Instructional Course Lecture

Differentiating Hip Pathology From Lumbar Spine Pathology: Key Points of Evaluation and Management

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Abstract

The diagnosis and treatment of patients who have both hip and lumbar spine pathologies may be a challenge because overlapping symptoms may delay a correct diagnosis and appropriate treatment. Common complaints of patients who have both hip and lumbar spine pathologies include low back pain with associated buttock, groin, thigh, and, possibly, knee pain. A thorough patient history should be obtained and a complete physical examination should be performed in these patients to identify the primary source of pain. Plain and advanced imaging studies and diagnostic injections can be used to further delineate the primary pathology and guide the appropriate sequence of treatment. Both the surgeon and the patient should understand that, although one pathology is managed, the management of the other pathology may be necessary because of persistent pain. The recognition of both entities may help reduce the likelihood of misdiagnosis, and the management of both entities in the appropriate sequence may help reduce the likelihood of persistent symptoms.

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Hip and lumbar spine pathologies often occur in combination, which may result in substantial disability.[1-3] Patients with both hip and lumbar spine pathology commonly have low back pain (LBP) with associated buttock, groin, thigh, and, possibly, knee pain. The diagnosis and treatment of these patients may be a challenge because overlapping symptoms may delay a correct diagnosis and, therefore, appropriate treatment.

Offierski and MacNab[4] originally described the term "hip-spine syndrome" in 1983. The authors classified hip-spine syndrome as simple, complex, secondary, or misdiagnosed. In patients with simple hip-spine syndrome, the primary source of symptoms is clear despite coexistent hip and lumbar spine pathologies. In patients with complex hip-spine syndrome, however, no clear source of symptoms is known despite a detailed physical examination. Patients with complex hip-spine syndrome require additional diagnostic tests, including diagnostic injections. In patients with secondary hip-spine syndrome, both pathologies are interdependent, and the symptoms of one region are secondary to the pathology of the other. The authors reported that flexion contracture of the hip that results in compensatory hyperlordosis of the lumbar spine, which causes foraminal stenosis, especially at L3-4, is an example of secondary hip-spine syndrome. Similarly, scoliosis that causes pelvic obliquity and acetabular tilt may result in uncovering of the femoral head. In patients with misdiagnosed hip-spine syndrome, the primary source of pain is incorrectly diagnosed, which results in inappropriate, expensive treatment.

Unsurprisingly, hip and lumbar spine pathologies may mimic one another. Several studies have reported on the source of referred hip pain, which includes all lumbar nerve roots via the sciatic, obturator, and femoral nerves.[5,6] Surgeons should understand how to perform a comprehensive evaluation of and appropriately treat patients with potential hip and lumbar spine pathologies.

History

A thorough patient history is crucial to differentiate hip pathology from lumbar spine pathology. A thorough patient history begins with an assessment of the temporal onset, duration, severity, location, and character of the pain and the antecedent trauma. Surgeons must determine whether a patient has pain with activity, at rest, or both. Pain at night and the presence or absence of pain-free intervals may indicate a tumor or an infection. Traditionally, groin pain is associated with hip pathology, and buttock and back pain is associated with lumbar spine pathology; however, overlap exists between hip and lumbar spine pathologies. Pain from hip osteoarthritis (OA) can be localized to the groin (84%), buttock (76%), anterior thigh (59%), posterior thigh (43%), anterior knee (69%), shin (47%), and calf (29%).[7,8] In general, difficulty with putting on shoes or getting in and out of a car are associated with hip pathology. A burning or electric character to pain may be more suggestive of lumbar spine pathology, especially if accompanied by a nerve-root signature or associated numbness or weakness. The ability of a patient to ambulate with a forward posture, which is known as the shopping cart sign, or improvement in pain in a sitting position may indicate lumbar stenosis. The inability of a patient to lie on his or her side is likely caused by trochanteric bursitis rather than lumbar radiculopathy or intra-articular hip pathology. Clicking, snapping, or pain with movement of the hip likely indicates intra-articular hip pathology. Some patients may describe hip pain in which he or she grasps the lateral aspect of the hip with his or her thumb and index finger in the groin (C-sign). Changes in posture may highlight potential psoas pathology if pain is felt in the groin and thigh or spinal instability if pain is felt in the lower back. A history of startup groin pain (ie, pain that usually improves after 5 to 10 steps and then gradually returns) may indicate a loose total hip arthroplasty (THA) component. Startup back or buttock pain may indicate spinal instability.

Physical Examination

The physical examination of a patient with potential hip and lumbar spine pathologies should include inspection and palpation of the affected areas, an observation of gait, and a comprehensive hip and spinal evaluation. Surgeons should observe a patient's posture, muscle atrophy, previous surgical scars, limb-length discrepancy, pelvic obliquity, and lower limb and spinal alignment (coronal, sagittal, and rotational). If a limb-length discrepancy exists, blocks should be placed under the patient's short leg to obliterate pelvic obliquity before observing spinal alignment. The forward bend test should be performed to assess spinal rotational deformity; in a patient's attempt to achieve extension, pain may indicate lumbar stenosis or spinal instability. Palpation for areas of tenderness over the greater trochanter, sacroiliac joints, groin, buttock, and lumbar spine and evidence of step-off between spinous processes may be clues to the more likely pathology. An observation of a patient's gait may help surgeons assess for antalgic gait or the presence of an abductor lurch. Walking on the heels and toes may indicate subtle weakness as a result of L4 through S1 nerve involvement. The Trendelenburg test should be performed. Although a positive Trendelenburg test has been reported to indicate hip pathology, the Trendelenburg test also may be positive in patients with L5 radiculopathy as a result of the innervation of the gluteus medius and minimus.

Hip range of motion testing should be performed, assessing for loss of internal rotation with pain at terminal range of motion, which indicates hip pathology.[9-12] Groin pain and thigh pain have been reported in 55% and 57% of patients with hip pathology, respectively; however, buttock pain and pain distal to the

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Table 1

Common Provocative Tests for Hip and Lumbar Spine Pathologies

Provocative Test	Description	Common Pathologies
Straight leg raise test	The examined leg is raised with the knee extended.	Lumbar radiculopathy (lower lumbar nerves), with pain elicited from 30° to 60°
Contralateral straight leg raise test	The contralateral leg is raised with the knee extended.	Lumbar radiculopathy (lower lumbar nerves), with pain elicited in the other leg from 30° to 60°
Femoral nerve stretch test	With the patient in the supine position, the hip is extended and the knee is flexed.	Lumbar radiculopathy (upper lumbar nerves)
Thomas test	In the supine position, the patient grabs one knee and flexes it to the chest. The test is positive if the examined leg does not extend fully.	Hip flexion contracture of the examined leg
Ober test	With the patient lying on the unaffected side and the knee flexed to 90°, the symptomatic hip is brought from abduction to adduction.	Iliotibial band tightness
Anterior impingement test (FADIR test)	Hip flexion to 90°, with forced internal rotation and adduction	FAI, labral tear, or piriformis syndrome with groin pain
Posterior impingement test (FABER test)	Hip flexion, abduction, and external rotation	Sacroiliac joint dysfunction with buttock pain Intra-articular hip pathology (FAI) with anterior and lateral pain
Seated piriformis stretch test	With the patient in a seated position, flexion and adduction with the internal rotation test	A positive test, which recreates posterior pain at the level of the piriformis or external rotators, indicates possible sciatic nerve entrapment.
Active piriformis contraction test	The patient pushes the heel down into the table, abducting and externally rotating against resistance as the examiner monitors the piriformis.	Pain and weakness may indicate sciatic nerve entrapment.
Trendelenburg test	With the patient standing on one leg, the opposite hemipelvis drops.	Weakness of gluteus medius on the standing leg

FABER = flexion, abduction, external rotation; FADIR = flexion, adduction, internal rotation; FAI = femoroacetabular impingement

knee have been reported in 71% and 22% to 47% of patients with hip pathology, respectively.[5] The sensitivity and specificity of groin pain for hip dysfunction has been reported to be 84.3% and 70%, respectively. On physical examination, patients with pain caused by hip pathology are seven times more likely to have a limp and report groin pain and are 14 times more likely to have limited internal rotation compared with patients with pain caused by lumbar spine pathology.[9]

A thorough neurologic examination of the upper and lower extremities for upper motor neuron signs is crucial. Several provocative tests can help clarify whether symptoms are caused by hip or lumbar spine pathology (Table 1). Positive provocative tests that likely indicate lumbar spine pathology include the straight leg raise, contralateral straight leg raise, and femoral nerve stretch tests. Surgeons should observe patients with hip flexion contracture, which may result in a false-positive femoral nerve stretch test. Positive provocative tests that likely indicate hip pathology include hip impingement tests, such as the FADIR (flexion, adduction, internal rotation) test or the FABER (flexion, abduction, external rotation) test; the snapping iliopsoas test; and instability tests. Compression at the sacroiliac joint and a positive FABER test may indicate sacroiliac joint arthritis.

Diagnostic Tests

Plain radiography is the first-line imaging modality that should be performed to determine the likely source of pathology. AP radiographs of the pelvis and cross-table lateral radiographs should be obtained in patients in whom hip OA is suspected. In addition to standing AP radiographs of the pelvis, 45°- or 90°-Dunn lateral or frog-lateral radiographs of the hip are useful to assess for femoral head asphericity, and false-profile radiographs are useful to assess for acetabular dysplasia. Radiographs of the spine should be obtained with the patient in a standing position, depending on pathology. If lumbar spine pathology is suspected, AP and lateral radiographs should be obtained; however, lateral flexion-extension radiographs can help identify instability or spondylolisthesis. If spinal malalignment is present, 36-inch AP and lateral standing radiographs should be obtained to assess alignment from the femoral heads to the lower cervical spine.

Although MRI and CT can help differentiate hip pathology from lumbar spine pathology, they are not first-line imaging modalities. MRIs of the spine can demonstrate nerve-root compression, epidural lesions, infection, disk and soft-tissue pathology in the lumbar spine, and the paraspinal muscles (including the psoas muscles). MRIs of the hip (± MRI arthrograms or delayed gadolinium-enhanced MRIs of cartilage) can demonstrate chondrolabral pathology, cartilage lesions, the ligamentum teres, and extra-articular soft-tissue pathology. CT scans of the lumbar spine aid in the evaluation of fusion, spondylolysis, stress fractures, or bony tumors and can be used in combination with CT myelograms for patients in whom MRI is contraindicated. Three-dimensional CT reconstructions of the hip allow surgeons to better assess for camshaft and pincer deformities, acetabular morphology, and suspected femoral neck stress fractures. CT scanograms can be used to assess for femoral rotational deformities. Care should be taken to correlate a patient's diagnostic tests with his or her history and physical examination because positive findings increase with patient age.

If the etiology of a patient's pain remains unclear or coexistent hip and lumbar spine pathologies are suspected, additional information may be required. Electrophysiologic studies can help differentiate radiculopathy from peripheral nerve disorders, such as neuropathy, if other diagnostic tests are equivocal. Normal electrophysiologic findings do not eliminate the possibility of radiculopathy.[13,14] Leriche syndrome, which is a form of internal iliac artery stenosis, can result in buttock and thigh pain. In patients with vascular claudication, symptoms typically are relieved with standing alone and may be located below the knees.[15] Patients with vascular claudication may have diminished pulses, skin discoloration, and loss of extremity hair. Vascular studies, including the ankle-brachial index, duplex ultrasonography, and magnetic resonance angiography, can help rule out peripheral vascular diseases. Selective nerve-root injections (transforaminal), epidural injections, and intra-articular hip injections can be used as a diagnostic or therapeutic modality. Hip injections have an 87% sensitivity and a 100% specificity for hip pathology and can help predict the success of surgical interventions such as THA.[16-18] The sensitivity of epidural steroid injections for lumbar spine pathology in the setting of hip-spine syndrome has been less well defined.[6]

Differential Diagnosis

The development of differential diagnoses for hip, spine, and other pathologies is based on the principles of probability and importance (Table 2). More common pathologies, such as hip OA or lumbar radiculopathy, are more probable in patients who have back and lower extremity pain. However, some pathologies, such as tumors, stress fractures, and infections, cannot be missed because they may result in substantial consequences, although these pathologies are less probable in patients with back and lower extremity pain.

Hip Pathology

Arthritic Hip Pathology

Hip OA is diagnosed as either primary or secondary as a result of entities such as gout, chondrocalcinosis, or hemochromatosis. Often, hip OA occurs in combination with lumbar stenosis and back pain (Figure 1). Studies have reported that patients with persistent back pain after THA who undergo management of the lumbar spine have improved symptoms.[19-22] Other studies have reported the resolution of back pain after the management of hip disease in patients undergoing THA or arthroscopic hip surgery, such as that for the management of a labral tear.[23-25]

In a study of 25 patients with hip OA and LBP who underwent THA, Ben-Galim et al[23] reported improvement in both hip and back scores at a follow-up of 2 years. In a retrospective study of 3,206 patients with hip OA (566 of whom also had LBP) who underwent THA, Prather et al[24] reported that, although all of the patients had improved pain and hip scores, the patients without LBP had greater improvement in function and pain relief, incurred fewer medical charges per episode of care, and spent fewer days in the hospital per episode of care compared with the patients who had LBP. In a study of 113 patients with pain extending into the back (21%), shin (7%), and calf (3%) who underwent THA, Hsieh et al[26] reported complete pain relief in 110 of the patients within 12 weeks postoperatively. In a study of 344 patients with hip OA (170 of whom also had LBP) who underwent THA, Parvizi et al[25] reported on the resolution of LBP in 66.4% of the 170 patients in whom it was noted preoperatively. Conversely, LBP developed in 20% of the 174

Table 2

Differential Diagnoses for Hip, Spine, and Other Pathologies That May Mimic One Another

Intra-articular Hip Pathologies	Extra-articular Hip Pathologies	Spinal Pathologies	Other Pathologies
Hip osteoarthritis	Stress fracture	Lumbar stenosis with or without spondylolisthesis	Sacroiliac joint pathology
Septic arthritis	Greater trochanteric bursitis	Lumbar disk herniation	Sciatic nerve tumor
Stress fracture	Iliotibial band tendinitis	Foraminal stenosis	Intrapelvic tumors
Osteonecrosis	Gluteus medius or gluteus minimus tear	Facet cyst	Insufficiency fracture of the sacrum
Failed total hip arthroplasty	Iliopsoas tendinitis	Nerve-root sheath tumor	Peripheral vascular diseases (including Leriche syndrome)
Labral tear	Coxa sultans (internal or external snapping hip)	Spondylolysis and isthmic spondylolisthesis	Osteitis pubis
Femoroacetabular impingement	Piriformis syndrome	Iatrogenic causes (ie, misplaced pedicle screw)	Paget disease
Loose bodies (synovial chondromatosis, pigmented villonodular synovitis, osteochondritis dissecans)	Subgluteal space syndromes (deep gluteal, hamstring pathology, pudendal nerve, and ischiofemoral impingement)	Sagittal spinal malalignment	Peripheral neuropathy
Chondral damage	Adductor strain	Psoas pathology (abscess, hematoma, malpositioned hardware, transpsoas approach)	Shingles
Capsular laxity	—	—	Meralgia paresthetica
Ligamentum teres rupture	—	—	Sports hernia

patients in whom it was not noted preoperatively within 1 year postoperatively, which suggests that the management of hip pathology may exacerbate lumbar spine pathology. In a study of a cohort of patients who had exacerbated lumbar spine symptoms after THA, McNamara et al[19] reported improved symptoms in the patients who underwent decompression. Pritchett[27] reported that 21 patients with lumbar stenosis who underwent THA had foot drop postoperatively. Therefore, decompression of symptomatic severe lumbar stenosis occasionally is recommended before THA.

Nonarthritic Hip Pathology

Femoroacetabular Impingement and Labral Tears

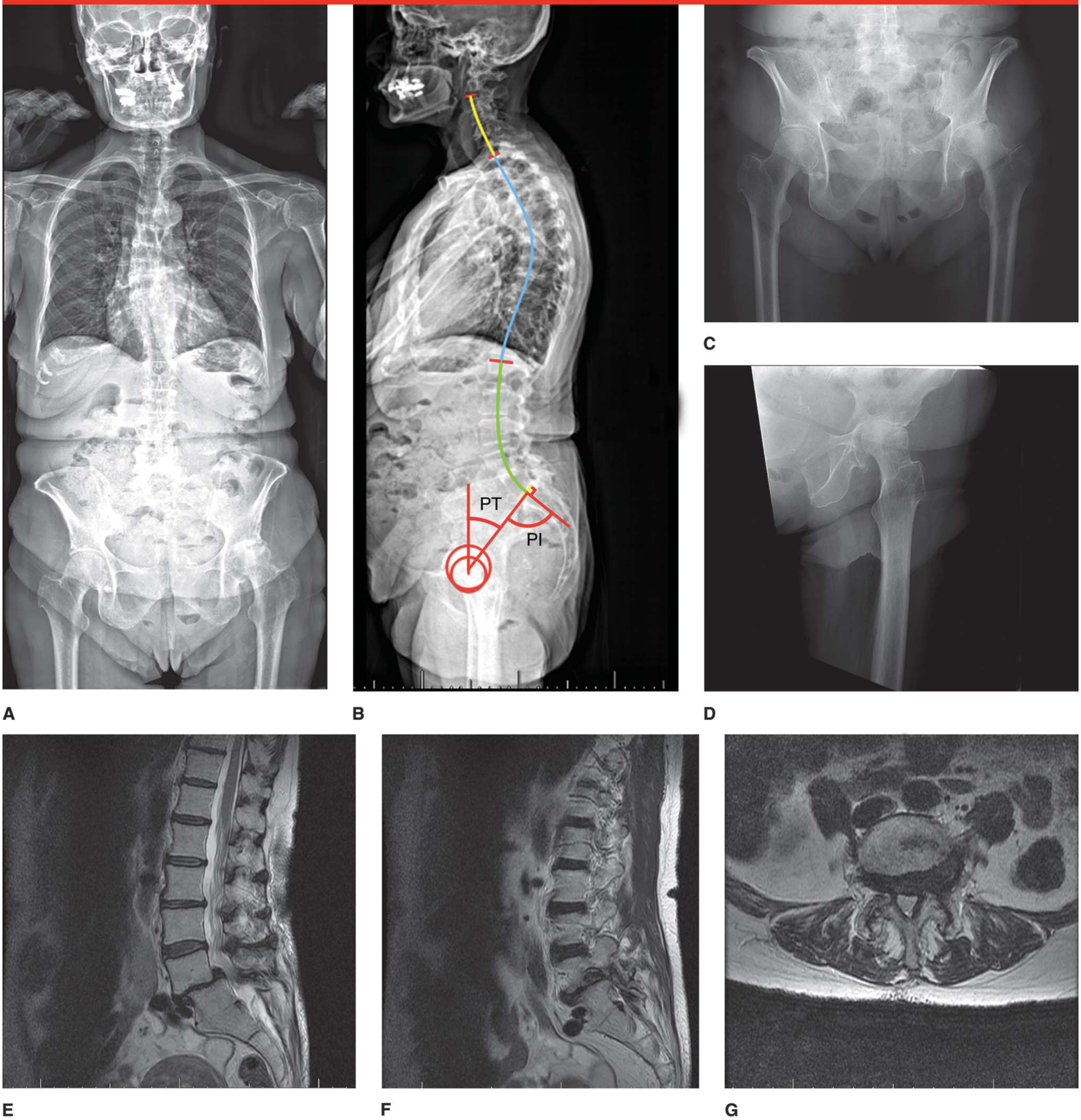
Femoroacetabular impingement (FAI) refers to altered geometry of the proximal femur and/or acetabulum, which leads to a conflict between the femoral neck and acetabular rim. Long-standing symptomatic FAI may result in labral tears and, subsequently, intra-articular chondral damage and early-onset OA. Camshaft impingement results from femoral head-neck junction abnormality, which affects the acetabulum. Pincer impingement results from acetabular overcoverage. Coexistent pathology is common in patients with FAI.

Clohisy et al[3] and Burnett et al[28] described the standard physical examination for patients in whom FAI is suspected, which includes hip range of motion, anterior impingement (FADIR test), and posterior impingement (FABER) tests. Isometric strength testing and a gait analysis are the mainstays of a comprehensive physical examination. Groin pain has been reported in as many as 92% of patients with FAI, and a positive anterior impingement test has been reported in as many as 88% of patients with FAI. Lateral hip pain, buttock pain, knee pain, and LBP have been reported in as many as 67%, 29%, 27%, and 23% of patients with FAI, respectively. Imaging studies that should be obtained in patients in whom FAI is suspected include plain radiographs and MRI arthrograms. Studies have reported that the intra-articular injection of bupivacaine during magnetic resonance arthrography is 92% sensitive, 97% specific, and 90% accurate for the diagnosis of FAI.[29-32] MRI can be used to assess asphericity (α angle) of the femoral head.

Greater Trochanteric Pain Syndrome

Greater trochanteric pain syndrome includes disorders that cause pain

Figure 1



AP (**A**) and lateral (**B**) radiographs of the spine demonstrating pelvic tilt (PT) of 36°, pelvic incidence (PI) of 89°, lumbar lordosis of −59°, and pelvic incidence-lumbar lordosis of 30° in a 75-year-old woman who had low back pain with associated left groin, lateral thigh, and knee pain. In panel **B**, the yellow line indicates cervical spine alignment, the blue line indicates thoracic spine alignment, and the green line indicates lumbar spine alignment. AP radiograph of the pelvis (**C**) and lateral radiograph of the left hip (**D**) demonstrating avascular necrosis of the left femoral head with collapse and secondary arthritis of the left hip. Midline sagittal T2-weighted MRI of the lumbar spine (**E**), left of midline sagittal T2-weighted MRI of the lumbar spine (**F**), and axial T2-weighted MRI of the lumbar spine through L4-5 (**G**) showing broad-based disk herniation with moderate to severe central and lateral recess lumbar stenosis. The patient was diagnosed with left hip osteoarthritis and L4-5 spondylolisthesis in combination with lateral recess and L4-5 foraminal stenosis left of midline. The patient underwent total hip arthroplasty of the left hip and had substantial pain relief in her back and lower extremity.

over the lateral hip, including trochanteric bursitis, external snapping hip, and gluteus minimus/medius dysfunction (tendinopathy/tears). Classic findings of greater trochanteric pain syndrome include pain with palpation over the lateral hip, a positive Ober test, the Trendelenburg sign, a Trendelenburg gait, and advanced abductor dysfunction. Hip abduction weakness and pain with resisted external rotation or pain with standing on one leg also are key physical examination findings of greater trochanteric pain syndrome. In a study of 24 patients with refractory greater trochanteric pain syndrome, Bird et al[33] reported that gluteus medius tears were observed on the MRIs of 45.8% of the patients.

Coxa Saltans (Snapping Hip Syndrome)

Internal snapping syndrome refers to the abrupt snapping of the iliopsoas tendon over the iliopectineal eminence as the hip moves from flexion into extension, which is accompanied by an audible snap, apprehension, and groin pain. External snapping syndrome refers to the snapping of the iliotibial band over the greater trochanter as the hip moves from extension into flexion. External rotation of the leg in extension followed by internal rotation of the hip as it moves into flexion can accentuate the snapping. Trochanteric bursitis is common in patients with snapping hip syndrome as a result of the thickened, tight iliotibial band.

Subgluteal Space Syndromes

Subgluteal space syndromes include deep gluteal syndrome, hamstring pathology, pudendal nerve impingement, and ischiofemoral impingement.[34,35] The subgluteal space is bordered by the posterior aspect of the femoral neck and is located anterior to the gluteus maximus, lateral to the linea aspera, and medial to the sacrotuberous and falciform fascia below the sciatic notch. Deep gluteal syndrome involves sciatic nerve entrapment, which is most commonly caused by the piriformis and results in diffuse buttock or posterior thigh pain and occasional radiating symptoms. A positive seated piriformis stretch test and a positive active piriformis contraction test are key physical examination findings of deep gluteal syndrome. Ischiofemoral impingement refers to the narrowing of the ischiofemoral space between the lesser trochanter and the ischial tuberosity. Patients with ischiofemoral impingement have atypical groin and/or posterior buttock pain, and pain in these patients is reproduced via a combination of hip extension, adduction, and external rotation. MRIs of patients with ischiofemoral impingement often demonstrate narrowing of the ischiofemoral space and an abnormal signal or edema in the quadratus femoris muscle.[36]

Stress Fractures

Stress fractures are classified as insufficiency fractures or fatigue fractures. The femoral neck is the most common site of stress fractures. A stress fracture should be suspected in long-distance runners; patients with metabolic bone diseases; patients being treated with long-term diphosphate therapy; and patients who report groin, thigh, or knee pain. Pain in patients with a stress fracture is worse with weight bearing and improves with periods of rest. Technetium TC-99m bone scan and MRI are imaging modalities that are sensitive for the diagnosis of stress fractures.

Painful Total Hip Replacement

Several unique factors must be considered in patients with pain after THA. In most of these patients, a thorough history with regard to the surgery, the perioperative period, and the patient's recent health; a complete physical examination; and appropriate imaging studies will allow surgeons to correctly identify the source of pain. Early-onset pain may indicate an infection, instability of the implant, or heterotopic ossification. Late-onset pain may indicate an infection, synovitis, metallosis, osteolysis, instability or loosening of the implant, inadequate hip biomechanics (eg, inadequate offset, limb-length discrepancy), or soft-tissue (psoas, rectus femoris) inflammation or impingement. Acetabular loosening commonly results in groin pain and buttock pain. Thigh and or knee pain may be caused by femoral loosening. Activity-related pain or startup pain are caused by component instability. Plain radiographs always are indicated in patients with pain after THA. Serial radiographs allow surgeons to assess changes in implant positioning, which may help isolate the source of pain. More advanced imaging studies, such as MRI, CT, and nuclear imaging, allow for a more detailed evaluation and should be obtained in patients in whom the source of pain is unclear. Laboratory studies (eg, complete blood count, erythrocyte sedimentation rate, C-reactive protein levels) and hip aspiration should be obtained in patients in whom they are warranted.

Lumbar Spine Pathology

Radiculopathies

Radicular pain may mimic referred hip pain in the groin, thigh, or buttock. Radiculopathy from the L1 through L3 nerve roots is more likely to mimic referred hip pain in these areas; however, L5 radiculopathy may result in referred pain in the buttock, lateral aspect of the hip, and thigh. L5 radiculopathy may mimic meralgia paresthetica. Radiculopathy may occur as a result of several pathologies, including disk herniation, spondylolisthesis, foraminal stenosis, iatrogenic injury (ie, misplaced pedicle screw), facet cysts, or nerve sheath tumors. Typically, patients with radiculopathy report an electric character to lower extremity pain, which may be worse in a sitting position, in a standing position, or with a change in posture; however, the pain may not always have a nerve-root signature. Motor weakness, sensory deficits, and absent reflexes likely indicate radiculopathy rather than hip pathology. The straight leg raise test and the contralateral straight leg raise test are specific but less sensitive for the diagnosis of radiculopathy from the L4 through S1 nerve roots, and the femoral nerve stretch test is a provocative test for the diagnosis of L2 and L3 radiculopathy. Imaging studies that can be obtained to confirm radiculopathy include MRI, CT myelography, and/or electromyography. A diagnostic or therapeutic nerve-root block can be performed to further confirm radiculopathy; however, Saito et al[6] reported that nerve-root blocks mask hip pathology by interfering with sensory nerve pathways.

Neurogenic Claudication

Neurogenic claudication can manifest as buttock and posterior thigh pain with ambulation; however, patients with neurogenic claudication also may have thigh and leg aching or heaviness/weakness with ambulation, which are symptoms similar to those of patients with hip OA. Lumbar stenosis, with or without spondylolisthesis, is the underlying pathology in patients with neurogenic claudication. Vascular claudication must always be ruled out. Although patients with neurogenic claudication may have decreased ambulation tolerance as a result of leg pain, patients with lumbar stenosis can continue to ambulate by leaning forward with an ambulatory support, which is known as the shopping cart sign. Trochanteric bursitis is common in patients with lumbar stenosis and spondylolisthesis; therefore, it must be considered in the differential diagnosis.

Spondylolysis and Isthmic Spondylolisthesis

Typically, spondylolysis occurs in young athletes, especially those who participate in sports that require repeated hyperextension of the lumbar spine. Patients with spondylolysis have unilateral or bilateral LBP that may radiate to the buttock. The pain may improve with periods of rest, with bracing, or by avoiding hyperextension. Oblique lumbar radiographs may demonstrate a pars defect; however, CT often is required to confirm a diagnosis of spondylolysis. Pars defects can be active or inactive; therefore, technetium bone scans or single photon emission CT scans should be obtained. Selective injection of a pars defect can help surgeons determine if the lesion is substantial.

Isthmic spondylolisthesis refers to an anterior translation of the cephalad vertebra in patients with a pars defect. Patients with unstable isthmic spondylolisthesis may report startup pain when they first get out of a bed or stand up from a chair that improves after a period of walking. Radiculopathy as a result of foraminal stenosis is common in patients with isthmic spondylolisthesis. Standing, flexion-extension radiographs of the lumbar spine can aid in the evaluation of subtle instability.

Sacroiliac Joint Pathology

Patients with sacroiliac joint pathology may have unilateral or bilateral buttock pain. Typically, pain is worse with walking down a hill and with a tight belt. Physical examination findings of sacroiliac joint pathology include tenderness to palpation, pain with compression over the sacroiliac joint, and a positive FABER test. The FABER test also may be positive in patients with posterior chondrolabral pathology of the hip. A sacroiliac joint injection can aid in differentiating posterior chondrolabral pathology of the hip from other hip pathology and lumbar spine pathology.

Psoas Pathology

Psoas pathology can manifest as groin and thigh pain and weakness on hip flexion. Causes of psoas pathology include psoas abscess, hematoma, malpositioned devices (ie, pedicle screw), and the transpsoas approach for lumbar fusion. Patients with psoas pathology may report difficulty in standing up from a chair or pain with full hip extension. Physical examination findings of psoas pathology include pain with resisted flexion and a positive psoas stretch test. MRI with contrast and laboratory tests (eg, erythrocyte sedimentation rate, C-reactive protein level, complete blood count) are useful to assess for a suspected abscess, and CT is useful to assess for malpositioned devices.

Sagittal Spinal Deformity

Adult degenerative scoliosis, which includes sagittal spine deformity (SSD), is a common pathology that affects 60% of individuals aged >65 years.[37] SSD may result in substantial pain and disability.[38,39] Hip OA is common in many patients with SSD. Although SSD is most commonly degenerative, it also may result from a fracture, Scheuermann kyphosis, spondylolisthesis, iatrogenic flatback, or neuromuscular disorders. Patients with SSD use several compensatory mechanisms, including lordosis of flexible spine segments, increased pelvic tilt (posterior tilt), posterior pelvic shift, and hip and knee flexion, in an attempt to stand in an upright position[40] (Figure 2). The abnormal mechanics of the gluteal muscles, paraspinal muscles, and quadriceps may result in back, buttock, and thigh pain. A fixed flexion deformity of the hip may prevent a patient from using hip extension to compensate for SSD. The pelvis is the common vital entity in SSD and hip OA.

Pelvic tilt can be measured using two different methods; however, the relationship of the two methods has yet to be defined (Figure 3). Pelvic tilt can be determined by measuring the angle between the anterior pelvic plane (from the anterior superior iliac spine to the pubic symphysis)[41] and a vertical line to the floor. Hip arthroplasty surgeons favor this method for the measurement of pelvic tilt because subcutaneous landmarks of the anterior pelvic plane aid in acetabular component orientation. However, the accuracy of the anterior pelvic plane has been called into question because of variable overlying soft tissues. Alternatively, pelvic tilt can be determined by measuring the angle between the plane from the bicoxofemoral axis to the center of the sacral plate and a vertical line to the floor. This method for the measurement of pelvic tilt has been reported to correlate with preoperative and postoperative health-related quality-of-life scores in patients with adult spine deformity. Spine surgeons aim for <20° of pelvic tilt in patients who undergo a spinal realignment procedure.

Acetabular anteversion is altered by the position of the pelvis. A reduction in pelvic tilt (anterior tilt) will functionally retrovert the acetabulum. Conversely, an increase in pelvic tilt (posterior tilt) will functionally antevert the acetabulum. A 1° increase in pelvic tilt (posterior tilt) will result in a 0.7° increase in functional acetabular anteversion[42,43] and a nonlinear increase in functional inclination.

Pelvic tilt changes with posture. Several studies have suggested that pelvic tilt is similar in the supine and standing positions; however, this is not true in patients with SSD, and, therefore, supine radiographs of the pelvis in patients with SSD may not indicate the true functional position of the pelvis. In a sitting position, pelvic tilt increases approximately 22°,[44] and acetabular anteversion increases approximately 15° (Figure 4). This increase in acetabular anteversion improves posterior coverage of the femoral head, which reduces the risk for dislocation and prevents anterior femoroacetabular implant impingement. Spinopelvic fusion eliminates the flexibility of the lumbar spine and a patient's ability to alter pelvic tilt during postural changes.[45] Similarly, a patient with increased pelvic tilt as a result of SSD will have less postural variation in pelvic tilt. Although a fixed flexion contracture may theoretically prevent a patient from increasing pelvic tilt to compensate for SSD and result in decompensation of a patient's SSD, pelvic tilt has not been reported to substantially change after THA.[46,47] We cannot recommend THA as a surgical method to improve sagittal spine posture.

Pelvic tilt and acetabular anteversion increase as the severity of a patient's SSD increases. In a study of 33 patients (41 hips) with adult spine deformity who underwent spinal deformity correction, Buckland et al[48] reported that excessive acetabular prosthetic anteversion (>25°) was observed on the preoperative standing radiographs of 68% of the hips (Figure 5). Excessive acetabular prosthetic anteversion likely accounts for the increased risk for anterior dislocation in patients with ankylosing spondylitis[49] and may result in edge-loading, ceramic squeak, and increased bearing surface wear. The goal of spinal deformity correction is to increase lumbar lordosis and reduce pelvic tilt via instrumentation and fusion. Acetabular anteversion decreases as pelvic tilt decreases (Figure 5). Buckland et al[48] reported that the surgical realignment of SSD resulted in a mean

Figure 2

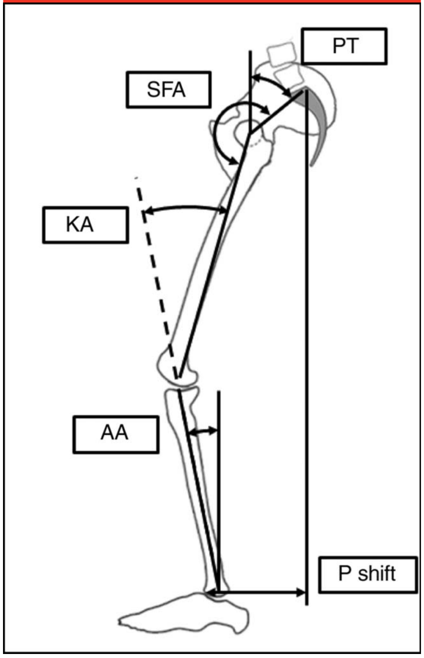
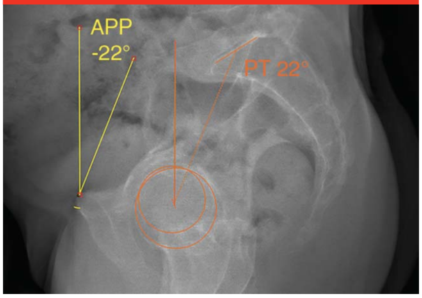


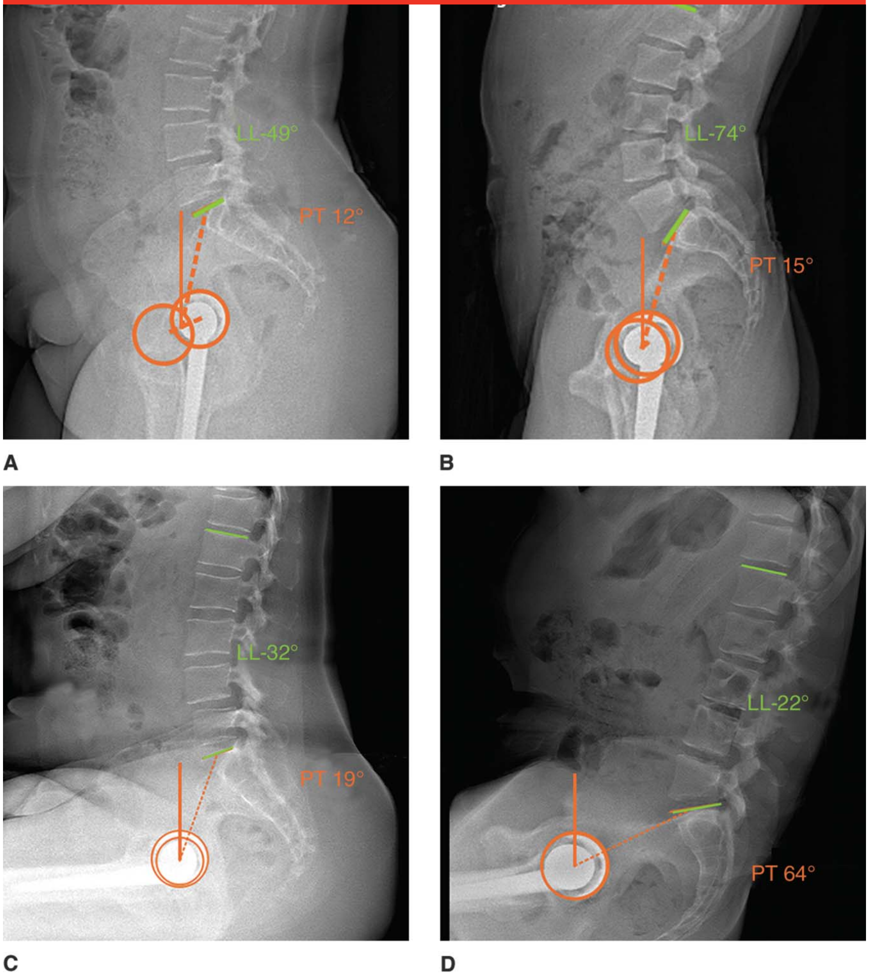
Illustration of a lower extremity showing how lower limb compensatory mechanisms that are used by patients who have a sagittal spine deformity are measured. Pelvic tilt (PT) is the angle between a line drawn from the center of the femoral head to the midpoint of the sacral plate and a vertical line to the floor. Posterior pelvic shift (P shift) is the offset between a vertical line from the posterosuperior corner of the sacral end plate to the floor and anterior cortex of the distal tibia. The sacrofemoral angle (SFA), which measures hip extension, is the angle between a line drawn from the middle of the sacral end plate to the center axis of the hip and a line drawn from the center axis of the hip to the femoral axis. The knee flexion angle (KA) is the angle between the mechanical axis of the femur and the mechanical axis of the tibia. The ankle flexion angle (AA) is the angle between the mechanical axis of the tibia and a vertical line to the floor.

Figure 3



Lateral radiograph of a pelvis demonstrating that pelvic tilt (PT) can be determined by measuring the anterior pelvic plane (APP; denoted in yellow) or the position of the sacrum relative to the center of the hip (denoted in orange). (Reproduced with permission from Buckland AJ, Vigdorchik J, Schwab FJ, et al: Acetabular anteversion changes due to spinal deformity correction: Bridging the gap between hip and spine surgeons. *J Bone Joint Surg Am* 2015;97[23]:1913-1920.)

Figure 4



Lateral radiographs of the pelvis in two different patients demonstrating changes in pelvic tilt (PT) between standing (**A** and **B**) and sitting (**C** and **D**) positions. Note that, in both patients, pelvic tilt increases in the sitting position as a result of decreasing lumbar lordosis (LL); however, the increase in pelvic tilt is different in each patient.

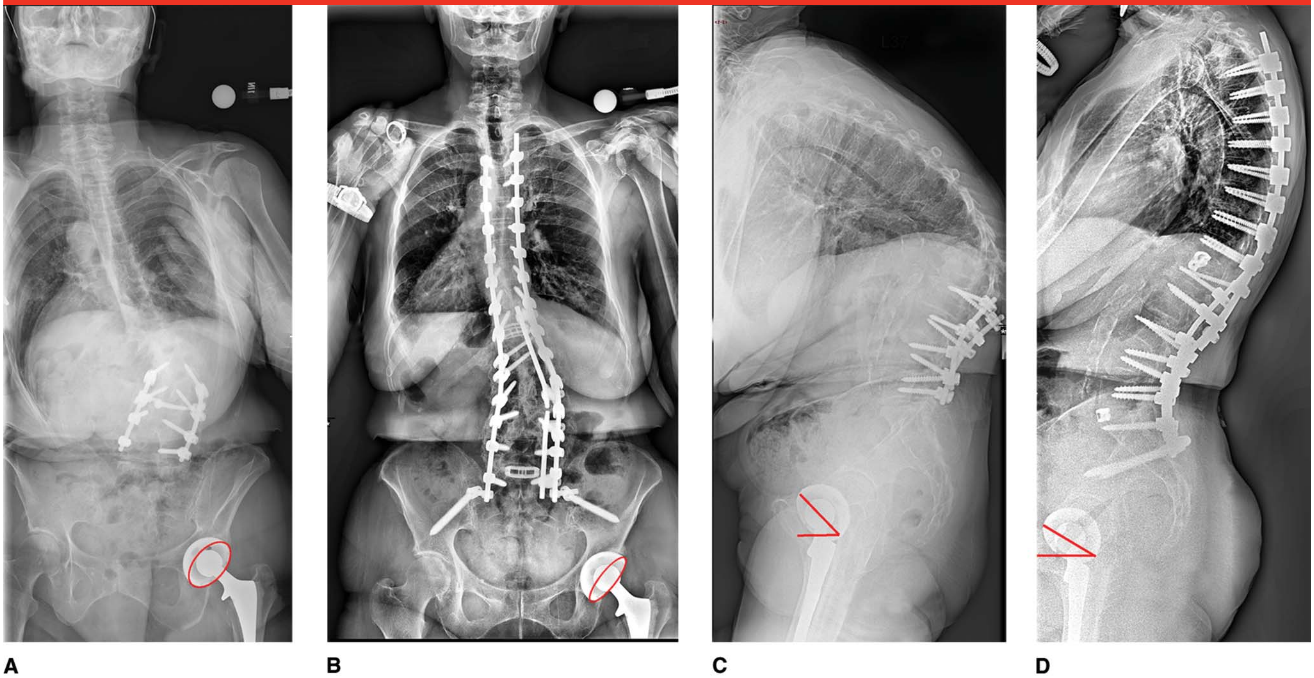
decrease in acetabular anteversion of 5°; however, the authors reported that acetabular anteversion can decrease as much as 23°. The authors also reported that an iatrogenic increase in lumbar lordosis of 3.2° or a reduction in pelvic tilt of 1.1° resulted in 1° of acetabular retroversion.

The decision of whether to perform a spinal realignment procedure or THA as the initial intervention in patients in whom hip and lumbar spine pathologies occur in combination is a challenge. A thorough patient history should be obtained and a complete physical examination of the spine and both of the hips should be performed to identify the primary source of a patient's pain. Patient preferences may guide whether the spine or the hip is managed first. If THA is being considered as the initial intervention in a patient with asymptomatic SSD, a pelvic tilt–adjusted acetabular orientation may help avoid excessive prosthetic anteversion.[50] If a spinal realignment procedure is likely to be performed after THA, the surgeon should consider the effect of the spinal surgery on the orientation of the acetabular component in the preoperative planning for THA. Spinal deformity correction should be performed before THA in patients in whom SSD is substantial and considerable spinal deformity correction is required.

Summary

In patients who have back and lower extremity pain, a systematic patient history and a comprehensive physical examination are necessary to identify the principal cause of pain. Diagnostic imaging studies and injections are used to further define the primary source of symptoms and guide the appropriate sequence of treatment. Although one pathology is managed, secondary causes of pain may need to be addressed if symptoms persist. The identification of both causes of pain may help reduce the likelihood of misdiagnosis and unnecessary treatment and, thus, reduce the likelihood of persistent symptoms.

Figure 5



Preoperative (**A**) and postoperative (**B**) AP radiographs and preoperative (**C**) and postoperative (**D**) lateral radiographs of a spine demonstrating changes in acetabular anteversion after sagittal spine deformity correction. Note that the size of the acetabular ellipse (red oval) in panel **A** is decreased after deformity correction (**B**), which indicates decreased anteversion. The ante-inclination of the acetabulum (red angle) in panel **C** also is decreased after deformity correction (**D**). (Reproduced with permission from Buckland AJ, Vigdorchik J, Schwab FJ, et al: Acetabular anteversion changes due to spinal deformity correction: Bridging the gap between hip and spine surgeons. *J Bone Joint Surg Am* 2015;97[23]:1913-1920.)

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