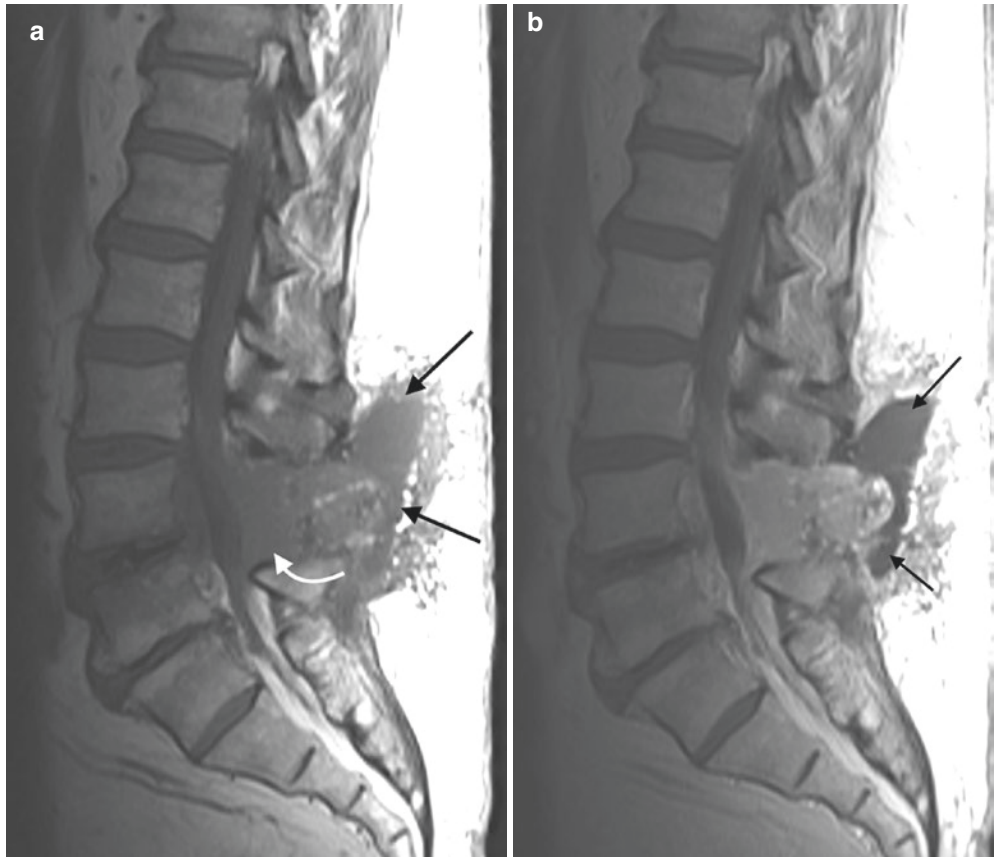


Fig. 9.10 A 53-year-old female with fever and back pain presenting for fluoroscopic-guided aspiration of the L4-L5 disk space, previously noted to be abnormal on an MRI study. The patient is status post extensive spinal fusion for scoliosis 3 months prior to presentation. Oblique and AP fluoroscopic images (**a**, **b**) of the lumbar spine show a 13-gauge needle (*arrow*) advanced into the L4-L5 disk using a left posterior oblique approach



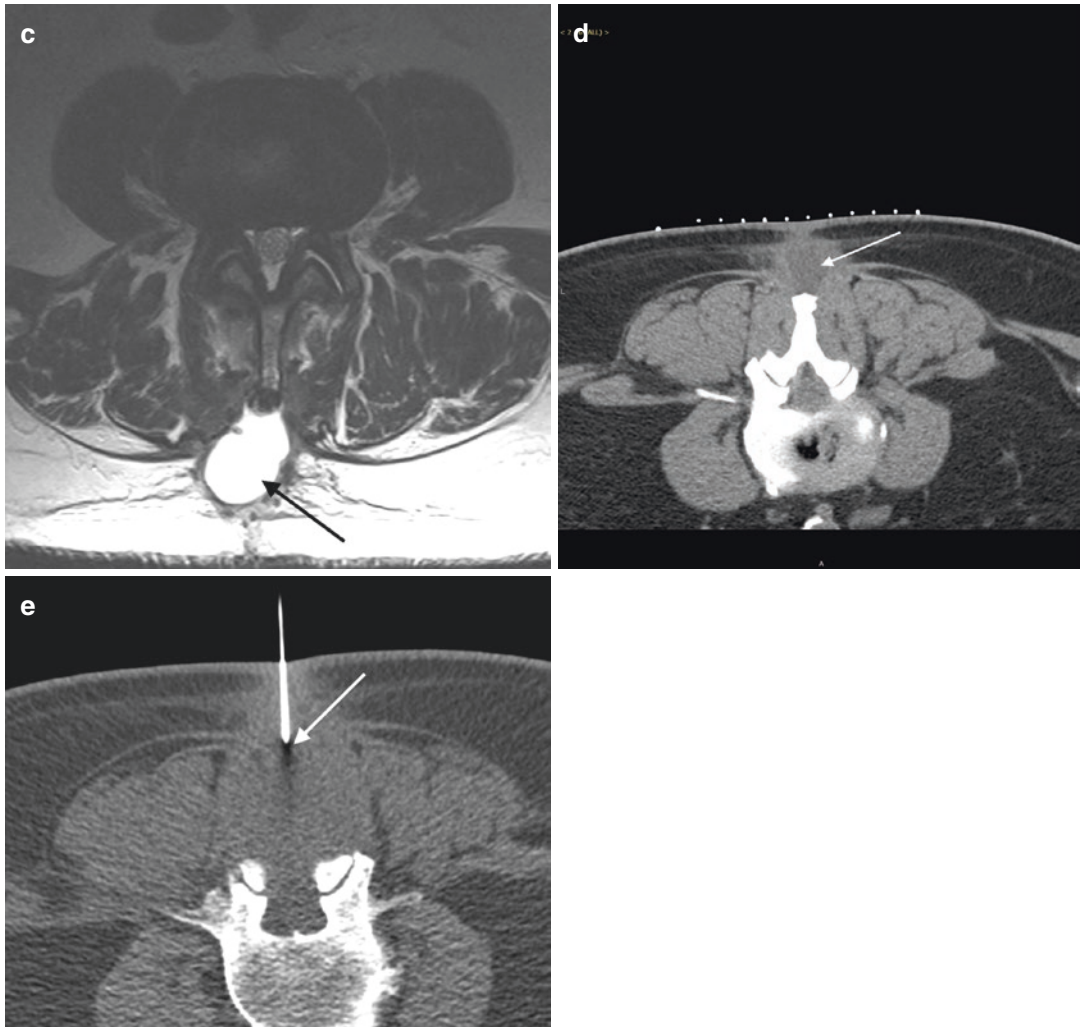


Fig. 9.11 (continued)

Fig. 9.11 A 76-year-old male with low back pain following a laminectomy and diskectomy for an L4-L5 extruded disk herniation. T1-weighted sagittal image (**a**) shows a laminectomy (*curved arrow*) and a posterior paraspinal fluid collection (*arrows*). The collection (*arrows*) does not enhance as shown on the contrast-enhanced T1 image (**b**) and is well circumscribed and hyperintense (*arrow*) as shown on the T2-weighted axial image (**c**). The patient's laboratory parameters (WBC, ESR, CRP) were all normal, and he was afebrile; nevertheless, because of his pain symptoms, the surgeon requested an aspiration drainage procedure. This was performed using strict aseptic technique and with initiation of intravenous antibiotic prophylaxis at the start of the procedure. Axial CT image in soft tissue algorithm (**d**) with skin grid in place shows the hypodense fluid collection (*arrow*) just superficial to the spinous process. A coaxial system (**e**) with a small guide cannula (*arrow*) was used to aspirate the collection – a seroma

from conservative management to percutaneous or surgical drainage depending on the nature and extent of the patient's symptoms. Hematomas are uncommon in the postoperative spine patient, occurring in less than 1% of cases (Jain et al. 2014). They are extravascular collections of blood, which result from iatrogenic manipulation and are found at or immediately adjacent to the operative site. Hematomas have variable imaging characteristics depending on the stage of hemorrhage. On CT, acute hemorrhage is hyperdense and decreases in density as time progresses. Signal changes on T1- and T2-weighted MR sequences follow the evolution of blood products within the collection. Because of their location within the epidural space, epidural hematomas may cause spinal cord compression and edema and require immediate spine surgical consultation for possible evacuation. Pseudomeningoceles are collections of cerebrospinal fluid (CSF) that extend from the spinal canal into the adjacent paraspinal soft tissues and are typically the result of a breach of the dura mater. Pseudomeningoceles follow the imaging characteristics of CSF on CT and MRI and may also contain a small hematocrit level due to hemorrhage. Variable treatment options are available and include observation with monitoring, compression bandages, epidural blood patch, percutaneous or surgical drainage, or direct surgical repair of the dural defect. An abscess is a focal collection of infected fluid. Edema of the paraspinal soft tissues or epidural space can be present and with contiguous spread of infection may progress into an abscess. Paraspinal and epidural abscesses can have a variable imaging characteristics depending on stage and water content. Classically, they appear as a thick-walled fluid collection, which demonstrates avid irregular wall enhancement following the intravenous administration of contrast agent. In many instances, it may be difficult to distinguish between an abscess, pseudomeningocele, and seroma on diagnostic imaging examinations. Positive blood cultures and persistently elevated CRP are laboratory findings suggestive of infection. Ultimately, percutaneous or open surgical drainage may be necessary for diagnostic evaluation with therapeutic implications. Because it is highly desirable to avoid superinfecting a sterile fluid collection, image-guided percutaneous aspiration procedures are best discussed with the referring clinician in order to develop the appropriate treatment plan for the patient.

> The diagnosis of spine infection in normal patients, immunocompromised patients, or postoperative spine patients requires a high index of clinical suspicion and utilizes a combination of clinical, laboratory, and imaging findings.

9.8.1 Indications

The indication for performing image-guided percutaneous spine biopsy is to diagnose or exclude the presence of spine infection and, when spine infection is indeed present, to identify the causative microorganism. Suspected spine infection is the second most common indication for spine biopsy, after suspected metastatic disease in a patient with known primary malignancy (Tehranzadeh et al. 2007). Spine infections are typically mono-microbial with *Staphylococcus aureus* accounting for the majority of cases. *Mycobacterium tuberculosis*, *Escherichia coli*, and *Brucella* are other common pathogens that have been identified as a source of spine infection. Despite a suspicious clinical picture, including imaging findings that are consistent with spine infection, a definitive causative organism can only be obtained by microscopic analysis of an infected specimen. The offending pathogen may be harvested from the infected spine segment or, less commonly in the case of sepsis, from a positive blood culture. Identifying the causative organism is important as it can change patient management by allowing clinicians to adjust the antibiotic treatment regimen and tailor other treatments specific to the patient's condition (Rankine et al. 2004). Image-guided percutaneous spine biopsy may be considered in patients with suspected spine infection, based on the clinical presentation, laboratory data, and imaging studies, when a microbiologic

diagnosis for a known associated organism has not been established by blood cultures or serologic tests (Berbari et al. 2015; Garg et al. 2014).

9.8.2 Contraindications

Bleeding diathesis and uncorrected coagulopathy (INR > 1.5 or platelets < 50,000/mm^3) are the primary contraindications to performing image-guided percutaneous biopsy in patients with suspected spine infection. Discussion with the referring physician and the patient is critical to determine the appropriate actions in either temporarily discontinuing or reversing anticoagulant and antiplatelet medications prior to spine biopsy procedures to reduce the risk of bleeding or thromboembolic events (*refer to the Chap. 1 Pre- and Peri-procedural Planning and Patient Management for Spine Biopsies*). Informed consent must also be obtained from the patient or an appropriate designated individual prior to performing image-guided biopsy.

9.9 Image Guidance and Biopsy Techniques

Image-guided percutaneous sampling of vertebral lesions and the intervertebral disk for suspected infectious spondylitis is a safe procedure that offers several advantages compared to open surgical biopsy (De Lucas et al. 2009). Percutaneous image-guided spine biopsy procedures can be performed efficiently and expeditiously within an imaging suite and do not require an operating room or an overnight hospital stay, therefore resulting in overall lower healthcare costs. Furthermore, image-guided spine biopsy procedures do not require general endotracheal anesthesia and have a lower risk of procedure-related infection or bleeding resulting in lower morbidity and complication rates as compared to open biopsy. The option for an image guidance modality is ultimately determined by the preference of the operator and equipment availability. Although the use of ultrasonography and magnetic resonance imaging have been described for performing percutaneous spine biopsy, conventional fluoroscopy, CT, or CT with fluoroscopy are the most frequently used modalities for performing image-guided spine biopsy. Conventional fluoroscopy with a multidirectional fluoroscope enables prompt access to the vertebral body or intervertebral disk with real-time monitoring of the biopsy needle relative to the level of interest. Coaxial exchanges are quickly performed with fluoroscopic guidance. Nevertheless, subtle or small lesions may not be visible or accessible with this form of imaging guidance (Kim et al. 2013). Furthermore, many critical structures such as the aorta are not well visualized with fluoroscopy. CT is advantageous in that it provides a comprehensive view of all anatomic and critical structures within the biopsy field. The biopsy needle tip location and trajectory relative to the target lesion and/or disk can be readily and precisely monitored with CT, lessening the likelihood of injury to adjacent neurovascular structures. CT fluoroscopy increases the efficiency and safety of percutaneous CT-guided spine procedures, combining the real-time benefits of fluoroscopy and the axial resolution of CT (Wu et al. 2014).

9.10 General Considerations

Communication and discussion between the operator and the referring clinician regarding the patient and the intended biopsy procedure is very important prior to performing the spine biopsy procedure. Although percutaneous image-guided spine biopsy procedures are regarded as safe and effective procedures, both the performing radiologist and referring clinician should agree that the biopsy results will affect the patient's clinical management and that this benefit firmly outweighs the risks of this interventional procedure. Additionally, if there is concern that the site to be sampled may be a malignant bone lesion, a multidisciplinary team approach with discussion between the radiologist, surgeon, oncologist, infectious disease specialist, and pathologist can be essential for patient management. Before proceeding with biopsy, the operator must review the patient's clinical data, including medical and

surgical history and laboratory results, as well as perform a thorough review of all imaging studies. Adherence to these basic principles will ensure that a biopsy is indeed indicated while avoiding unnecessary procedures. It will also help to determine the optimal location and spine level to sample. Written informed consent including the risks and benefits of the procedure should be explained to the patient and/or patient's family, as well as the alternatives to percutaneous sampling including open surgical biopsy or continued medical monitoring with imaging surveillance.

Helpful steps when considering a biopsy for spine infection:

1. Obtain all pertinent clinical information (history, past medical history, past surgical history, current and recent medications, medical allergies).
2. Review all pertinent recent and prior imaging studies.
3. Consult with the referring clinician when possible.
4. Obtain and/or order laboratory studies (white blood cell count with differential, ESR, CRP; coagulation profile if necessary).

9.11 Preparation

Pre-procedural laboratory parameters including hematocrit, hemoglobin, platelet count, and coagulation profile (prothrombin time [PT], partial thromboplastin time [PTT], and international normalized ratio [INR]) should be acquired. The operator should be aware of concurrent patient medications that may be contraindicated or perhaps alter the biopsy results. Patients on antiplatelet and/or anticoagulant therapies should have these medications temporarily discontinued prior to biopsy to minimize bleeding. In the setting of suspected vertebral spondylodiskitis, a white blood cell count with differential, an erythrocyte sedimentation rate (ESR), and a C-reactive protein (CRP) should also be obtained. It should be noted if the patient has recently been placed on or is currently on antibiotic therapy. If the patient is indeed already receiving antibiotics, then the biopsy procedure should be performed within 48 h of commencing antibiotic therapy, or antibiotics should be discontinued for at least 48 h prior to performing the biopsy. The operator must be aware of any potential patient drug allergies, especially reactions to anesthetic agents and intravenous radiographic contrast media. Ideally, patients should not eat or drink (NPO status) for a minimum of 8 h prior to the procedure. A majority of image-guided spine procedures can be performed utilizing local anesthetic administration and intravenous sedation and analgesia. Intravenous sedation usually consists of a combination of a short-acting benzodiazepine (Versed) for anxiety relief, as well as an analgesic agent such as fentanyl (Sublimaze). It is best to obtain intravenous access via the forearm or hand, as the patient's arms are often bent during the procedure, a position that often compromises the functionality of antecubital venous access. Automated patient monitoring equipment, including a pulse oximeter, an electrocardiogram, and a blood pressure monitor, adds yet another level of safety to these procedures.

Patient positioning is dependent upon the anatomic region of interest and lesion location. The prone position is preferred for accessing the thoracic and lumbosacral spine, as well as the posterior elements of the cervical spine. Accessing cervical intervertebral disk spaces and vertebral body lesions is performed with the patient in the supine position in order to facilitate an anterior approach. All patients, regardless of the spine biopsy location, are prepared for the procedure using a standard protocol. Once written informed consent and intravenous access are obtained, the patient is placed on the CT or fluoroscopy table in a position to facilitate a safe and successful biopsy, without causing discomfort to the patient. A "time-out" is then initiated by the operator to verify the correct patient and procedure to be performed. Intravenous sedation and analgesia can also be administered at this time.

9.12 CT Guidance

A radiopaque grid is placed on the skin over the anticipated skin entrance site, followed by acquisition of scout images in the frontal and lateral projections. After review of the preliminary images through the spine level of interest, an entrance site is selected and marked with a skin marker. The skin is then prepped via standard sterile technique and draped. The skin entrance site is then anesthetized utilizing a local anesthetic agent (e.g., 2% lidocaine) utilizing a 25-gauge needle, which is advanced deeper along the expected needle path and trajectory. For deeper local anesthesia, additional anesthetic agent may be administered using a 22-gauge needle. Utilizing a #11 scalpel blade, a small crosshair skin incision is made to facilitate placement of larger caliber needles through the skin and superficial fascia. A coaxial bone biopsy needle system utilizing a single needle pass to access the target is our preferred method for biopsy of vertebral osteomyelitis, minimizing the possibility of injuring normal tissues and critical structures. The biopsy needles can be advanced through a guide cannula that is "parked" at the level of interest. Disk aspiration is facilitated by utilizing a 20-mL syringe connected to the biopsy needle so as to create negative pressure while performing needle excursions within the area of suspected infection. Once the needle is confirmed to be within the desired disk space, craniocaudal and mediolateral angulation of the needle can also be performed with each sample to increase specimen yield. The location of the biopsy needle should be monitored with CT for each attempted needle pass, to confirm the location of the needle relative to the area of interest and relative to adjacent critical anatomic structures. The aspirated intradiskal material and/or subchondral bone are placed into sterile containers and submitted for microbiological analysis. Aspirated blood can also be submitted for microbiologic analysis.

9.13 Biopsy Technique: The Cervical Spine

An anterior approach (*as described in Chap. 4 Cervical Spine Biopsy*) is used to access the cervical intervertebral disk space. These are not frequently performed as cervical spine infections are less common than thoracic or lumbar spine infections. The general principles in terms of using coaxial technique to minimize needle insertions adjacent to critical anatomic structures, optimal visualization and avoidance of these critical structures, and optimal lesion targeting to maximize specimen yield are particularly important in this region of the spinal axis, where the spine structures are smaller and surrounded by several important vascular and nonvascular structures. CT aids in optimal visualization of critical structures and their anatomic relation to the suspected site of infection within the cervical spine. In some cases, however, fluoroscopic techniques with manual retraction of the carotid space structures can yield quick and safe access to the intervertebral disk.

9.14 Biopsy Technique: The Thoracic Spine

When sampling the intervertebral disk space of the thoracic spine, care must be taken to avoid the lung and pleura, the thoracic aorta, and the spinal cord. The thoracic spine can be accessed via transpedicular or extrapedicular posterolateral approaches. Transpedicular approaches in the thoracic spine are employed when sampling suspected foci of osteomyelitis that occupy an accessible portion of the vertebral body. The margins of the pedicle, especially the medial margin, should be visualized, while the needle traverses the pedicle into the vertebral body. There are three extrapedicular posterolateral approaches including the costotransverse, transcostovertebral, and intercostal routes of access (Figs. 9.7 and 9.12).

The costotransverse approach is a well-established approach to sample thoracic vertebral body lesions (Fig. 9.7). This approach requires needle placement between the vertebral transverse process and the tubercle of the corresponding rib. The head of the rib articulates with superior vertebral costal facet, which is located in the posterolateral superior aspect of the vertebra immediately caudal to the superior endplate, thus allowing access to lesions in the upper portion of

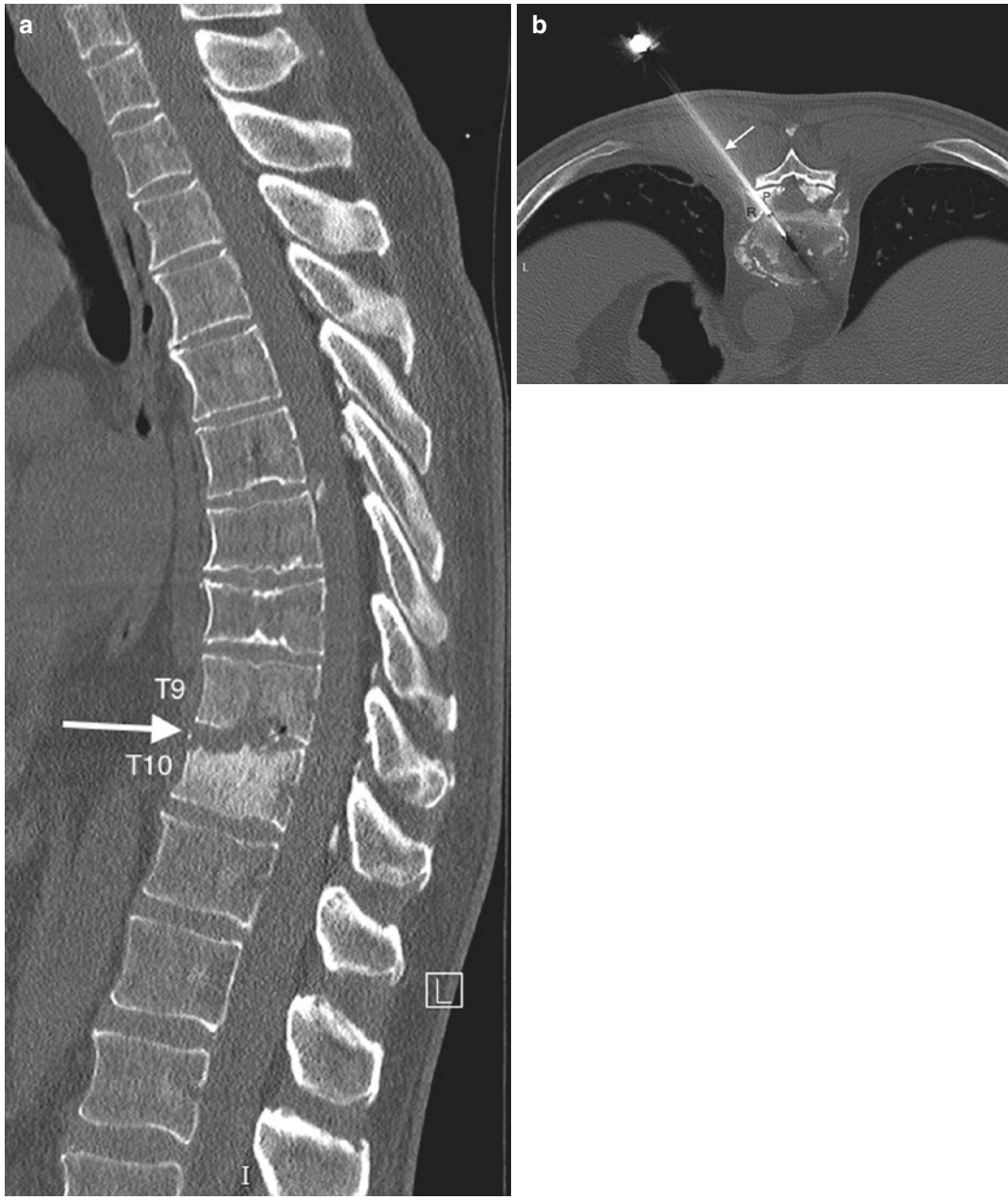


Fig. 9.12 A 65-year-old male with clinically proven acute osteomyelitis, culture positive for *S. aureus*. Reformatted sagittal CT image in bone window algorithm (**a**) shows irregularity, sclerosis, and erosion of the T9-T10 vertebral endplates (*arrow*). Axial CT image (**b**) acquired during biopsy shows the biopsy needle (*arrow*) advanced in an anatomical groove between the head of the left tenth rib (*R*) and the pedicle (*P*), a transcostovertebral approach, and safely entering the T9-T10 disk space

the vertebral body, as well as entry into the intervertebral disk space along the superior endplate of the corresponding accessed vertebra. The posteromedial margin of the rib prevents the needle from puncturing the pleura, and the transverse process prevents entrance into the spinal canal. Damaging the costotransverse articulation is a theoretical risk with the costotransverse approach.

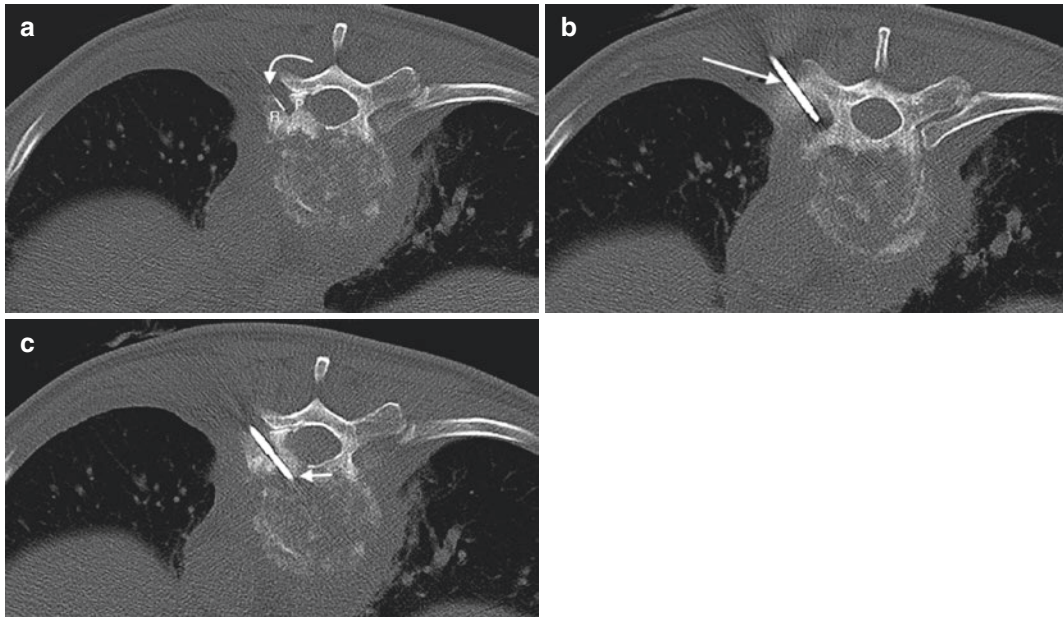


Fig. 9.13 A 59-year-old male with a history of previously treated *Streptococcus anginosus* infectious spondylitis at T9-T10 presents with back pain and elevated ESR and CRP. Axial CT image (**a**) acquired during biopsy shows a spinal needle (*curved arrow*) entering the groove between the pedicle (*P*) and rib (*R*), a transcostovertebral approach. Axial CT images (**b**, **c**) acquired during biopsy show advancement of a bone biopsy needle (*small arrow in* **c**) through a guide needle (*large arrow in b*) into the T9-T10 disk space for successful sampling of the T9-T10 disk and adjacent vertebral endplate

The transcostovertebral approach is a modification of the costotransverse approach (Fig. 9.12). This is an excellent approach for sampling the intervertebral disk space and adjacent vertebral endplate when osteomyelitis is suspected (Fig. 9.13). The needle trajectory is located slightly superior to the costotransverse joint, and the biopsy needle system is advanced in a groove formed between the pedicle and head of the corresponding rib, preventing inadvertent lung puncture and injury to the exiting nerve root. This anatomical groove is located just above the transverse process, which allows more freedom for needle angulation and, as with the costotransverse approach, allows access to lesions within the superior aspect of the vertebral body and the adjacent intervertebral disk space, facilitating both vertebral endplate and disk sampling.

The posteromedial intercostal approach is infrequently performed, but it is a reported technique that is used to access paravertebral thoracic soft tissue masses that extend from the vertebral body into the adjacent paravertebral soft tissues. Needle placement is located within the posteromedial intercostal space, anterior to the head of the rib and the costovertebral joint. Given the more tangential needle trajectory, sampling vertebral body lesions with intact cortex via the intercostal approach assumes a higher risk of inadvertent lung puncture because the needle has a tendency to be deflected anteriorly. This approach also has the added risk of causing intercostal vascular injury. When using this approach to sample a paravertebral soft tissue mass, it might be helpful to infiltrate a few milliliters of sterile normal saline into the paravertebral soft tissues so as to create more space for needle manipulation by pushing the parietal pleura and lung anteriorly.

9.15 Biopsy Technique: The Lumbar Spine

In lumbar spine biopsy, the critical anatomic structures of interest include the abdominal aorta, inferior vena cava, kidneys, bowel, and

exiting spinal nerves. Accessing the lumbar intervertebral disk spaces and the adjacent subchondral vertebral endplates for evaluation of vertebral osteomyelitis is performed via the transpedicular or the extrapedicular posterolateral approach. The transpedicular approach is often utilized for lesions that are located within the pedicle or are centrally located within the vertebral body. Access to the intervertebral disk can also be obtained by utilizing the transpedicular approach (Michel et al. 2006). For this approach, the biopsy needle is placed in the groove between the superior articular process and the transverse process, thereby directly entering the ipsilateral pedicle. The upper lumbar vertebral disk spaces and vertebral endplates are often oriented either parallel or angled superiorly relative to the needle trajectory; therefore, once the needle passes through the pedicle, cranial angulation is performed to sample both the superior endplate and the disk space with a single biopsy pass (Fig. 9.3). Care must always be taken not to penetrate the medial cortex of the pedicle as this would constitute a breach into the spinal canal and its contents. The transpedicular approach is preferred by some operators as compared to the posterolateral approach due to the shorter and more direct path of the former. Nevertheless, efficient and successful biopsy of the intervertebral disk and vertebral endplate can be performed by utilizing the posterolateral approach (Fig. 9.4). The entry site and trajectory are through the soft tissues just lateral to the superior articular process before entering the disk space or the lateral vertebral cortex. The exiting lumbar nerve roots pass through the upper portion of the neural foramen, just posterior to the disk-endplate complex. The posterolateral route allows access to the disk space by traversing the inferior margin lateral to the neural foramen. Careful attention to the patient's anatomy and imaging guidance will help to avoid injury to the exiting nerve root. In the lumbar spine, this can be achieved with CT guidance or with fluoroscopic guidance. While the advantages of CT have already been described, lumbar disk biopsy can be quickly and safely performed using fluoroscopic guidance. This requires craniocaudal angulation of the fluoroscope in order to align the vertebral endplates at the level of interest. Next, the fluoroscope is rotated ipsilateral oblique in a mediolateral direction depending on the side of percutaneous access (toward the right on the patient's right side and toward the left on the patient's left side). This maneuver effectively creates a "scotty dog" configuration on the fluoroscopic image such that superior articular process projects over the disk space of interest anywhere from 30 to 50% along the visualized width of the disk space. A steeper oblique angulation allows for access of the more median and posterior aspect of the disk. The biopsy needle system will "ride" along the lateral aspect of the superior articular process in order to access the disk space (Fig. 9.14). The biopsy needle system can also be angled cephalad to sample the inferior cortical endplate or caudal to sample the superior cortical endplate.

A lateral access route (Garces and Hidalgo 2000) which places the patient in a lateral decubitus position displaces the abdominal viscera forward and allows for direct access to the lumbar vertebral body, intervertebral disks, and paravertebral masses while avoiding the nerve roots, bowel, kidneys, and vessels. The transforaminodiskal method (Sucu et al. 2003) is an alternative to the posterolateral approach.

9.16 Challenging Disk Biopsies

L5-S1 disk space biopsy can pose a challenge. With fluoroscopic guidance and a steep oblique lateral-to-medial approach, along with craniocaudal angulation to align the L5 inferior vertebral endplate and S1 superior vertebral endplate, the fluoroscope is used to create a radiolucent triangular portal of entry to the

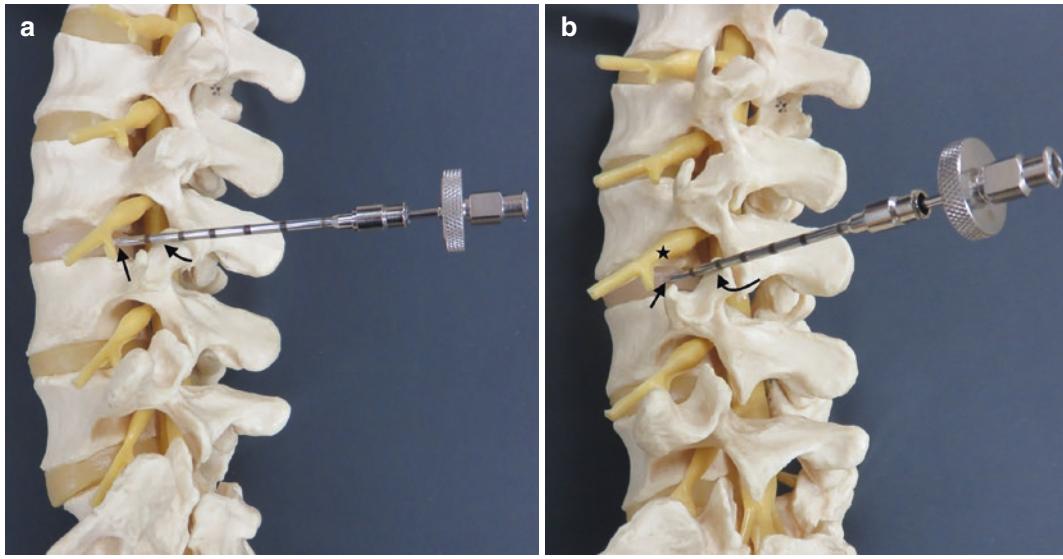


Fig. 9.14 Photographs of a lumbar spine model with a coaxial needle biopsy system inserted via posterolateral approach. Lateral view (**a**) shows guide needle overlying the superior articular process (*curved arrow*) and then passing underneath the exiting nerve root (*arrow*) to enter the disk space. Oblique view (**b**) again shows the close proximity of the guide needle as it passes over the superior articular process (*curved arrow*) to then enter the disk (*arrow*) beneath the exiting nerve root (*star*)

disk (Fig. 9.15). The anatomic relations of this radiographic inverted triangle include the iliac crest laterally, the S1 superior articular process medially, and the L5 inferior vertebral endplate superiorly. This approach helps to avoid the exiting L5 nerve root. Sometimes, due to the patient's intrinsic spinal axis geometry, it is not possible to access the L5-S1 disk despite maximal angulation maneuvers. In this situation, it is often helpful to use abdominal and pelvic bolsters to correct for steeply oriented disk spaces or, alternatively, place the patient in a prone oblique position. Bolsters can also be utilized when performing L5-S1 disk biopsy with CT guidance. Alternatively, angulation of the CT gantry parallel to the L5-S1 disk space can be helpful in gaining access for disk sampling. As previously mentioned, a transpedicular approach with appropriate angulation of the needle, depending on which pedicle is entered (L5, angle caudally, or S1, angle cranially), can be used to access the L5-S1 disk and vertebral endplate (Fig. 9.3).

9.17 Disk Aspiration Techniques

Obtaining a satisfactory specimen from a disk biopsy is not an easy task. The conventional method for attempting to biopsy the disk is to place a small gauge needle within the disk and to aspirate using continuous suction with a syringe that is attached to the needle as the needle is moved back and forth within the disk. This is often followed by the injection of a small amount of sterile saline into the disk and aspiration of the saline lavage. Neither of these techniques is particularly suited to obtaining disk material due to the small caliber of the aspiration needle (often 18–22-gauge), the connective tissue characteristics of the disk annulus, and the high viscosity of disk material. An alternative to this approach is to perform a mixed vertebral endplate disk biopsy by angling the bone biopsy needle into the vertebral endplate.

Another technique that can be used to perform a disk biopsy is to utilize a percutaneous

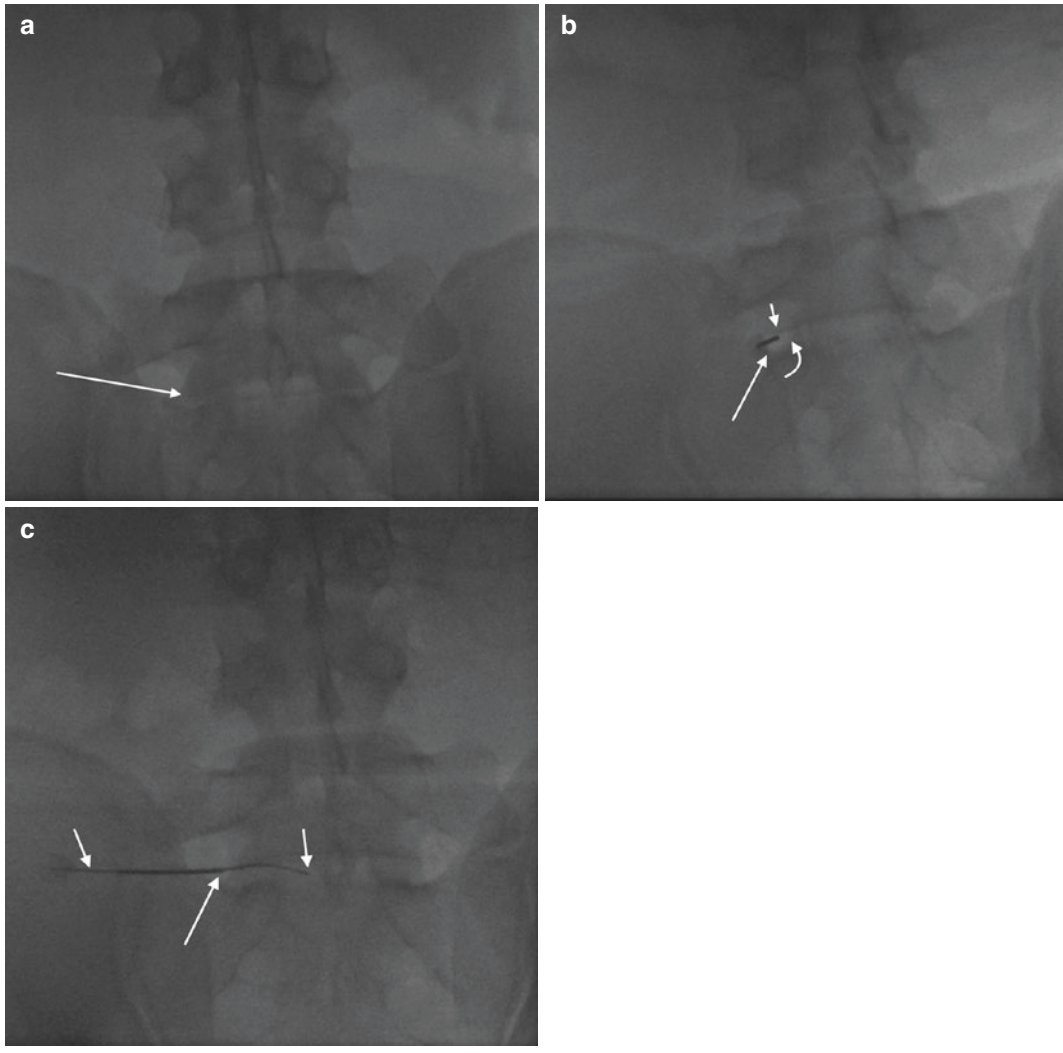


Fig. 9.15 Fluoroscopic approach to the L5-S1 disk space. Frontal radiograph (**a**) shows L5-S1 disk (*arrow*). In order to access this disk space, the fluoroscope is angled both in the craniocaudal direction, so as to align the vertebral endplates at L5-S1, and in an ipsilateral mediolateral orientation so as to keep the iliac crest from obscuring and preventing access to the disk space. The result of these fluoroscopic maneuvers should result in an image (**b**) that projects the superior articular process of S1 (*curved arrow*) over the L5-S1 disk space. A radiolucent inverted triangle is formed by the inferior endplate of L5 (*small arrow*), the iliac crest (*large arrow*), and the superior articular process of S1 (*curved arrow*) as shown on the oblique radiograph (**b**). A needle can then be advanced with a "down-the-barrel" approach toward the disk. In this case, an insert needle (*small arrows*) has been advanced into the disk through a guide needle (*large arrow*) as shown on the frontal radiographic projection (**c**)

diskectomy device (Wattamwar and Ortiz 2010). A 13- or 17-gauge guide needle is advanced into the margin of the disk (Fig. 9.16). A 6-in. automated percutaneous device is then inserted coaxially via the guide needle into the disk. The device is then activated, and its excursions to and fro within the disk are actively monitored with fluoroscopy. This device is able to aspirate infected purulent fluid material within the disk as well as disk tissue. Coaxial technique allows for multiple passes with this device in order to obtain adequate amounts of disk specimen for subsequent microbiologic and histopathologic analysis. The initial experience with this type of device has been extremely favorable in terms of obtaining an adequate specimen yield. In addition, the guide needle can then be exchanged over a removable hub insert needle, with subsequent placement of a bone biopsy system that can then be used to obtain specimens from the adjacent vertebral endplates.

9.18 Specimen Handling

The operator should obtain as much specimen as reasonably possible, be given the location and extent of the suspected infectious process, and be given the limitations of the biopsy tools that the operator is using. Specimen handling and transfer are important steps in the biopsy process for spine infection. Under optimal conditions, specimens should be submitted for both microbiologic and pathologic analysis. All microbiology specimens should be placed in sterile containers and transported as soon as reasonably possible to the microbiology laboratory. The clinical, including whether or not the patient is already on antibiotic therapy, and imaging information should be communicated with the request for microbiologic analysis. If a specific pathogen, for example, *Mycobacterium tuberculosis*, is suspected, then this information should also be communicated to the laboratory personnel. Most specimens are submitted for bacterial, fungal, and mycobacterial stains and cultures. The specimens (e.g., mycobacterial) may be kept for a long period of time, and the operator should periodically check for the final results of each specific test. For pathology, the specimens can be placed in a container with 10% formalin and then transported to the pathology department. Bone specimens will require additional processing time in order to allow for appropriate decalcification prior to histopathologic analysis.

Key Review Points

1. The incidence of spine infection appears to be increasing.
2. The imaging diagnosis of spine infection is improved by not only being aware of the early imaging findings in spine infection but also by suspecting this diagnosis.
3. MRI is the imaging modality of choice for helping to diagnose spine infection.
4. Spine biopsy, whenever possible, is best performed before the initiation of antibiotic therapy.
5. A persistently elevated CRP for greater than 2 weeks following spine surgery is an early indication of postoperative spine infection.
6. Postoperative paraspinal fluid collections are common and include seroma, hematoma, pseudomeningocele, and abscess. Percutaneous image-guided biopsy is sometimes requested to exclude an infected collection.
7. Coaxial techniques with sampling of the intervertebral disk and the adjacent vertebral endplates maximize specimen yield.

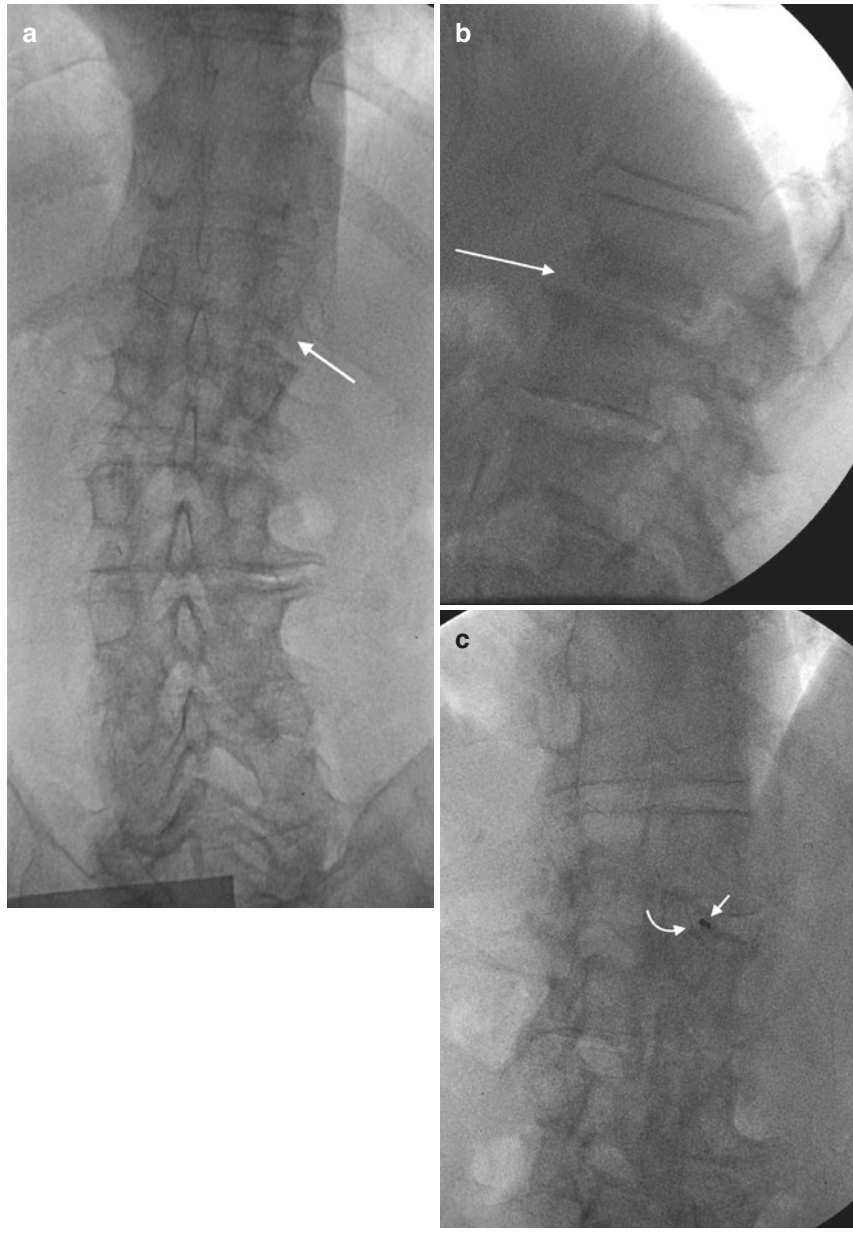


Fig. 9.16 An 85-year-old male with intermittent low back pain and abnormal gait. Frontal projection of the lumbar spine (**a**) shows vertebral endplate erosion at T12-L1 (*arrow*). Lateral radiograph of lumbar spine (**b**) shows disk space narrowing and reactive sclerosis at T12-L1 (*arrow*). Oblique fluoroscopic image (**c**) of lumbar during the spine biopsy shows advancement of a 17-gauge spinal needle (*arrow*) adjacent to the superior articular process of L1 (*curved arrow*). Note that this mediolateral angulation of the fluoroscope places the superior articular process (*curve arrow*) or ear of the "scotty dog" at least 30–40% of the width of the vertebral body as seen on this projection. A lateral fluoroscopic image (**d**) shows the needle tip (*arrow*) at the posterior aspect of the T12-L1 disk with subsequent advancement into the disk (*arrow in* **e**). The stylet of the needle is removed, and an aspiration of the disk is performed with the needle left in place. A percutaneous diskectomy device is then coaxially inserted into this guide needle (*arrow*) as shown on this lateral fluoroscopic image (**f**), and disk material is obtained. The diskectomy device is removed, and the guide needle is left in place such that a 20-gauge insert needle with a removal hub is then inserted into this guide needle. The 20-gauge insert needle (*small arrow*) serves as a guide pin for a coaxial exchange for a bone biopsy guide cannula (*large arrow*) and introducer (*curved arrow*) as shown in the lateral fluoroscopic image (**g**) and frontal fluoroscopic image (**h**). Lateral (**i**) and frontal (**j**) fluoroscopic images show a trephine biopsy needle that is inserted coaxially through the guide needle and angled cephalad in order to sample the inferior endplate of T12 (*arrows*)

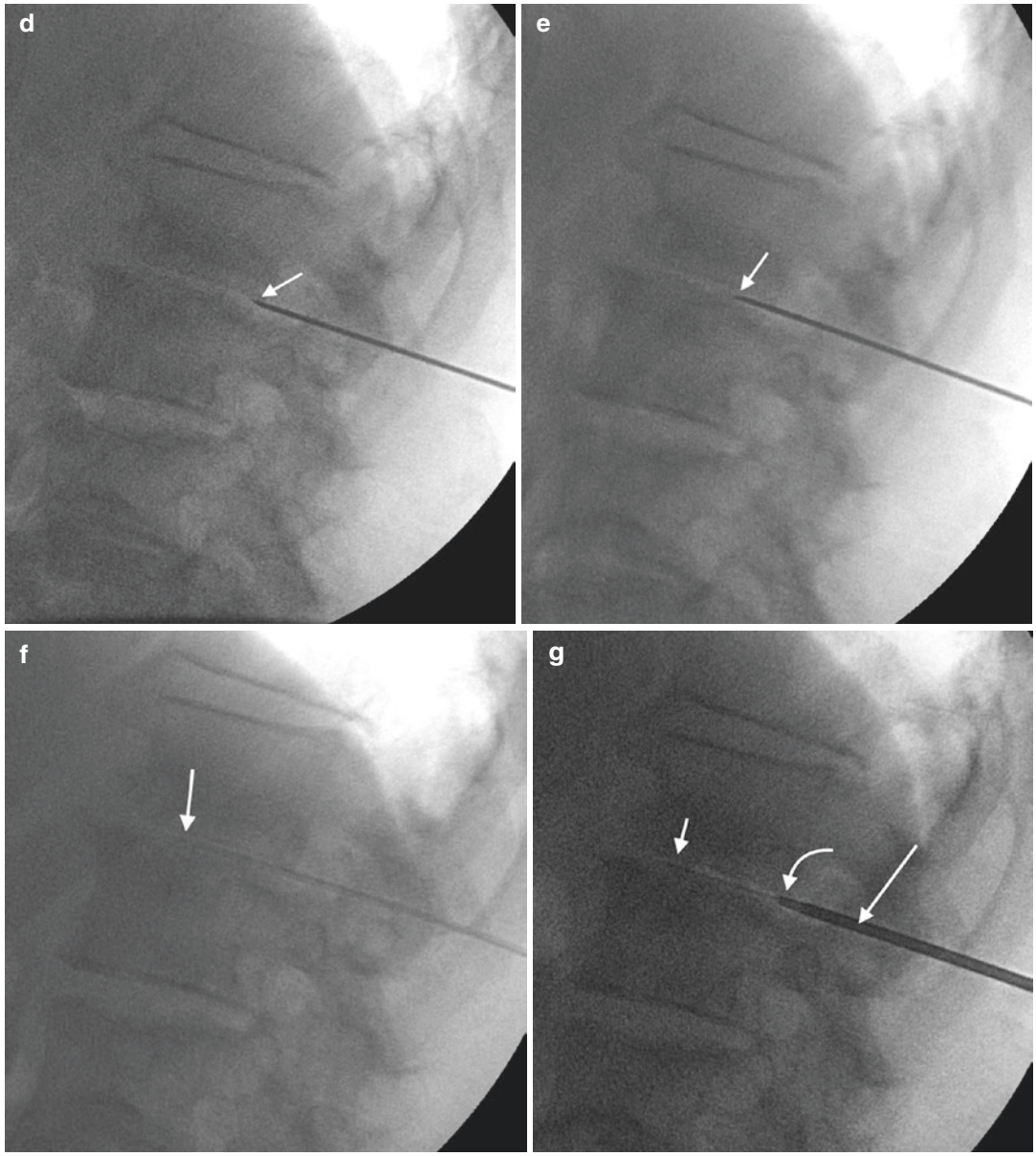


Fig. 9.16 (continued)

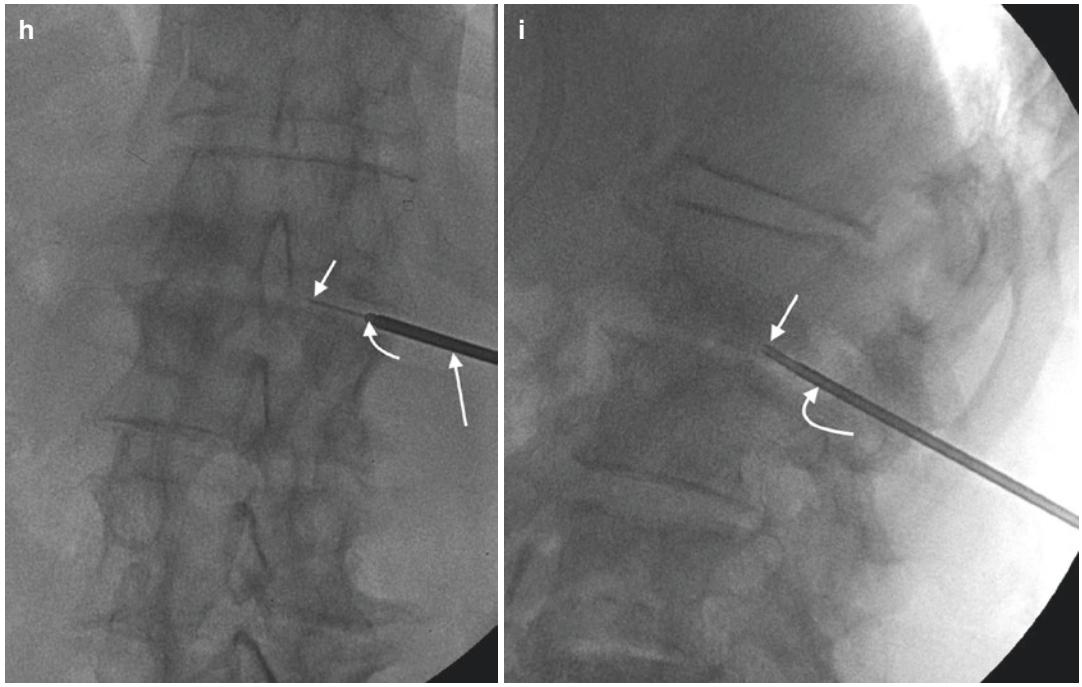


Fig. 9.16 (continued)

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