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# SPECT/CT in Postoperative Painful Hip Arthroplasty

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**Consecutive milestones in hip arthroplasty design and surgical technique have contributed to the successful and cost-effective intervention this procedure has become today in maintaining mobility and quality of life in patients with osteoarthritis, fracture, or other hip conditions. With the increasing prevalence of hip joint replacements, the need for improved diagnostic imaging tools to guide revision surgery has risen in parallel. Over the last few years, promising data have emerged on the potential role of bone SPECT/CT imaging in the assessment of patients with recurrent pain after arthroplasty. This review summarizes the trends in hip arthroplasty surgery (partial vs total arthroplasty; cemented vs cementless arthroplasty; resurfacing arthroplasty) and prosthesis design (bearing materials; stem designs) over the last decade. In particular, the impact on the biomechanics and interpretation of bone SPECT/CT findings is discussed, with emphasis on integrative reporting in the following frequently encountered conditions: lysis/aseptic loosening, septic loosening, heterotopic ossification, periprosthetic fracture, tendinopathies, and adverse local tissue reactions. Based on the available literature data, bone SPECT/CT is increasingly being used as second-line imaging modality when conventional investigations are nondiagnostic. Further outcome research is warranted to examine whether this technique could be used earlier in patient management.**


## Introduction

First performed in 1826 in Philadelphia, hip arthroplasty has revolutionized the treatment of severely deformed or injured hip joints by improving functional outcome and quality of life.[1] Nowadays, it is one of the most commonly performed inpatient surgical procedures in the United States. The diagnosis most often leading to hip arthroplasty is osteoarthritis (±90%), with the remainder performed because of fracture, avascular necrosis, rheumatoid arthritis, or other conditions.[2] In 2010, an estimated 2.5 million individuals were living with a total hip replacement in the United States, up from 1.6 million in 2000, and representing 0.83% of the total population. This percentage was higher among women than men, and increased with age reaching 5.6% at 80 years.[3] During that same period, the number of total hip arthroplasties (THAs) per year in the United States among patients aged 45 and over increased from 138,700 to 310,800, and this number is expected to increase even further because of population growth and aging.[4] Although hip replacement surgery is a cost-effective intervention to maintain mobility and quality of life, it is associated with a considerable cost to the US healthcare system, totaling $21 billion in 2015.[5] With the increasing prevalence of joint replacements, the number of revision surgeries has grown in parallel. Across all types of hip replacement, the most common reasons

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**Table 1** Reasons for Revision Surgery in Primary Painful Hip Arthroplasty

| Reason for Revision | %* | Key Characteristics |
|---|---|---|
| Lysis/Aseptic loosening | 50% | Mechanism: Results from inadequate initial fixation, mechanical loss of fixation over time, or biological loss of fixation because of particle-induced osteolysis around the implant. Exposure to particles released from the construct and their resistance to degradation results in a pathologic response promoting osteolysis.[6] Typically, a fibrous tissue membrane consisting of fibroblasts and macrophages is formed encapsulating the implant.[7] Symptoms: New-onset and increasing pain with activity or weight-bearing, or start-up pain, that improves with resting, following a pain-free interval after initial surgery. Pain localizing to the groin or buttock suggests acetabular involvement, whereas femoral stem loosening tends to project to the thigh and leg.[8] |
| Pain | 20% | Recurrent pain is a nonspecific symptom after hip replacement surgery and may be caused by the implant, infection, bone alterations, soft-tissue, or nerve injuries.[9] |
| Instability/Dislocation | 15%-20% | Mechanism: Associated with higher age, female gender, and presence of cognitive or neurologic disorders, but also by surgical factors. A higher risk of dislocation is seen with smaller femoral heads (22-28 mm vs 32 mm) and when a posterolateral surgical approach is used compared with a direct anterior or anterolateral technique.[10,11] Symptoms: Instability/dislocation can be a very distressful complication causing severe hip pain, difficulty moving, and inability to bear weight on the extremity. |
| Infection | 10%-20% | Mechanism: Rapid onset symptoms occurring less than 3 mo after surgery are usually associated with high-virulence pathogens (eg, *Staphylococcus aureus* or Gram-negative bacilli) that infect the periprosthetic space at the time of operation or as complication of postoperative wound dehiscence. In contrast, slow and progressive symptoms (3-12 mo after surgery) suggest infection in the perioperative period with low-virulence pathogens (eg, *Propionibacterium acnes* or coagulase negative *Staphylococcus*). Finally, infection occurring many years after surgery and after a prolonged period of no pain and good function usually indicates hematogenous seeding from a distant site of infection/trauma (eg, *S. aureus*, *Streptococcus* spp., or Gram-negative bacilli).[12,13] Symptoms: The clinical presentation varies widely according to time frame and pathogen, but generally includes progressive joint pain and/or stiffness. Also, the pain pattern may mimic that of aseptic loosening, but pain at night or at rest should also raise the suspicion of infection. Local signs of infection consist of edema, erythema, warmth, tenderness, effusion, cellulitis, or sinus tract formation. Systemic symptoms such as fevers, chills, or night sweats may also occur.[8] |
| Adverse local tissue reaction (ALTR) | 11% | Mechanism: ALTRs are associated with metal-on-metal bearing surfaces and are caused by an inflammatory response to small metal debris particles. This response can lead to metallosis, bursal soft tissue masses (pseudotumor), and generalized synovitis and tissue damage. The inflammatory response can be both macrophage-induced cytotoxicity stimulated by metal debris and a type IV delayed hypersensitivity reaction to metal particles, known as aseptic lymphocytic vasculitis-associated lesion.[14] Symptoms: ALTRs have wide spectrum of clinical presentations but may lead to muscle, capsule, and soft tissue degradation, as well as tendinopathy, and can be the origin of pain, instability, and dysfunction.[14] |
| Peri-prosthetic fracture | 8%-10% | Mechanism: Periprosthetic fractures can be a devastating complication of total hip arthroplasty, often associated with poor bone quality in osteoporosis and frail patients, and local factors as loosening of the femoral stem, periprosthetic osteolysis, or other factors resulting in fracture even after low-energy falls.[15] Symptoms: Pain and loss of function dominates the clinical picture. |
| Wear | 1%-10% | Mechanism: Increased wear of bearing surfaces is associated with a higher incidence of osteolysis.[16] Symptoms: Associated symptoms are those of lysis/aseptic loosening. |
| Other | 5% | These include component failure/fracture, malalignment, incorrect sizing, leg length discrepancy, and unreported reasons. |

*Range of reported proportions of revision procedures performed for this reason in consulted registries. Categories are not mutually exclusive, and definitions may vary across registries.

for revision surgery are summarized in Table 1. Despite the availability of advanced diagnostic techniques, unexplained pain is the reason for implant revision in approximately one of five patients, and research has shown that functional outcomes after revision surgery depend on a correct diagnosis before surgery.[17] These findings highlight the importance of a well-considered and effective preoperative diagnostic imaging workup. This review summarizes the emerging role of hybrid bone SPECT/CT imaging in the assessment of recurrent pain after hip arthroplasty.