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Bone SPECT/CT in Postoperative Spine

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Back pain is a common problem and the diagnosis and treatment depend on the clinical presentation, yet overlap between pain syndromes is common. Imaging of patients with chronic back pain in both pre- and postoperative scenarios include radiological, radionuclide, and hybrid techniques. In general, these techniques have their own advantages and limitations. The aim of surgery is to eliminate pathologic segmental motion and accompanying symptoms, especially pain. However, surgical procedures are not without complications and localizing the cause of the pain is often challenging. Radiobisphosphonate bone SPECT/CT is reported to be useful in evaluating benign orthopedic conditions and it often provides valuable information such as accurate localization and characterization of bone abnormalities. In this review, routinely used spinal surgical techniques and procedures are discussed, as well as the acute and delayed complications related to spinal surgery, the role of conventional imaging, and the potential uses of radionuclide bone SPECT/CT to diagnose pseudoarthrosis, cage subsidence, loosening and misalignment, hardware failure, and postoperative infection.

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Introduction

Low back pain (LBP) is a common problem and the diagnosis and treatment vary depending on clinical presentation. Imaging of patients with LBP in pre- and postoperative scenarios includes radiological, radionuclide, and hybrid techniques, which are often guided by clinical presentation and each of these techniques has its own advantages and limitations. In general, management of back pain is often conservative in early stages and patients with spinal instability undergo surgery, even though the indications for spinal fusion surgery have not been well defined or universally ac-

cepted, in particular for degenerative disease. Majority of patients with back pain may not require surgical therapy and the aim of surgery is to eliminate pathologic segmental motion and accompanying symptoms, especially pain.¹ However, surgical procedures are not without complications and localizing the cause of the recurrent or persistent pain in postsurgical patients is often challenging. Radionuclide bone SPECT/CT provides valuable information such as accurate localization and characterization of bone abnormalities and identifies potential pain generators.² However, understanding the spectrum of increased tracer uptake reflecting fusion instability or physiological remodeling after surgery is often challenging and the evidence supporting bone SPECT/CT is limited but evolving.³⁻⁵ In this review, we will discuss the spectrum of spinal surgical procedures, typical acute and delayed complications, causes of recurrent pain after surgery, and the role of radionuclide bone SPECT/CT.

Spine Surgery

Back pain is treated with nonsurgical (pharmacologic and physical therapy) and surgical methods (minimally invasive or open procedures). In general, common indications for surgery include instability, spondylolisthesis, degenerative disc disease, recurrent disc herniation, pseudoarthrosis, and so on.¹ Surgery is performed with an aim to eliminate pathologic

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Table 1 Lumbar Spinal Fusion: Instrumentation and Surgical Approaches^{1,6-10}

| Instrumentation Used in Fusion | Surgical Approaches | Surgery |
|---|--|---|
| Rigid stabilization Interbody spacers Plates or rods with pedicle screws Translaminar or facet screws Hartshill rectangle Interbody grafts and implants Biological substances: bone grafts Synthetic materials: stainless, titanium, carbon polymers Nonmetallic synthetic spacers Dynamic stabilization devices Pedicle screws and artificial ligaments Interspinous process decompression devices Posterior element replacement systems | Posterior surgical approaches Posterior lumbar interbody fusion Transforaminal Lumbar Interbody Fusion Posterolateral fusion Anterior surgical approaches Anterior lumbar interbody fusion Stand-alone lumbar interbody fusion | Vertebral body replacement (corpectomy) After a resection (tumor, infection, or major trauma) May involve one or more segments Additional stability is provided by insertion of lateral, anterior, or posterior screws with plates or rods Total disk replacement Performed in patients with pain believed to originate primarily from disc degeneration The goal is to avoid arthrodesis-related complications (pseudarthrosis, iliac crest donor site pain, and degeneration of the adjacent segment) Spinal dynamic stabilization Alternative to fusion in patients with low back pain originating from chronic degeneration of the lumbar spine Reduces or limits stress placed on adjacent segment to the level of fusion |

segmental motion and accompanying secondary symptoms such as pain. The common surgical procedures include decompression or arthrodesis with instrumentation⁶ such as discectomy and laminectomy, interbody fusion (bone grafting and scaffold or cage), and osteosynthesis (pedicle screws and plate).⁷ The used surgical approaches include anterior interbody fusion, extreme lateral interbody fusion, posterior interbody fusion, transforaminal interbody fusion, and posterolateral fusion.⁶ Each of these methods boasts specific advantages when it comes to the sparing of muscle, bone, and other adjacent structures, as well as to any limitations to the size of intervertebral material that can be implanted, and to the ability to be used in case of redo surgery.

Spinal Devices and Implants

Surgical fixation devices and implants have undergone significant advances and implants for cervical, thoracic, lumbar, and sacral segments are now available, which can be used with or without additional bone grafting.⁶ The common devices for lumbar spine surgery include (1) rods (single or multiple spine segments; single or double), which can also be fashioned as required and can be attached to the spine by hooks, pedicle screws or sublaminar or interspinous wires or cables⁶; (2) plates with various sizes and shapes for anterior or posterior spine fusion^{6,10}; (3) facet or translaminar or screws (attaches lamina of two adjacent vertebrae); (4) interbody spacers (solid [ramp] or hollow [cages]); and (5) dynamic stabilization devices (can be used alone or with other instrumentation), which include artificial ligaments, interspinous decompression systems and posterior element replacement systems, and so on (Table 1).⁶⁻¹⁰

Postoperative Complications

In general, like in all surgical procedures, spinal surgery is also associated with complications and these are reported to

occur in up to 15%-30% patients.^{11,12} Complications are often labeled as failed back surgery or failed back pain syndrome (patients with recurrent symptoms or in whom surgery failed to fully correct the problem).^{6,11,12} Patients might present with pain after surgery, in the early postsurgical phase (acute or early presentation) and later in the course of healing or remodeling (chronic or late presentation).¹³ The early or late complications related to spinal surgery are listed in Table 2.^{6,13-18} Early recognition and management are often important to prevent further complications and morbidity.

Bone SPECT/CT After Spine Surgery

Radionuclide bone scans are used in the assessment of patients with symptoms after spinal surgery. In general,

Table 2 Causes of Recurrent Pain After Spinal Surgery^{1,6-18}

| Acute Causes | Late Causes |
|------------------------------|---|
| Infection | Hardware failure |
| Spinal or foraminal stenosis | Pseudoarthrosis |
| Hardware malposition | Facet joint degeneration |
| Hemorrhage | Instability |
| Pseudomeningocele | Spondylolysis |
| Pain source not treated | Spondylolisthesis |
| Lateral recess stenosis | Dural tears, epidural scar, or fibrosis |
| Nerve injury | Recurrent disc herniation |
| | Osteophytosis |
| | Infection |
| | Arachnoiditis |
| | Junctional kyphosis |

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