Early Hip Disorders: Advances in Detection and Minimally Invasive Treatment

Joseph C. McCarthy, MD,
Editor

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Early Hip Disorders

Advances in Detection and Minimally Invasive Treatment

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Cover illustration: The hip joint distracted with an arthroscope within. The three insets are representative hip pathologies seen with arthroscopy: loose body, labral tear, and synovial impingement (Courtesy of Dr. William Stillwell).

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Preface

This book is the outgrowth of a paradox. Despite quantum advances in radiologic imaging procedures during this generation, many patients with unremitting hip joint symptoms have remained without a specific diagnosis. At the fulcrum of this dilemma are the constraints of conventional magnetic resonance imaging techniques. Unlike the knee joint, where MRI accuracy for detecting meniscal tears is high, analogous MR sequences applied to the hip joint are not nearly as sensitive or specific. McCarthy and Busconi demonstrated, when comparing independent readings of MR images to arthroscopically confirmed labral tears, that the radiologic test had a less than 5% chance for visualizing the abnormality.[1] Several other authors have corroborated this finding.[2,3]

Fueling this paradox further, clinicians are increasingly averse to performing surgical interventions for diagnostic purposes. This is especially true in the hip. Conventional surgical approaches, such as the posterolateral approach often utilized during total hip replacement, may result in osteonecrosis of the unresected femoral head. Alternative methods, such as the anterolateral or transtrochanteric approach, may result in protracted muscle weakness or trochanteric nonunion. Other well-documented risks of open arthrotomy, such as heterotopic bone formation, neurovascular injury, deep vein thrombophlebitis, wound and joint infection have further made clinicians reticent about performing diagnostic arthrotomy. In addition, the inpatient stay associated with the open procedure is costly and commits the patient to an extended rehabilitation program.

Despite the previously noted limitations, patients are more active than ever before. They are living longer, are active physically and athletically later in life, and have higher expectations than previous generations. They are subjecting their hip joints to higher peak and torque loads through their activities or trauma. Thus it is not surprising that there are an increasing number of patients developing unremitting hip joint symptoms.

It is in this context that this book on advances in detection and treatment of early hip disease is so timely. The advent of arthroscopic, minimally invasive techniques to visualize the hip joint has greatly facilitated the understanding of articular cartilage injury and spawned the development of specific treatments.

The application of arthroscopic techniques to the hip joint has been a long time in coming. The relative depth of the hip when compared to other joints, the curvilinear contours of the articular surfaces, the thickness of the capsule, and the intra-articular negative joint pressure have all contributed to making the hip joint, until recently, appear inaccessible. However, improvements in distraction techniques, dedicated instruments for use in the hip, and developing surgical expertise have surmounted the anatomic constraints such that hip arthroscopy in skilled hands can now be performed safely as an outpatient procedure.

The 20 chapters in this book are divided into four principal sections. The first five chapters represent patient assessment. Because of the limitations of prior hip joint diagnostic techniques noted above, we have had to devise techniques that improve the clinician's diagnostic acumen in the office and in the radiology suite. The chapters in this section contain specific history and physical examination signs that are statistically correlated with the presence of labral tears and loose bodies. The advent of gadolinium-enhanced arthro-MRI scanning, pioneered by my collaboration with Dr. William Palmer of Massachusetts General Hospital and Dr. Arthur Newberg of New England Baptist Hospital, has greatly increased the radiologic sensitivity for detecting labral lesions.

Because of the extensive musculotendinous tissue envelope in which the hip resides, as well as the bony, chondral, synovial, and soft tissue lesions that occur, the chapter on treatment algorithms is especially useful, not only for orthopedists but also for primary care physicians and nurse practitioners.

The second major section focuses on operative preparation. Appropriate indications for arthroscopy, when conservative care has not resolved symptoms, are discussed. Patient safety is of utmost importance, and for that reason specific chapters are devoted to patient positioning, specific distraction principles, anesthesia considerations, and safe portal placement, with tools designed exclusively for the hip.

The third major section discusses specific pathologic entities within the hip, many of which were heretofore unrecognized. Many loose bodies, if unmineralized, are not well seen by CT or MRI but are readily identified and treated arthroscopically. Labral and chondral injuries unequivocally occur, provoke symptoms, and do not have healing potential; the importance of early recognition and treatment is thus underscored. Hip disease occurs in all age groups; thus the relevance of a chapter on pediatrics.

The final major section of this book addresses patient recovery and outcome. These factors are largely influenced by any surgical complications, thus a chapter on occurrence and avoidance. In addition, the hip requires not only smoothly functioning, contoured articular surfaces but also strong supporting musculature; thus a chapter is devoted to incremental rehabilitation. The proper indications for arthroscopic hip surgery can be assessed only in light of specific outcome analysis. Previous hip scoring systems have limited application because of their focus on end-stage arthritis and total joint replacement. The young, highly physically active patients who have arthroscopic intervention have required development of a statistically validated outcome scoring system. This system is discussed in chapter 19.

I am indebted to the 1400 patients who have entrusted me to arthroscope their hip joints. This privilege has allowed me to learn much about early hip disease. I will continue to devote my energies to further understanding even while developing improved treatment techniques. I hope that the readership finds this comprehensive treatise as informational and stimulating as I have found its preparation.

I am indebted to many people who have helped make this book possible. To my parents, who provided me with educational opportunities and intellectual zeal. To my teachers in the classes and science programs at the University of Notre Dame and Georgetown Medical School, who stimulated my mind and my soul and prepared me for a career in orthopedic surgery. To my orthopedic mentors at Tufts University, especially Henry Banks, who nurtured my education and trusted me with his patients. To Hugh Chandler at the Massachusetts General Hospital, whose surgical skills, personal wit, and passionate devotion to his patients I will forever emulate. To William Harris, my fellowship mentor, whose analytical dedication to every aspect of hip joint surgery will forever stimulate me. To my friends and colleagues at the New England Baptist Hospital, especially Roderick Turner and Benjamin Bierbaum, who entrusted me as a partner and collaborator. To the authors, whose curiosity, wisdom, and reflective skills were paramount in completing their work. Special thanks to my office staff, operating room staff, and the Tufts residents and Aufranc fellows whom I have the privilege of working with. To Jo-Ann Lee, whose professionalism, excellence in research, and attention to detail are an inspiration and ensured that this book would be completed. And to Rob Albano, Josh Pasternak, and the editorial staff at Springer-Verlag, who have handled every detail of narrative and visual material with patience, organization, and thoroughness.

Joseph C. McCarthy, MD

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Section I
The Painful Hip

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1
Assessment of the Painful Hip

Joseph C. McCarthy, Brian D. Busconi, and Brett D. Owens

Patients who present to a physician with hip pain will generally have a definable diagnosis based on a thorough history, physical examination, and radiologic evaluation. There exists a subset of patients, however, who develop intractable hip pain with reproducible physical findings yet escape a definitive diagnosis despite extensive noninvasive radiologic evaluation. This pain is often refractory to nonoperative management including rest, anti-inflammatory medications, and physical therapy. In this subset of patients, hip arthroscopy has the greatest potential value for diagnostic and potentially therapeutic purposes.

History

Of course, the first step in evaluation is an accurate history and physical. The history should focus on prior hip problems and the use of special braces during infancy and childhood. It is important to know if the patient has had prior hip surgery or trauma to the hip. Patients should be asked about increased or unusual activities in order to rule out stress fractures and overuse injuries. Patients should also be asked about alcohol use, steroids, and other medications, including nonsteroidal anti-inflammatory drugs (NSAIDs). They should be asked about what causes the pain to begin and what activities or medications tend to improve the pain. Patients should be queried regarding other systemic illnesses or a history of cancer.[1]

When a patient presents with hip pain, a thorough history is the initial and perhaps the most important interaction. The location, duration, frequency, and pattern or radiation of pain, as well as factors that improve or worsen it, are essential components of a thorough history. A patient who presents with acute onset of pain and stiffness will generate a completely different set of potential diagnoses and treatment algorithms.

Pain location is perhaps the most important factor in differentiating intra-articular from extra-articular causes of hip pain. Pain in any location from the lower back through the pelvic girdle and to the proximal thigh is often considered “hip pain.” True intra-articular hip pain will cause pain in the groin area with occasional radiation to the knee. Lateral thigh pain often is secondary to trochanteric bursitis, and buttock pain often is secondary to lumbar pathology. Pain radiating below the knee also generally indicates lumbar pathology.

Past medical, surgical, and developmental histories are also important components of a thorough examination of a patient with hip pain. Significant medical factors include a history of corticosteroid use, alcohol use, coagulopathies, collagen-vascular and inflammatory disorders, malignancies, and any chronic medical conditions. These can provide insight into conditions such as avascular necrosis, pathologic fracture or impending fracture, and the arthritides. It is also important to determine if any prior surgery was done in the pelvic region and if there was any prior trauma to the area. Developmental history can provide information regarding any childhood sepsis or dysplasia, either of which can cause adult hip discomfort.

Occupational and recreational histories are also important, as certain sports and activities (soccer, martial arts, rugby, marathon running) have been associated with an increased incidence of degenerative hip disease in comparison to the general population.[2–8] In addition, job satisfaction should be ascertained, as those dissatisfied with work may be less likely to return to their occupations after a minor injury.

A history of any potential trauma is important, as even a relatively minor injury can generate hip pathology. High-level athletes who develop intractable hip pain associated with their sports have demonstrated predictable pathology, with 92% having anterior labral tears and 80% having anterior labral tears with associated anterior acetabular chondral defects (watershed lesions).[9] Similar pathology has been found in patients who develop intractable hip pain after relatively minor trauma, with 98% having anterior labral tears and 58% having the “watershed lesion.”[1] Many of these patients sustained injuries in occupational settings. History can thus be predictive of injury pattern in certain circumstances.

A patient's symptoms can also provide clues to distinguish between mechanical and inflammatory conditions. Those with mechanical disorders, such as a torn labrum or loose bodies, will frequently complain of a painful click or unpredictable "locking" of the joint. They also frequently describe a "catching" sensation when moving from hip flexion to extension.[10] Both groups generally complain of anterior groin pain and stiffness, with limitations in motion. Those with inflammatory conditions may have more pain at rest and may have multiple joint involvement. Differentiating between intra-articular and extra-articular pathology can be difficult on history alone.

Physical Examination

A thorough physical examination, including a baseline temperature and vital signs, should be performed. Patients who complain of hip pain and are febrile need to be worked up aggressively in order to rule out hip pyarthrosis. Though hip infections are rare in skeletally mature individuals without a prior history of hip surgery, one must always consider this diagnosis, especially with the growing number of immunocompromised patients. Usually, pyarthrosis can be ruled out with a careful history and exam, but radiographs and laboratory studies are additionally helpful. Occasionally, a hip aspirate is required to eliminate the possibility of joint sepsis. Other rare causes of hip discomfort and fever include psoas abscess, prostatitis, pelvic inflammatory disease, and urinary tract infection.

The examination begins as the patient walks into the office, with assessment of gait pattern. Intra-articular hip disorders will be manifested by a Trendelenburg gait, but unfortunately some extra-articular causes can present with a similar gait pattern. The patient must be adequately undressed for proper examination. Inspection normally reveals a level pelvis. Pelvic obliquity suggests leg length discrepancy or scoliosis, which may or may not be associated with hip disease. Range of motion of the spine will help demonstrate any true spinal abnormality. This examination should include lumbar range of motion as well as motor, sensory, and reflex testing of the lower extremities. A straight leg raise, prone and supine, should also be performed to exclude nerve root irritation. An upper level lumbar herniated disc (L2–L3 or L3–L4) can produce pain radiating to the groin, thus mimicking hip pain. Contracture of the hip may cause a compensatory obliquity of the pelvis. If inspection of the pelvis is difficult because of the patient's size, palpation should be performed at the body prominences to determine position and symmetry.

Observe the resting posture of the hip. The ligaments of the hip are so oriented that pressure in the joint space is least when the hip is slightly flexed, abducted, and externally rotated. Therefore, patients with an acute synovitis or effusion tend to maintain the hip in this position. Trendelenburg's test is performed following inspection. The patient is asked to stand on one leg and lift the other leg with the hip and knee flexed. Normal patients will lift the pelvis contralateral to the stance limb. Patients with deficient abductor muscles or a hip disorder that causes pain on contraction of the muscles have an impairment of this normal mechanism. Consequently, these patients will allow the pelvis to drop contralateral to the stance phase side, or may shift the upper body over the stance phase leg to reduce muscular demand.

The groin should also be examined for inguinal and femoral hernias. The pubis also should be palpated to assess for tenderness, which may indicate a condition such as osteitis pubis or athletic pubalgia. Tenderness in the medial proximal thigh may indicate an adductor tendonitis that can also mimic true hip pain.

The hip examination consists of range of motion testing and provocative tests for intraarticular pathology. Patients with intra-articular and certain extra-articular hip disorders will have limitations in range of motion in comparison to the unaffected hip. Provocative tests for labral tears include moving the hip from a flexed, externally rotated, and abducted position to an extended, internally rotated, and adducted position to test for anterior pathology; and moving from a flexed, internally rotated, and adducted position to an extended, abducted, and externally rotated position to test for posterior pathology. If positive, these tests produce a painful click or cause the patient to complain of a painful searing sensation.[11]

The bony landmarks of the pelvis and femur also should be palpated. Lateral pain most commonly occurs with trochanteric bursitis, but one must beware of attributing all lateral pain to bursitis, as an occult femoral neck fracture can have a similar presentation, especially in an elderly patient. (Figure 1.1)

Unfortunately, intra-articular hip pathology such as labral tears, loose bodies, and chondral defects can still escape diagnosis on history and physical examination alone. Radiographic evaluation is necessary in all cases of hip pain, as it will aid in diagnosis for most common hip disorders.

Sources of Referred Pain

If the cause of hip pain is not clear, one should not forget to perform an abdominal examination to rule out both intra-abdominal and retroperitoneal sources for hip discomfort. The patient should be asked to Valsalva in order to rule out direct and indirect inguinal hernias that can sometimes masquerade as anterior groin pain.[12] Female patients who have hip pain of unspecified etiology often require referral to a gynecologist and a pelvic examination to rule out an ovarian cyst. An

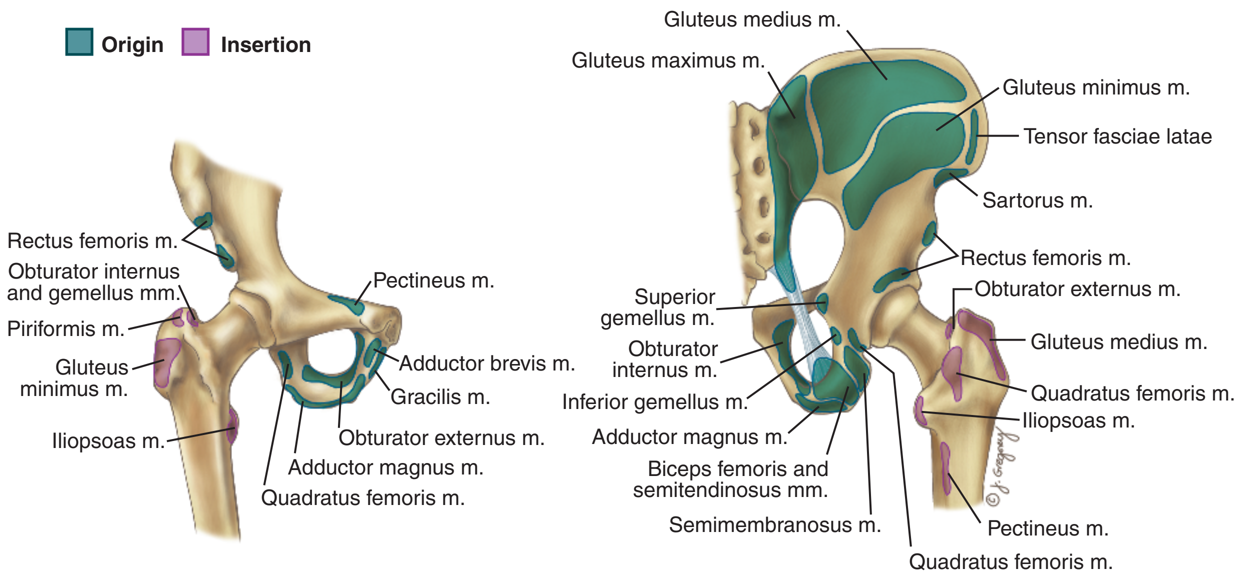

FIGURE 1.1. Anatomy drawing showing bony landmarks and muscle attachments of the hip and thigh.

adnexal mass can often be palpated on exam, and an ultrasound can confirm this diagnosis.[13] A patient with a femoral pseudoaneurysm can present with vague anterior groin discomfort that can be confused with hip pain. In these rare cases, the tender region will be pulsating and will often have a bruit. A careful history often reveals a previous cardiac catheterization or some trauma to the femoral artery or anterior groin.[14] Examination of the lower abdomen and flank should alert the physician to nephrolithiasis or pelvic inflammatory disease if either is present. These conditions can irritate the pelvic floor and cause pain radiating to the anterior groin.[15] In males the testicles should be examined in order to rule out epididymitis, prostatitis, urethritis, or a hydrocele.[16] A urinary tract infection can also present with hip pain, especially in female athletes who do not maintain adequate hydration.[17] These patients usually have itching and burning complaints as well as pain referred to the groin. As usual, the diagnosis is confirmed with a urinalysis and treated with hydration and antibiotics.

If the patient is noted to have a tender spine or decreased lumbar range of motion, radiographs of the thoracolumbar spine should be obtained, and the patient should be referred to a spine specialist if there are any positive findings. If the patient is noted to have an inguinal hernia, referral to a general surgeon would be most appropriate for confirmation of the findings as well as treatment. Patients thought to have an ovarian cyst should be examined and treated by a gynecologist. Patients with femoral aneurysms or pseudoaneurysms should be evaluated by a vascular surgeon. Additionally, a patient with pelvic inflammatory disease, nephrolithiasis, epididymitis, prostatitis, or a urinary tract infection will often have systemic signs and warrant evaluation in a primary care setting or perhaps an emergency room.

Radiographic Evaluation

Plain radiographs will be effective in diagnosing most intra-articular hip disorders. An anteroposterior (AP) radiograph allows for comparison between the two hips with respect to leg lengths, extent of degenerative arthropathy or dysplastic change, and possible bony lesions throughout the pelvis. A frog-leg lateral radiograph of the hip is useful in the diagnosis and staging of avascular necrosis. Plain radiographs are not useful in diagnosing labral tears, chondral defects, or unmineralized loose bodies.[10]

Fluid in the hip joint is best detected by ultrasonography. This is the preferred method in diagnosing arthritis of the joint. It is also valuable for diagnosing a child with a suspect transient synovitis. The amount of joint fluid can thus be determined and will be helpful in the decision whether to perform a joint aspiration for lowering intra-articular pressure. Ultrasonography is also indicated for an undisplaced hip fracture where a hemarthrosis might cause high pressure. Increased intracapsular pressure in the hip compromises the blood supply to the femoral head, with a risk for later segmental collapse.

Bone scans are helpful in degenerative conditions and tumors, but their utility in diagnosing chondral defects and labral tears is unproven. Intuitively, a bone scan would not be expected to be accurate in these conditions. Computerized tomography (CT) scans are helpful in bony abnormalities about the hip, but are not as effective in delineating soft tissue abnormalities. When combined with arthrograms, CT scans may be more beneficial in defining intra-articular pathology.

Magnetic resonance imaging (MRI) scans of the hip are helpful for detecting subtle degenerative changes and extra-articular soft tissue abnormalities. Perhaps their greatest use in the hip is in the diagnosis and staging of avascular necrosis. MRI scans are also useful in detecting occult tumors about the hip and pelvis. These scans have not been accurate in the diagnosis of labral and chondral pathology.[10] The addition of intra-articular gadolinium (MRI arthrography) appears to be the most promising imaging modality for labral pathology, but there is still a significant false negative rate (See Chapter 3).[18–21]

Physical examination and radiographic studies are diagnostic in the majority of cases of hip pain, but may be nondiagnostic for a particular subset of intra-articular hip pathology such as labral tears, chondral defects, and loose bodies. Differential injections about the hip can be a beneficial modality in these difficult cases. In addition, laboratory examination should include an ESR, a rheumatoid factor, and an HLA-B27 to rule out inflammatory arthritides and the spondyloarthropathies.

Hip Arthroscopy

Hip arthroscopy represents the gold standard for diagnosing and treating intra-articular causes of hip pain not otherwise recognized by standard evaluations. These disorders are generally labral tears, chondral defects, or loose bodies and can be treated arthroscopically in most cases, thus avoiding open incisions and associated comorbidity.[10] Although technically more difficult than knee or shoulder arthroscopy, hip arthroscopy represents a safe and effective means of diagnosing and treating intra-articular hip pathology.[10,22]

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2
Differential Diagnosis of the Painful Hip

Brian D. Busconi and Brett D. Owens

Hip and pelvis injuries encompass a wide spectrum of pathology resulting from repetitive microtraumatic stresses or acute traumatic forces. Fortunately, the majority of these injuries heal without permanent sequelae; however, accurate recognition and prompt appropriate treatment are required to minimize complications. Approximately 2.5% of all sports-related injuries are located in the hip and pelvic area. Epidemiological surveys suggest that injuries to the hip and pelvis account for approximately 5% of all injuries sustained by adult athletes. Runners and soccer players may also be somewhat more prone to injuries of the hip and groin. Soft tissue injuries include muscular, tendinous, or ligamentous inflammation, contusion or strain and rupture or avulsion. Skeletal injuries involve the epiphysis, physis, apophysis, metaphysis, or diaphysis. Skeletal pathology includes complete or incomplete fractures, stress reactions, dislocations, avulsion, infection, inflammation, and acquired pathologic conditions.

Hip pain typically regarded as nontraumatic (eg inflammatory conditions such as rheumatoid arthritis, juvenile arthritis and ankylosing spondylitis, infections, benign or malignant tumors, and metabolic bone disease) may be induced by physical activity and consequently present to the health care team. Nerve entrapment syndromes of the ilioinguinal, genitofemoral, and lateral cutaneous nerve of the thigh can manifest as pain and/or paresthesia in their respective territories. It is essential that systemic illness manifesting as hip pain is not overlooked and should be considered when the severity or course of the injury is not in keeping with the presumed diagnosis.

The differential diagnosis of hip pain must, in addition, include structures distant to the joint and periarticular tissues. The importance of referred pain from the lumbar spine, abdominal and pelvic viscera, genitourinary problems, sacroiliac problems, sporting hernias, osteitis pubis, and other pelvic conditions should also be considered. Similarly, pain from the knee and thigh may be referred proximally to the hip and vice versa.

Persistent hip pain can also originate from intra-articular pathology such as synovitis, loose bodies, avascular necrosis (AVN), acetabular labral tears, or infection. Pain is usually the chief complaint of patients with hip problems. These patients may present with pain over the anterior or lateral aspect of the hip, in the groin, or more medially in the region of the adductors, corresponding to the obturator nerve distribution. (Figure 2.1) Pain may radiate distally to the knee. Pain referred to the hip may be secondary to spinal problems, which must be considered in the differential diagnosis of patients with "hip" pain.

Most patients with hip pain have increased pain with activity. Measurements of joint forces reveal that peak forces at the hip can exceed four times body weight when going from a slow to fast walking speed. Jogging can increase this force up to six times body weight. This increased force is primarily generated by the muscles about the hip. (Figure 2.2) Those who complain of pain at rest usually have some inflammatory component to their disease. An infectious or neoplastic process may be present. Many patients will report increased pain as they begin activity. Pain is increased when the patient loads a joint that has been at rest. As the joint accommodates the new level of activity, pain subsides.

Patients with chronic progressive disease, such as osteoarthritis, report progressively severe pain. They often report prior problems (e.g. injury or childhood disease including developmental dysplasia, avascular necrosis or slipped capitofemoral epiphysis). Adults with avascular necrosis may describe the onset of pain months or years after cortisone use. Excessive alcohol ingestion may be a contributing cause of avascular necrosis.

Patients will complain of stiffness, which may be worst in the morning or may be a more constant problem affecting many activities of daily living. To obtain an accurate analysis, patients should be questioned to determine their impairment in walking, dressing, stair climbing, and foot hygiene.

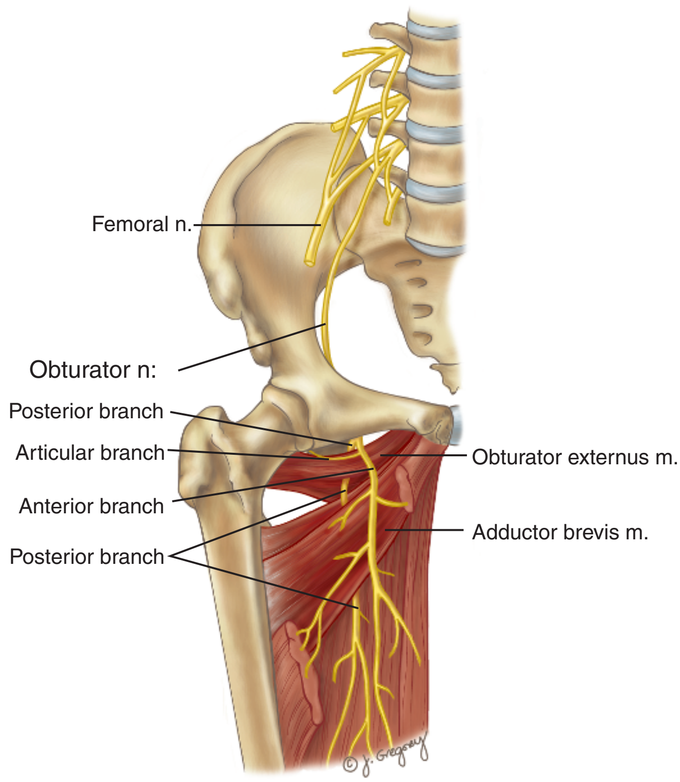

FIGURE 2.1. Drawing of the nerve supply to the pelvis and thigh.

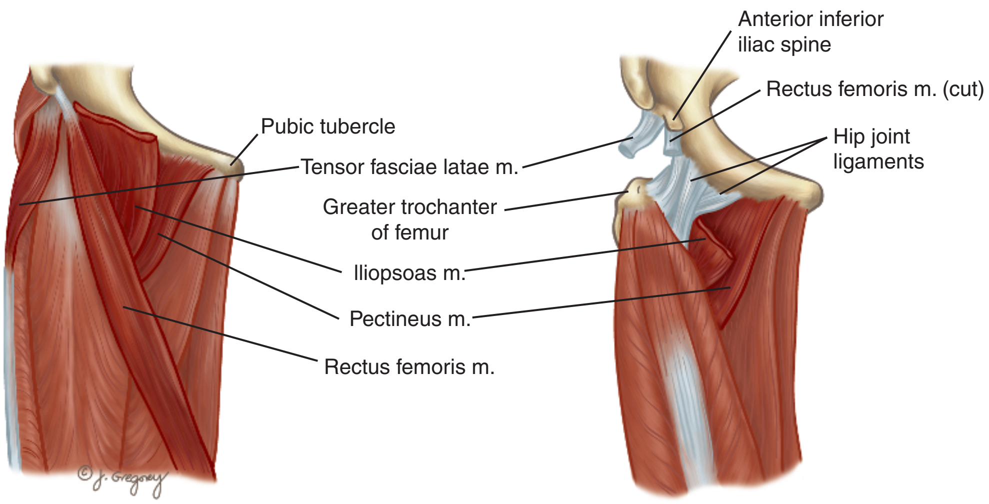

FIGURE 2.2. Drawing of the rectus tendon anatomy.

Contusions

Among the most frequently experienced hip and pelvic injuries sustained by competitive, skeletally immature athletes are soft tissue contusions.[1–3] Contusions usually result from direct blows to a specific soft tissue area, usually overlying a bony prominence. Contusions are most common in contact sports, especially football, but are also seen in volleyball, hockey, and basketball. In contact sports, the blow is usually caused by contact with another athlete. In noncontact sports, athletes usually sustain blows from contact with equipment (gymnastics), contact with high velocity projectiles (lacrosse ball), or contact with the playing surface.

Contusions are often found over the bony prominences of the pelvis, which include the iliac crest (hip pointer), greater trochanter, ischial tuberosity, and pubic rami. Because of the varied anatomy of the pelvis, contusions can be superficial, especially when they overlie a relatively subcutaneous bone or lie deep within a large muscle mass. It is important to determine the possible presence and extent of muscular hemorrhage, because an increase in muscular hemorrhage often results in more severe symptomatology and thus, a longer time before returning to sport.

Pain and hemorrhage over the iliac crest has been referred to as a hip point.[4,5] Injuries here include contusions, avulsion of the iliac apophysis, periostitis, and/or avulsion of the muscles that insert onto the iliac crest. On physical examination, the patient will have superficial or muscular hemorrhage which is painful on palpation. It is important to note by touch a defect which would indicate an avulsion injury. Patients have difficulty with rotation and side bending of the trunk. Anterior–posterior and oblique x-rays of the pelvis will rule out an avulsion fracture, periostitis, or acute fracture of the iliac wing.

Strains

Soft tissue injuries to the periarticular structures surrounding the hip and pelvis are the most common injuries seen. In general, the great majority of soft tissue injuries about the hip and pelvis are musculotendinous strains. The type of injury sustained is highly dependent upon: the skeletal age of the athlete, physical condition, and the biomechanical forces involved in both the sport and the nature of the trauma. The degree of injury can range from repetitive microinjury associated with each performance to a more significant single macroinjury caused by an abnormal biomechanical force. A certain degree of microtrauma occurs with every major exertional performance; that is immediately manifested by swelling, sensitivity, and a recovery interval. If additional moderate or severe micro- or macroinjury occurs, there may not be a normal healing response; this may lead to more significant changes in tissue structure and have a negative effect on future athletic performance. This section on soft tissue injuries will follow a correlative anatomic and functional approach to acute and chronic performance-related injuries to the hip and pelvis, as well as provide treatment guidelines.

A strain is an injury to a musculotendinous structure caused by an indirectly applied force. The most common mechanism of injury is a result of eccentric contraction or stretching of an activated muscle.[7,8] The site of injury is influenced by the rate of loading, the mechanism of injury, and local anatomic factors. Low rates of loading will result in a failure at the tendon–bone junction by bone avulsion or disruption at its insertion. High rates of loading result in intratendinous or myotendinous junction injuries.

These injuries can be graded on a three-level clinical grading system.[9] Grade 1 injuries involve a simple stretching of soft tissue fibers. Grade 2 strains involve partial tearing of the musculotendinous unit. Grade 3 injuries, which are unusual, are secondary to extremely violent forces causing complete disruptions. Diagnosis and treatment of these injuries will be described with each anatomic area. It is important to note that an injury which causes partial or complete soft tissue disruptions in adults can cause an apophyseal avulsion injury in children.

Athletic Pubalgia

The term "athletic pubalgia" refers to a chronic inguinal or pubic area pain in athletes, which is noted on exertion. The pattern of symptoms in these patients, operative findings, and the results of studies all suggest that the lower abdominal/inguinal pain is not usually due to an occult hernia. When this does occur, the occult hernia is usually found on the side opposite that of the principal symptoms.

The rectus tendon insertion on the pubis seems to be the primary site of pathology. Most patients describe a hyperextension injury in association with hyperabduction of the thigh. The location of the pain suggests that the injury involves both the rectus abdominis and adductor longus muscles. Other tendinous insertion sites on the pubic bone may also be involved.

The athletes have lower abdominal pain with exertion. A minority of patients have purely adductor-related pain, which is disabling. Most patients remember a distinct injury during exertion. Usually, the abdominal pain involves the inguinal canal near the insertion of the rectus muscle on the pubis. This pain causes a majority of patients to stop competing in sports.

MRI findings in athletic pubalgia are often nonspecific. On the other hand, 12% of patients have MRI findings which clearly indicate a problem at the rectus insertion site. The relatively small incidence of a specific diagnosis by imaging studies suggests that the problem may be an attenuation of the muscle or tendon due to repeated microtrauma. The MRI finding of adductor longus inflammation is consistent with athletic pubalgia.

Generally, the acute management of groin pain suspected to be athletic pubalgia is conservative, and includes rest, ice, compression, anti-inflammatory medications, and massage.[10] When the process continues over several months and the athlete cannot return to previously expected activity because of pain, an operation should be considered. Surgical treatment of athletic pubalgia requires a broad surgical reattachment at the inferolateral edge of the rectus muscle with its fascial investments to the pubis and adjacent anterior ligaments. We also perform an anterior and lateral release of the epimysium of the adductor fascia in order to expand this compartment. The epimysium is the layer of connective tissue that encloses the entire muscle. This kind of fascial release is often very successful in relieving the adductor symptoms in athletic pubalgia.[11]

Piriformis Syndrome

In 1928, Yeoman first described a syndrome involving compression of the sciatic nerve by the piriformis muscle. The nerve compression occurs as it exits deep to the piriformis muscle.[12] Patients complain of pain and symptoms in the sciatic nerve distribution. A history of past acute trauma to the buttock is often present. Patients will have difficulty sitting or participating in activities, such as ice skating, which involve hip flexion and internal rotation.[13] On physical examination, tenderness is present over the piriformis tendon in the gluteal area. Pain is elicited by forced internal rotation on an extended thigh, or Pace's sign, (ie pain and weakness on resisted abduction and external rotation of the thigh). Rectal or vaginal examination may produce pain in the piriformis area. An MRI can be helpful to demonstrate sciatic nerve inflammation in the area of the piriformis tendon.

Hamstring Syndrome

In 1988, Puranen described an entity called Hamstring syndrome, which was very common in track athletes.[14,15] Athletes have severe pain in and around the ischial tuberosity, which radiates down the posterior aspect of the thigh to the popliteal area. Any activity which stretches the hamstring can create this radiating pain. Sprinting, hurdling, and even sitting for long periods will cause pain. Physical examination elicits exquisite tenderness at the ischial tuberosity and, at times, reproduction of sciatic pain with percussion of the nerve at the ischial tuberosity. Resisted leg extension will reproduce the pain. The sciatic nerve is thought to be entrapped between the semitendinosus and the biceps femoris by a fibrous band which constricts the two muscles.

Inflammatory Disorders

Inflammation of the sacroiliac joint can occur with a variety of the spondyloarthropathies. Reiter's syndrome, psoriatic arthritis, ankylosing spondylitis, and inflammatory bowel disease commonly occur with sacroiliitis. In other patients, there may be sacroiliac pain without other signs of spondyloarthropathy. Pain may be from true synovitis of this joint, or from inflammation of the overlying muscles or ligaments.

Pain occurs over the sacroiliac joint region, with referred pain into the lower buttock and thigh. Pain over the greater trochanter and groin pain may also be present. Tenderness is present over the sacroiliac joint and in the region of the posterior superior iliac spine. Patrick's test may elicit pain in the involved joint. With the patient lying on one side, strong compression of the pelvis may cause pain. Hyperextension of the hip may also produce pain. X-rays frequently show no significant change. In the case of spondyloarthropathy, however, there may be irregularity or osteopenia of the subchondral bone, leading to "blurring" of the joint space. These changes are most commonly seen in the lower (synovial) part of the joint. Patchy areas of lucency and sclerosis may develop. With further progression, marked narrowing of the joint space occurs, and ankylosis can be present.

When sacroiliitis is a manifestation of an underlying spondyloarthropathy, treatment is dictated by the underlying inflammatory disease. In isolated cases of sacroiliac syndrome, symptomatic relief can be achieved by rest, application of local heat or ice, and use of nonsteriodal anti-inflammatory medication. A sacroiliac belt may also be helpful.

Inflammatory involvement of the hip joint may also be caused by rheumatoid arthritis.

Snapping Hip Syndrome

Snapping hip syndrome is a collection of extra-articular and intra-articular pathologies which can be not only painful and disabling to the athlete, but also confusing for the diagnostician.[16–18] Extra-articular snapping of the hip joint can be caused by the following: The iliopsoas tendon as it passes over the iliopectineal eminence or the lesser trochanter of the femur; the iliofemoral ligaments over the femoral head; the long head of the biceps femoris over the ischial tuberosity; or finally and most commonly the iliotibial band over the greater trochanter of the femur. It can be very difficult for the practitioner to distinguish these entities from more disconcerting intraarticular lesions, such as tears of the anterior labrum, synovitis, or loose bodies, which can also create a snapping or clicking sensation in the hip. However, as CT, MRI, and hip arthroscopy become more refined we are better able to differentiate these entities.

Another cause of snapping hip syndrome is irritation of the greater trochanter by the iliotibial band. The iliotibial band is a large flat tendinous structure that originates on the anterior superior portion of the iliac crest, crosses over the greater trochanter of the femur, and inserts onto the lateral condyle of the tibia. Iliotibial band syndrome is seen in athletes who undergo repetitive knee flexion, such as runners and cyclists.[17,19] Athletes have pain over the greater trochanter of the femur, the lateral thigh, or pain radiating down to the knee. Patients often complain that their “hip feels like it’s dislocating” or “it seems to pop in and out of joint.” If it is severe enough, the snapping sensation occurs during normal ambulation. Once this area becomes inflamed, running or rising from a seated position may cause it to hurt continuously.

Bursitis

Bursitis about the hip is a common condition secondary to inflammation of one of the three major bursae about the hip: the trochanteric bursa, the iliopsoas bursa, and the ischiogluteal bursa. These bursae facilitate the gliding of musculotendinous or ligamentous structures. Bursitis may be secondary to direct injury or overuse of the adjacent musculotendinous structures, or to degenerative changes in these structures. Because bursae are lined by true synovial tissue, bursitis also can occur with systemic disease, causing synovitis.

The trochanteric bursa is a large bursa that lies between the greater trochanter and the overlying junction of the gluteus maximus and tensor fascia lata, as these merge to form the fascia lata and iliotibial tract.

Ischiogluteal bursitis is inflammation of the bursa between the ischial tuberosity and the overlying gluteus maximus. This inflammation usually is associated with injury or with occupations requiring long periods of sitting. The patient complains of pain over the ischial tuberosity that is aggravated by sitting, and the pain may radiate into the posterior thigh. Tenderness is present overlying the ischial bursa, but swelling is rarely noted. X-rays are usually noncontributory.

The iliopsoas bursa is located between the iliopsoas muscle and the pelvis proximally, and between the hip capsule and the psoas tendon distally. Inflammation of the iliopsoas bursa will usually cause groin pain. Communication between the hip joint and psoas bursa is common.

Arthritis

Osteoarthritis is one of the most common diseases affecting the adult hip. This condition is often secondary to an underlying abnormality of the hip, such as developmental dysplasia, Legg-Calve-Perthes disease, or slipped capital femoral epiphysis. (Figure 2.3) In some cases, however, there is no identifiable cause, and in these situations the osteoarthritis is considered primary or idiopathic. As a result of these changes, motion in the hip becomes progressively restricted, first by painful synovitis and muscle spasm, then by secondary soft tissue contracture. In more advanced stages of the disease, there is loss of joint congruity, osteophyte formation, and mechanical block to motion superimposed on the soft tissue contracture.

Pain in osteoarthritis can be caused by this synovitis or by muscle spasm, capsular contracture, and pain fibers in bone and reparative granulation tissue. The patient presents with pain, which may be felt in the groin, buttock, anterior thigh, or knee. Pain is usually worse with weight-bearing, although there may be pain at rest. Initially, the pain may be intermittent, but with time it becomes more frequent, lasts longer, and becomes progressively severe. The patient may limp, which may be an antalgic limp or an “abductor sway.”

Motion is restricted and may be demonstrable as a flexion contracture. Abduction and internal rotation are usually more restricted than adduction and external rotation. The leg shortens with advanced disease. X-ray of the hip demonstrates varying changes, including narrowing of the joint space, subchondral bone irregularity with cyst and osteophyte formation, sclerosis of the subchondral trabecular bone, and lateral or superolateral subluxation of the femoral head.

Septic Arthritis

Adult patients rarely develop septic arthritis of the hip. Those patients who develop septic arthritis are frequently immunocompromised (eg patients with diabetes or renal failure, or those taking corticosteroids or chemotherapeutic agents). The intravenous drug abuser is also at increased risk. A healthy patient who develops septic arthritis presents acutely ill with high fever, exquisite pain, and decreased motion. An immunocompromised patient, however, may present without high fever and may not appear acutely ill. Range of motion may not be as painful.

Tuberculosis can occur in the hip joint as in any other synovial tissue. Pain, limited motion, subcutaneous abscess, or a draining sinus may be part of the presentation. In the advanced stages of this disease, x-ray changes are significant and demonstrate bone and joint destruction.

A patient suspected of having infectious arthritis of the hip must undergo joint aspiration and should be referred immediately to the orthopedist.

Avascular Necrosis

Avascular necrosis of the femoral head is well recognized in association with fractures of the femoral neck and dislocations of the femoral head in both adults and children. Fracture of the femoral neck is associated with a 15–30% risk of avascular necrosis. Dislocation of the hip is associated with a 10–15% risk of avascular necrosis. The primary cause of avascular necrosis of the femoral head after direct hip trauma is an interruption of the arterial supply to the femoral head secondary to the injury. Evidence suggests that avascular necrosis also may be the result of a short-duration shower of fat emboli that can occur after significant trauma. Avascular necrosis of the femoral head without recognizable injury is not well understood and may be multifactorial. In patients with sickle cell disease, avascular necrosis is thought to be associated with vascular thrombosis. Avascular necrosis has been commonly associated with alcoholism and long-term steroid use.

Avascular necrosis after brief exposure to corticosteroids occurs uncommonly and is not well understood, but the potential risk is certainly great enough to justify caution when prescribing systemic corticosteroids for prolonged periods. There is no known risk of avascular necrosis after single or repeated trigger-point or intra-articular injections. Avascular necrosis has also been noted in gout, Gaucher's disease, caisson disease, and in patients with altered hemostasis. In several large series of patients with avascular necrosis, the idiopathic category remains the largest group, followed by those with alcohol-related or corticosteroid-induced disease. Ve-

FIGURE 2.3. Plain radiograph of a patient with dysplasia and secondary osteoarthritis of the left hip.

nous compression has been implicated as a cause for avascular necrosis, especially in decompression sickness, pregnancy, or thrombophlebitis. Embolic causes typically are centered on fat emboli as the inciting event. Intraosseous fat embolism not only obstructs blood flow directly, but is also hypothesized to mediate vascular occlusion through an intermediary pathway of localized intravascular coagulation.

The pathologic change associated with the early phase of this disease is a segmental necrosis of the femoral head. The overlying articular cartilage is unaffected. With time, there is reparative tissue ingrowth with resorption of necrotic bone, accompanied by formation of new bone on necrotic trabeculae. With resorption, the area of segmental necrosis weakens, and a subchondral fracture can occur. Patients often have a marked increase in pain when this happens. Avascular necrosis is clinically categorized in stages based on the x-ray appearance of the hip.[20] The condition is frequently bilateral in nontraumatic cases.

Labral Tears

A torn acetabular labrum has been identified as a cause for hip discomfort in athletics. Its clinical features include a painful click in the inguinal area, catching, or giving way symptoms. In general, athletes will remember an antecedent traumatic event, which often involves sports that require forceful hip extension and rotation such as karate. On physical examination, the painful click can be reproduced by a McCarthy sign (with the opposite hip fully flexed, the affected hip is extended, first in external rotation then in internal rotation). Radiographic measures have been unreliable and have low diagnostic yields.

It is this group of patients with refractory hip pain, reproducible physical findings, and equivocal or negative radiographic studies in whom hip arthroscopy has been successful in diagnosis and treatment. Excellent results have been reported with arthroscopic debridement of the lesion. Return to sports has occurred in our series 6–8 weeks after debridement. Labral tears will be covered in further detail in the chapter on labral pathology.

Fractures and Dislocations

Trauma may result in actual fracture, dislocation, or both. These conditions must always be in the differential diagnosis; however, they will be covered in detail in the chapter on trauma.

Stress fractures of the femur and the pelvis are not common, but often are a source of great confusion in diagnosis. These injuries should be considered in athletes who do a great deal of chronic repetitive motion. They are often seen in track and field athletes, long distance runners, and army recruits. A stress fracture is generally defined as repetitive stress below the failure levels of bone in a time period inadequate to allow for bony remodeling.[21–26]

Femoral stress fractures are not as common as stress fractures involving the pelvis but, if not identified and treated appropriately, can lead to fracture displacement or AVN of the femoral head.[24,27,28] Athletes will present with pain in the groin area, which is persistent and is associated with a decreased range of motion in the affected hip joint. On physical examination, the patient will have a decrease in hip range of motion, especially with flexion and internal rotation. The groin will be painful to touch, and at times percussion of the greater trochanter will elicit pain.

Initial plain radiographs of the hip may be negative for 2–4 weeks following the onset of pain.[23,27,29] A technetium 99 bone scan is helpful to confirm the diagnosis of a stress fracture. Recently, magnetic resonance imaging (MRI) has been increasingly used.

Two types of femoral neck stress fractures have been described: transcervical (distraction) and compression.[25,30] The first type of stress fracture is a superior transverse fracture involving the superior portion of the femoral neck. It is a distraction injury and fortunately is uncommon in children. It is most commonly seen in an anterior–posterior view of the hip. Displacement is the major complication associated with the treatment of this fracture. Internal fixation is the recommended treatment for a type 1 fracture.[27,28]

If displacement does occur, it should be treated as an acute transcervical fracture of the proximal femur. The second type of fracture is a compression stress fracture, which is more common in children and rarely displaces.[21,28] These fractures are seen on the inferior medial aspect of the femoral neck and are frequently treated with nonweight-bearing status until there is radiographic evidence of callous and healing.

Pelvic stress fractures are also secondary to repetitive microtrauma, often occurring at the junction of the ischium and the inferior pubic ramus. They are very common in female runners between the ages of 19 and 48. The etiology has been postulated as being secondary to tensile stresses created by muscle contractions in the pelvis with the hip in extension.[31,32]

On clinical examination, the athlete often has pain in and around the inguinal area. The gait will be antalgic. Hip range of motion is usually pain-free and full. Noakes describes a positive standing sign in which the patient develops discomfort in the groin while standing unsupported on the leg with the corresponding pelvic injury.[32]

Radiographs, as with femoral stress fractures, may not be positive until 2–3 weeks after injury. A bone scan may be performed early to make the diagnosis.

Pediatric conditions such as slipped capital femoral epiphysis, Legg-Calve–Perthes, septic arthritis, and transient synovitis are covered in detail in the chapter on pediatrics.

Tumors

Hip or pelvic pain which persists for longer than expected following an apparently minor injury, or following no known antecedent trauma, must be evaluated for the possibility of a pathologic lesion.

The chief complaint of children with a pathologic lesion to the hip and pelvis is pain in the groin. The quality, location, and nature of the pain varies with the type of pathologic lesion involved and therefore this must be determined. Although most pediatric musculoskeletal tumors do not have associated systemic symptoms, possible symptoms include fever, chills, nausea, vomiting, or decreased appetite, and it is important to determine the presence or absence of these. A thorough physical examination of the pelvis and hip should be performed to ascertain the possible presence of masses, muscular atrophy, or neurovascular changes.

Radiographic evaluation of the affected area is essential. Anterior–posterior and lateral radiographs of the hip and pelvis are performed, and in most cases will be diagnostic. Further studies can include technetium 99 (^{99}Tc) bone scan, CT scan, and/or MRI.

Osteoid osteoma is a benign bone tumor of adolescents and young adults, most frequently affecting the hip and pelvis. It may therefore present as a hip pain syndrome in young athletes. Investigations are geared towards identifying the pathognomonic bony nidus. Plain radiographs may be normal, but linear tomograms, isotope bone scanning, and CT were valuable diagnostic aids. Return to sport was on average 4 months following a limited excisional biopsy via an anterior approach without the need for bone grafting, internal fixation, or cast immobilization postoperatively. The natural history suggests that spontaneous resolution and healing may occur after a prolonged period of time (2–3 years), so conservative management should be considered in surgically complex cases.

Common pathologic lesions to the hip and pelvis include benign lesions (unicameral bone cyst, osteoid osteoma, osteochondroma, or fibrous dysplasia), malignant neoplasm (Ewing's sarcoma and osteogenic sarcoma), and systemic endocrinopathies (hypothyroidism and renal osteodystrophy). Management of these pathologic lesions should be undertaken in an experienced facility where appropriate diagnostic staging, therapeutic agents, and/or surgical intervention can be employed.

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3
Imaging of a Painful Hip

Arthur H. Newberg and Joel S. Newman

The imaging workup of the patient with hip pain should begin with plain or routine radiographs of the pelvis and hips. Certainly, by obtaining an anteroposterior view of the pelvis, as well as a lateral radiograph (true lateral, frog lateral, or Lowenstein view) one can readily compare the right and left hips, and therefore a built-in comparison is available for the radiologist and orthopedist. The diagnosis in many cases is obvious; if the patient has had recent trauma, then one evaluates the alignment of the bones. The acetabular lines should be carefully scrutinized. The addition of oblique views of the affected hip may be necessary to evaluate the anterior and posterior columns of the acetabulum. If an acetabular fracture is identified, a CT scan is suggested to assess the position of the fracture fragments and to exclude intra-articular loose bodies. The CT is often vital for operative planning. If the trauma is repetitive and a stress or fatigue fracture is being considered, radiographs must be supplemented with either a radionuclide bone scan and/or MRI. In this chapter the authors will describe the imaging characteristics of several common atraumatic and traumatic lesions, as well as discuss the more advanced techniques of MRI and MR arthrography when assessing for more localized hip joint abnormalities.

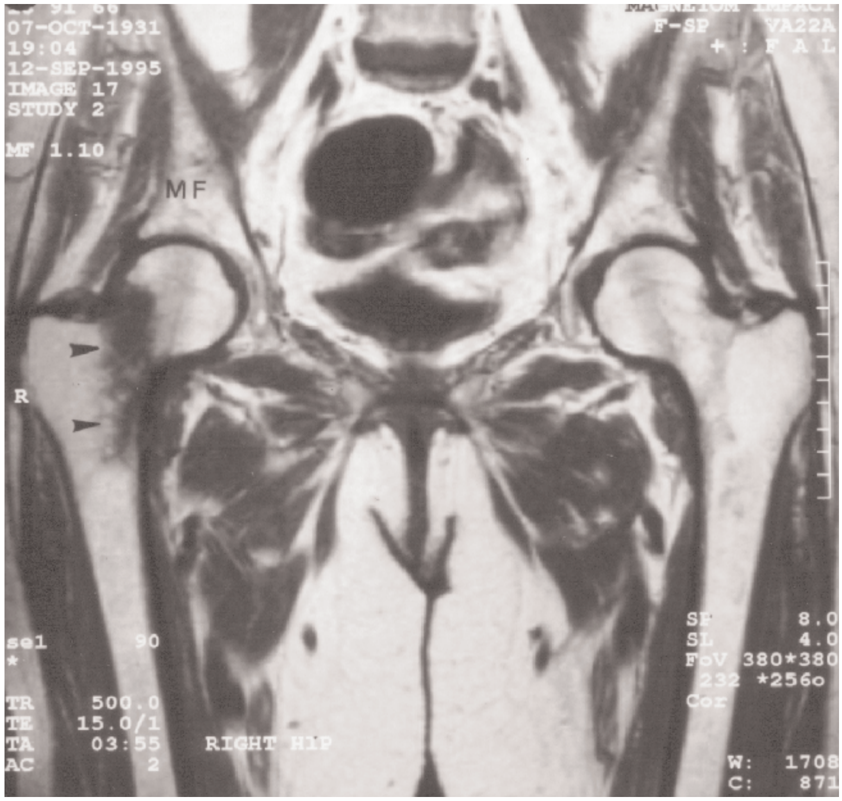
Fracture

The diagnosis of an occult hip fracture can be elusive. Often the initial radiographs are normal, especially in the elderly osteoporotic patient. In the athlete with a suspected stress fracture, it is best to choose MRI as the first advanced imaging test. MRI can be performed rapidly, is cost effective, and is sensitive and specific for the diagnosis of occult fracture. The new high-field-strength magnets operating at 1.5 Tesla are more comfortable for the patient. The bore of the magnet is now shorter, allowing for better patient acceptance.

It has been estimated that by the year 2040, 22% of the population of the United States will be over 65 years of age, which will result in an estimated half million hip fractures per year. Establishing the diagnosis of a nondisplaced, plain film-negative, occult hip fracture in an elderly patient can be a prolonged and costly process involving hospital admission, bed rest, and a radionuclide bone scan. Early detection of a hip fracture has increasingly important medical, economic, and legal implications in our changing health care environment.[1] In the past, radionuclide imaging was the first advanced imaging technique utilized. Performed properly, scintigraphy is both sensitive and specific in the diagnosis of hip fracture.[2] However, it is now clear that MRI can and should be the initial imaging modality following routine hip and pelvis radiographs, due to its high specificity and the additional clinically important information which MRI can provide. (Figure 3.1)

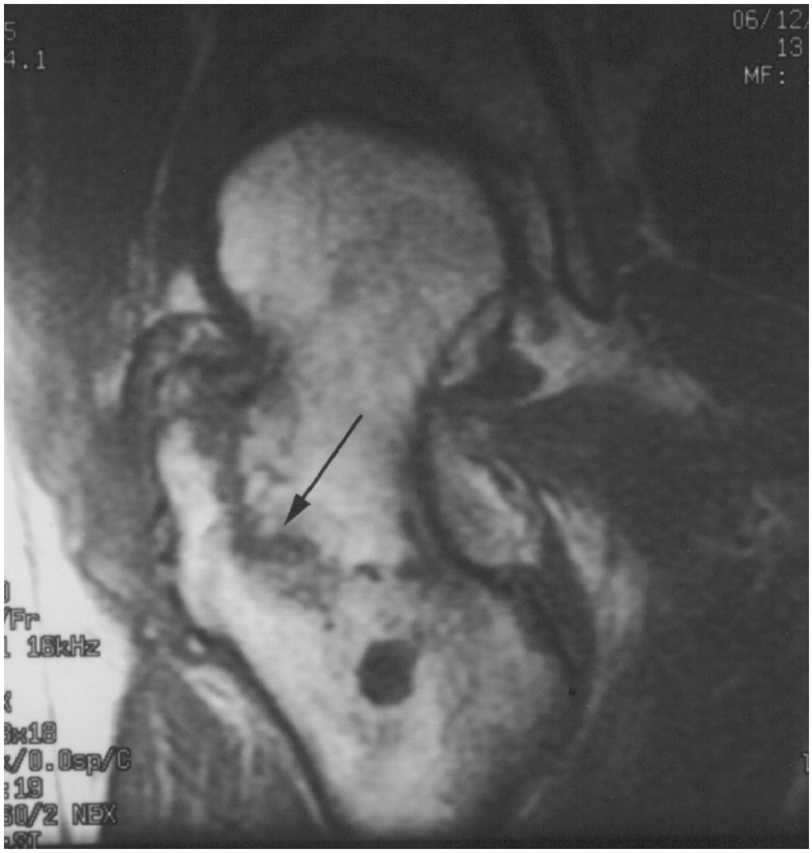
MRI with limited T1 weighted coronal images is 100% accurate in detecting occult hip fractures.[3] Scintigraphy is sensitive but is often nonspecific and may be negative immediately after the injury or fall, especially in the elderly. When MR imaging and clinical outcome were used as the standard of reference, the prospective accuracy of MR imaging in the diagnosis of the presence or absence of hip fracture was 100%.[4] A limited MRI is one way to evaluate the affected hip, however, we continue to perform a complete study in these patients because there is a high prevalence of occult pelvic fractures and soft tissue injuries identified when large-field-of-view, T1 weighted coronal sequences are combined with T2 weighted or STIR sequences. (Figure 3.2) In one study, 80% of patients referred for MRI because of suspected radiographically occult fracture had some bone or soft tissue abnormality detected with MRI.[5]

A



B

FIGURE 3.1. (A) Radionuclide bone scan in a 64-year-old female with right hip pain demonstrates increased uptake of the radiotracer in the intertrochanteric region of the right hip (arrow). (B) Coronal T1W1 image of the hip demonstrates a linear area of low signal extending vertically from the femoral neck laterally to the subtrochanteric area medially (arrowheads). This patient has an occult hip fracture.



A

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FIGURE 3.2. (A) Coronal T1W1 of the right hip in a patient with severe pain and negative radiographs following a fall at work. There is a wavy, low-signal-intensity line indicating an occult hip fracture (arrow). (B) A coronal STIR image just posterior to the hip demonstrates high signal in the soft tissues, representing edema and hemorrhage into the posterior thigh muscles.

Stress Fracture

Stress or fatigue fracture of the femoral neck in a young patient represents abnormal stress applied to normal bone. These stresses, none of which is individually capable of producing a fracture, lead to mechanical failure over time. Stress fracture of the femoral neck tends to remain asymptomatic until advanced.

Two types of femoral neck stress fracture have been described on the basis of their precipitating strain patterns. The "compressive" variety occurs along the lower medial border, displays a sclerotic appearance on plain films, and tends not to displace.[6] "Distraction" fractures along the superior portion of the femoral neck are typically radiolucent and are prone to become displaced due to tensile forces that act to pull the fracture margins apart.

MR imaging facilitates the early diagnosis of stress fracture. MR is extremely sensitive in the detection of pathophysiologic changes associated with stress injuries. Compressive, medial side femoral neck fracture in these athletes often presents with bone marrow edema best shown on T2, STIR, or frequency-selective, fat-suppressed sequences. (Figure 3.3) The increased water content of the associated medullary edema or hemorrhage results in high signal intensity against the dark background of suppressed fat, such that these sequences should maximize sensitivity.

Often a low-signal fracture line will be seen in the midst of the edema. (Figure 3.4) In a compliant patient, a stress fracture of the medial or compressive side of the femoral neck can often be treated conservatively. In one study of 10 patients with femoral neck stress fracture, the bone edema seen with STIR imaging resolved in 90% of the patients within 6 months. Therefore, if high signal is seen on STIR images more than 6 months following an injury, such abnormal signal intensity is likely to represent a new injury.[7] Edema resolution by MR imaging may represent an initial stage of healing, and full healing may require resolution of clinical symptoms as well.

A

FIGURE 3.3. (A) A 21-year-old female athlete presented with right hip pain and negative radiographs. A coronal T1W1 demonstrates an ill-defined area of low signal intensity in the right femoral neck.


B

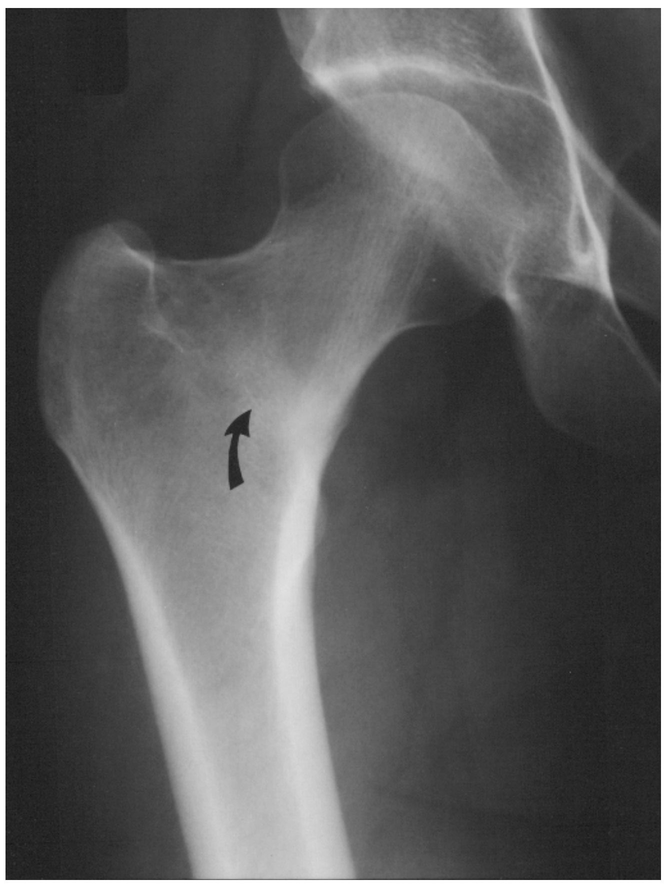

C

FIGURE 3.3. (B) Coronal STIR image demonstrates bone marrow edema of the right femoral neck. In addition, along the medial femoral neck, a low signal line represents a compression side femoral neck stress fracture (arrow). (C) A follow-up radiograph demonstrates characteristic findings of a stress fracture. There is ill-defined sclerosis of the medial femoral neck (arrow).

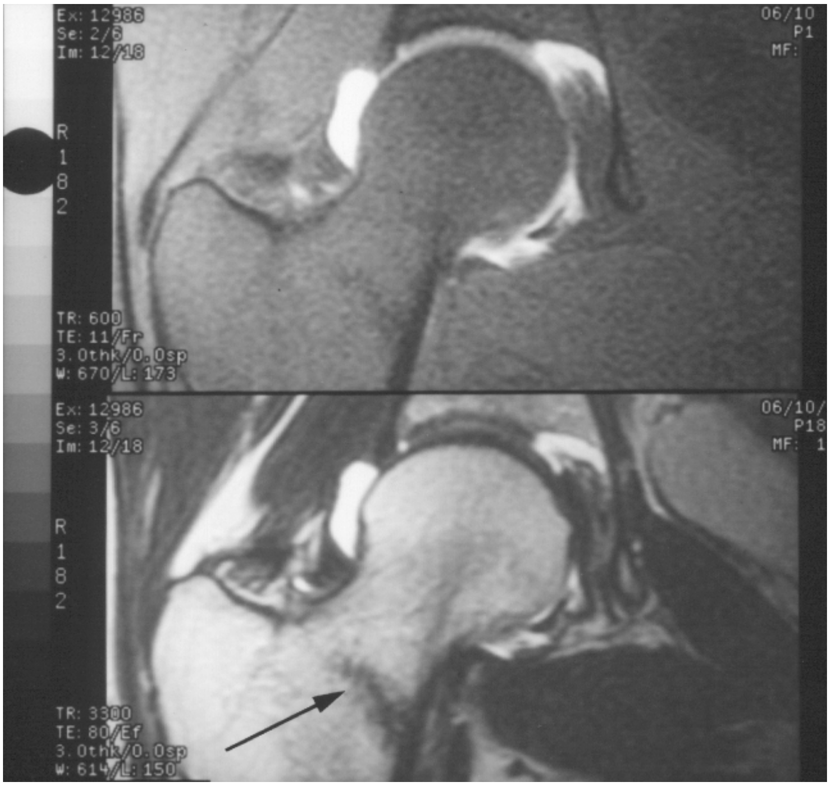


FIGURE 3.4. A 32-year-old woman complained of hip pain related to vigorous daily aerobics. The upper image from an MR arthrogram of the right hip is normal. The lower image demonstrates an unsuspected stress fracture of the femoral neck (arrow).

Dysplasia of Hips

Hip dysplasia (DDH) refers to a developmental anomaly of the hip regardless of its etiology. The femoral head, acetabulum, or both may be dysplastic. Hip dysplasia in adults can result from multiple causes, including neuromuscular diseases, cerebral palsy, slipped capital femoral epiphysis, Legg-Calvé-Perthes disease, injury, and epiphyseal dysplasia.[8] The presence of hip dysplasia can result in hip pain and premature osteoarthritis. DDH is divided into three types based on the severity of the disease: Type I — hyperlaxity of the joint; Type II — subluxable head; and Type III — dislocated hip (Figure 3.5). Subtle cases of DDH are being recognized more commonly (Figure 3.6). It is important to evaluate the slope of the acetabulum, as well as the amount of femoral head that appears uncovered by the acetabulum, and it is valuable to measure the CE angle of Wiberg. This angle is formed by measuring an angle off the vertical from the center of the femoral head to the lateral margin of the acetabulum. A normal CE angle measures greater than 25 degrees. Twenty to 25 degrees is borderline, and less than 20 degrees is diagnostic of acetabular dysplasia.[8]

FIGURE 3.5. Anteroposterior radiograph of the pelvis demonstrating longstanding bilateral congenital hip dislocation. Both hips have dislocated proximal to the true acetabulum and are posterior to the iliac wings.

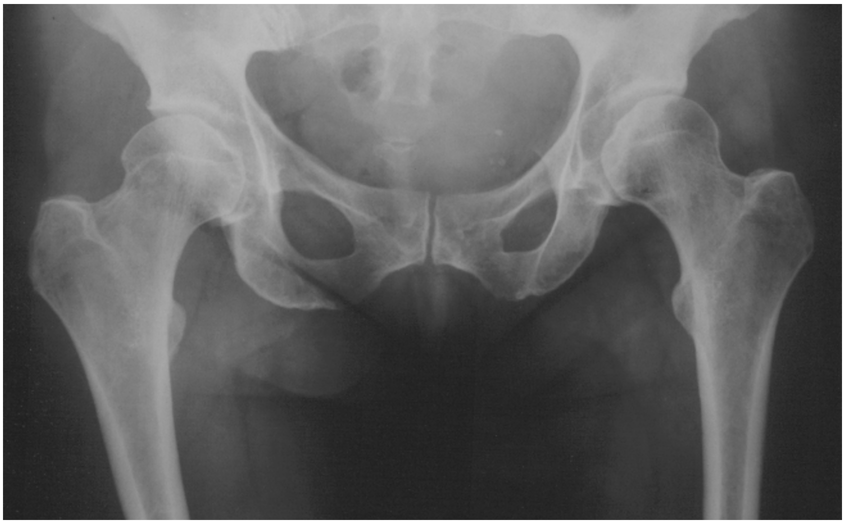


FIGURE 3.6. Anteroposterior radiograph of the pelvis demonstrates subtle findings of bilateral DDH. The femoral heads are not completely covered by the acetabulum, and the CE angle measures 20 degrees.

Bone Marrow Edema Syndromes

Another unusual but very important cause of hip pain in the adult is the transient bone marrow edema (BME) pattern recognized by MR imaging.[9] In many cases, this represents transient osteoporosis of the hip, an unusual but distinct syndrome characterized by self-limited pain and radiographically evident osteoporosis of the affected hip that can be distinguished from other causes of the BME pattern on the basis of clinical findings and radiographically evident focal osteopenia developing within eight weeks after the acute onset of hip pain.[10] (Figure 3.7) The term transient BME syndrome can be used to describe a patient in whom a reversible bone marrow edema pattern is seen on MR images. This pattern of bone marrow edema manifests on MR images as low signal on T1 sequences. The area of abnormal signal often involves the entire femoral head, neck, and may even extend into the subtrochanteric region.[11] Frequency-selective, fat-suppressed, T2 weighted sequences or STIR sequences will show very high signal in the affected areas. (Figure 3.8) Often a joint effusion accompanies this condition. Initially described in pregnant women, this entity is more common in middle aged men. Laboratory tests are normal, there is effusion of the affected hip and osteopenia of the femoral head and neck, and the radionuclide bone scan shows increased uptake in the involved hip. (Figure 3.7) This entity can resolve in several months and may affect the contralateral hip at a future time. Bone marrow edema may also be seen in osteonecrosis of the femoral head. Unlike those with other causes of bone marrow edema, these patients usually have one of the well-known risk factors, such as exogenous steroid use, alcohol consumption, systemic lupus erythematosus, sickle cell anemia, or Gaucher's disease. (Figure 3.9)

A B

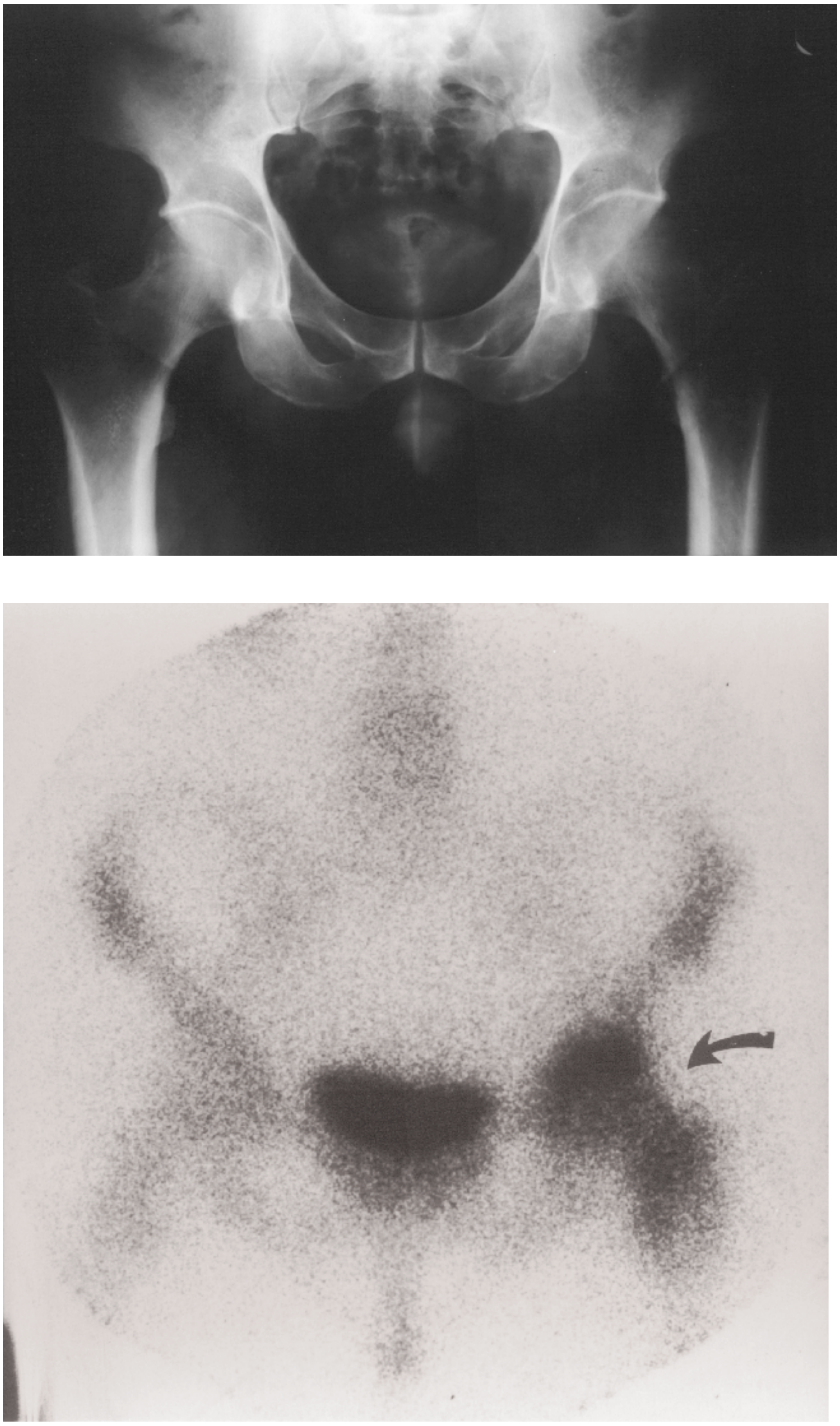
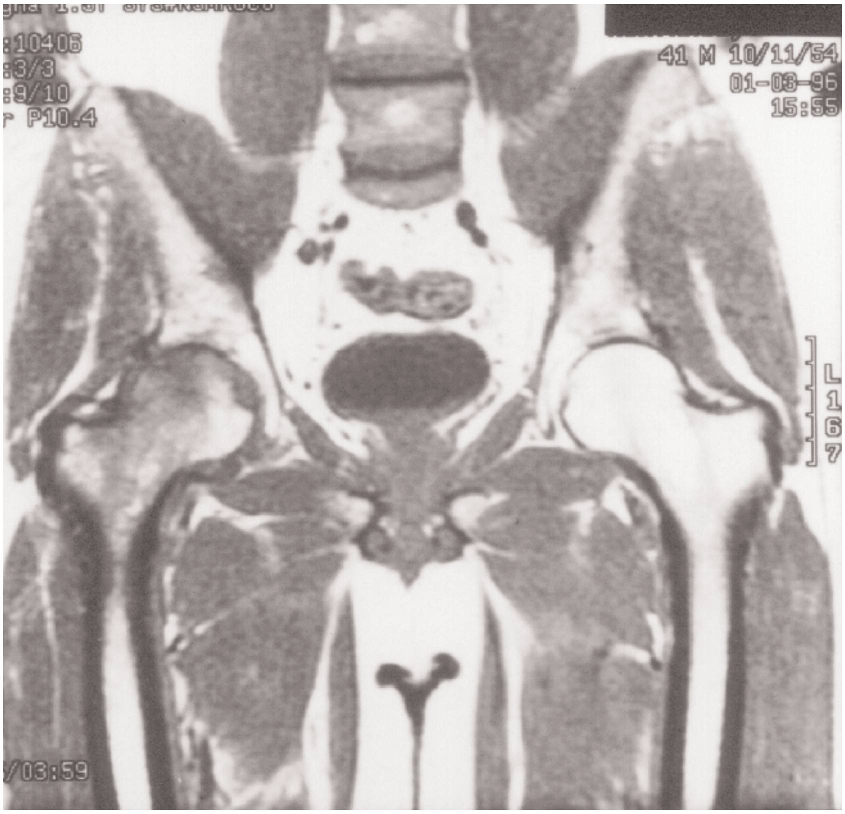


FIGURE 3.7. (A) A 41-year-old man presented with acute onset of severe left hip pain. There is osteoporosis of the left femoral head and neck. (B) A radionuclide bone scan demonstrates increased uptake of the left femoral head and neck (arrow) consistent with transient osteoporosis of the hip. An MR (not shown) confirmed the diagnosis.



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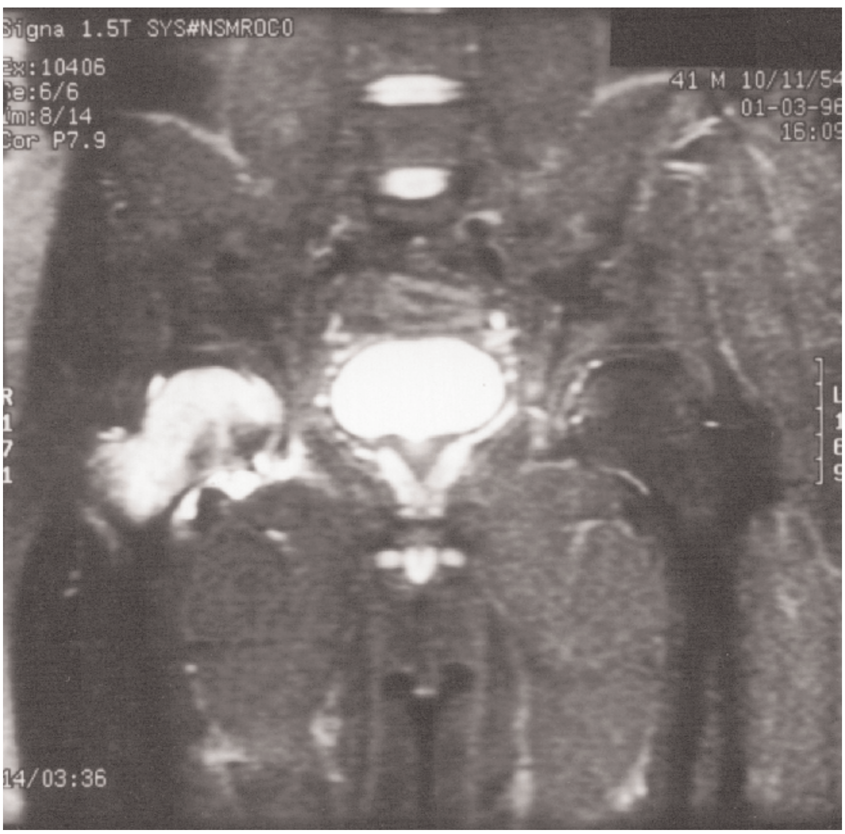

B

FIGURE 3.8. (A) A 41-year-old man presented with severe right hip pain. Coronal T1W1 of the hips demonstrates diminished signal in the right femoral head and neck. (B) Coronal STIR image demonstrates dramatically increased signal in the right femoral head and neck consistent with bone marrow edema.

C

FIGURE 3.8. (C) A follow-up coronal STIR image, 4 months later, demonstrates return of normal marrow signal in the right hip. The patient had a diagnosis of transient regional osteoporosis.

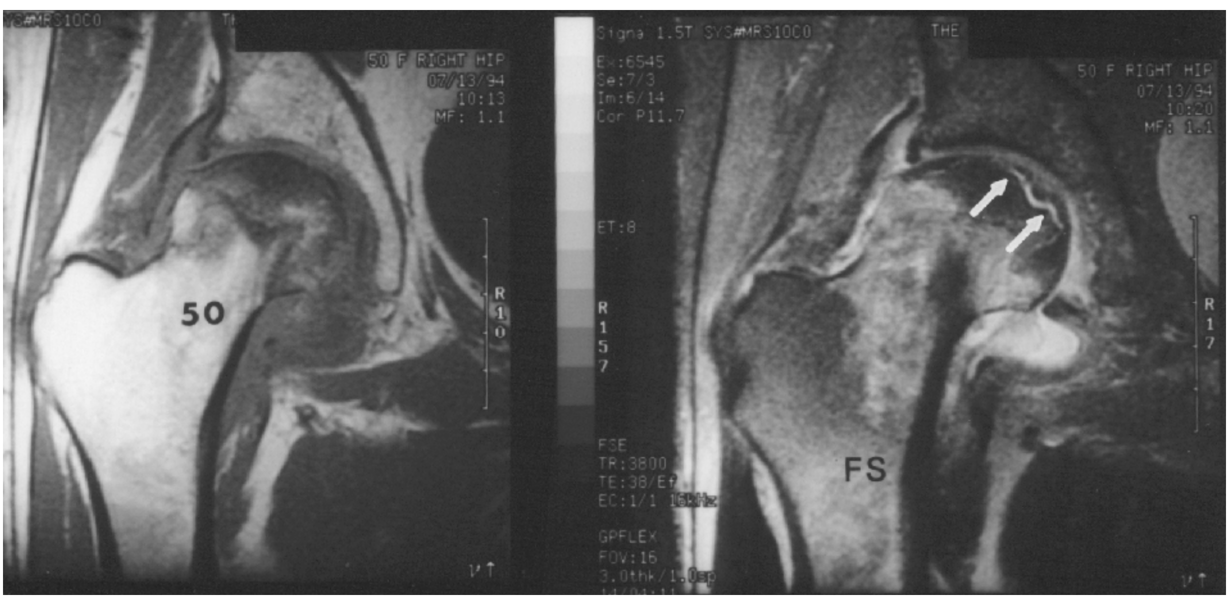

FIGURE 3.9. On the left, a T1W1 coronal image demonstrates low signal intensity of the femoral head. On the right, a fat-suppressed, proton density weighted coronal image demonstrates bone marrow edema of the femoral neck. There is a subchondral fracture, the crescent sign (arrows) along the superomedial femoral head. Note the joint effusion.

Isolated Monarticular Disease Processes

Routine hip radiographs will often be sufficient to explain a patient's symptoms. For example, soft tissue calcifications around the hip due to hydroxyapatite deposition disease suggest the diagnosis of calcific tendinitis or bursitis. (Figure 3.10)

If there is rapidly progressive narrowing of the hip joint and the symptoms are acute and severe, one must consider the diagnosis of septic arthritis. (Figure 3.11) The prompt and correct diagnosis of septic hip is essential, and the films must be evaluated carefully for evidence of joint space narrowing, osteoporosis, and loss of subchondral bone in the roof of the acetabulum, a very important sign of hip joint sepsis. (Figure 3.12) In the elderly, hip pain, limp, and deformity may be the result of Paget's disease. (Figure 3.13)

FIGURE 3.10. Anteroposterior radiograph of the right hip shows linear amorphous soft tissue calcification of the joint superior to the greater trochanter within the gluteus medius tendon, characteristic of calcific tendinitis due to hydroxyapatite deposition (arrow).

FIGURE 3.11. In this patient with septic arthritis, there is marked osteopenia of the right hip, loss of joint space, and loss of the well-defined subchondral bony rim of the superior acetabulum.

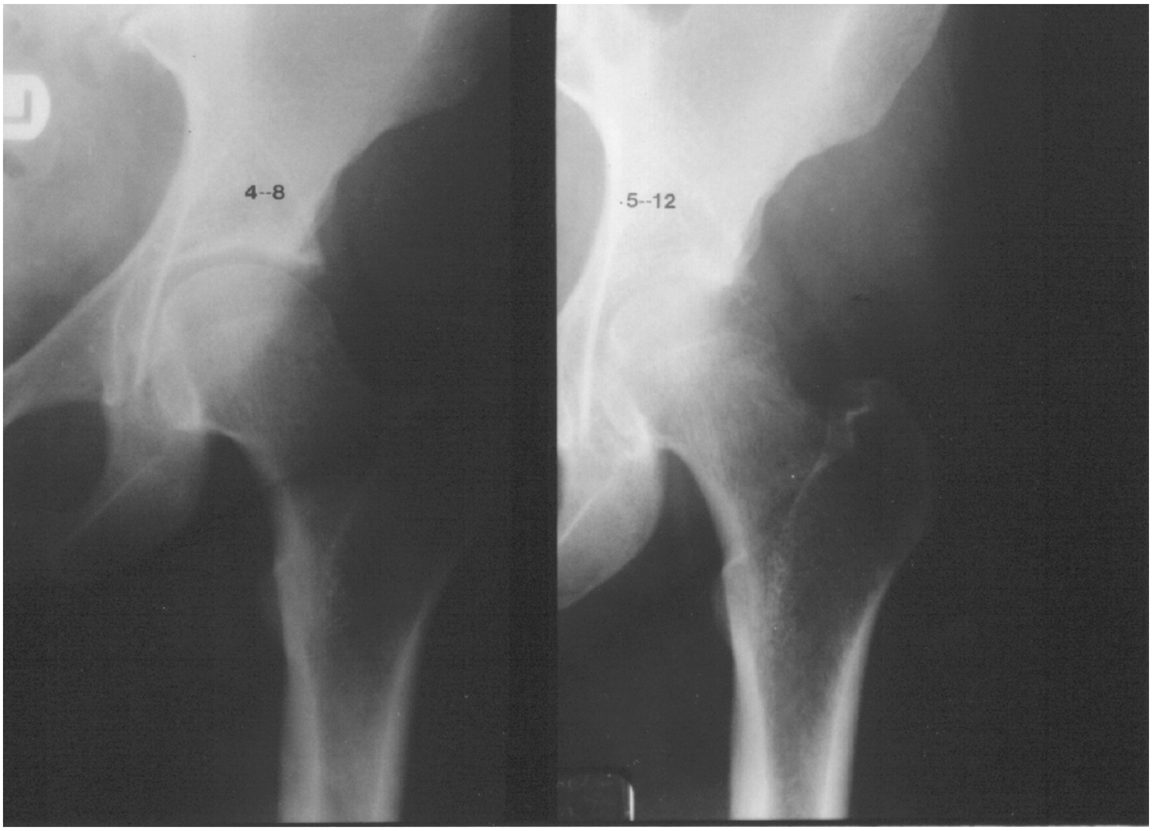

FIGURE 3.12. Radiographs of the left hip over a 5–week period demonstrating progressive joint space narrowing and loss of the normal bony subchondral dense line (“sorceil”) of the superior acetabulum. This finding is suggestive of septic arthritis.

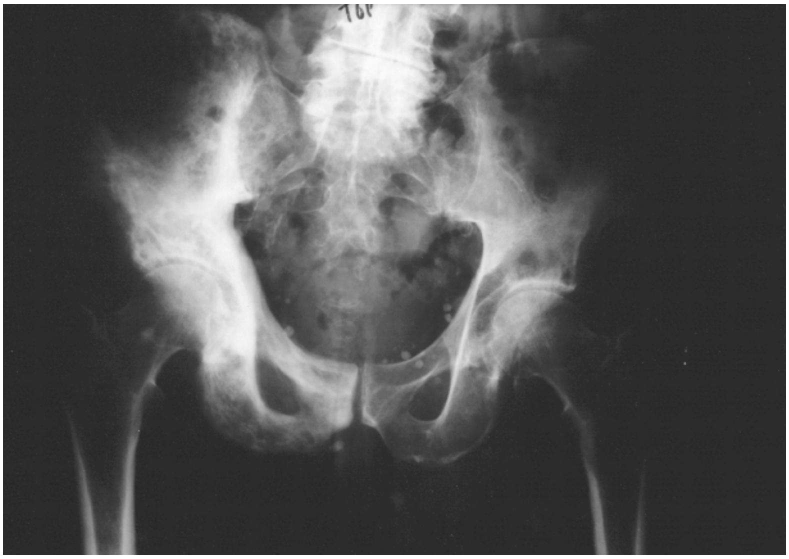

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Figure 3.13. (A) Anteroposterior radiograph of the pelvis demonstrates Paget's disease involving the right hemipelvis. There is bony sclerosis, cortical thickening, and expansion of the bone. (B) Whole body scan demonstrates an area of intense radionuclide uptake involving a large portion of the right hemipelvis (arrow). This large contiguous area of uptake is suggestive of Paget's Disease.

Other Localized Processes

The iliopsoas bursa is the largest normally occurring bursa in the body, and is present in 98% of adults. It generally measures 3–7 cm in length and 2–4 cm in width. When this bursa enlarges, it may enter the false pelvis via the retroperitoneum. Communication with the hip joint is demonstrated in approximately 15% of normal adults and 30–40% of patients with hip disease.[12] The ilipsoas bursa may fill during a hip arthrogram, especially in patients with arthritis or total hip arthroplasty. Occasionally, an iliopsoas bursa is identified on a CT scan performed for another reason. (Figure 3.14) The less experienced image interpreter can confuse iliopsoas bursa enlargement with lymphadenopathy. In patients who develop iliopsoas bursitis, there is pain in the hip region with anterior radiation to the knee. There is point tenderness inferior to the inguinal ligament and 2 cm lateral to the femoral artery, and often a palpable mass is present.

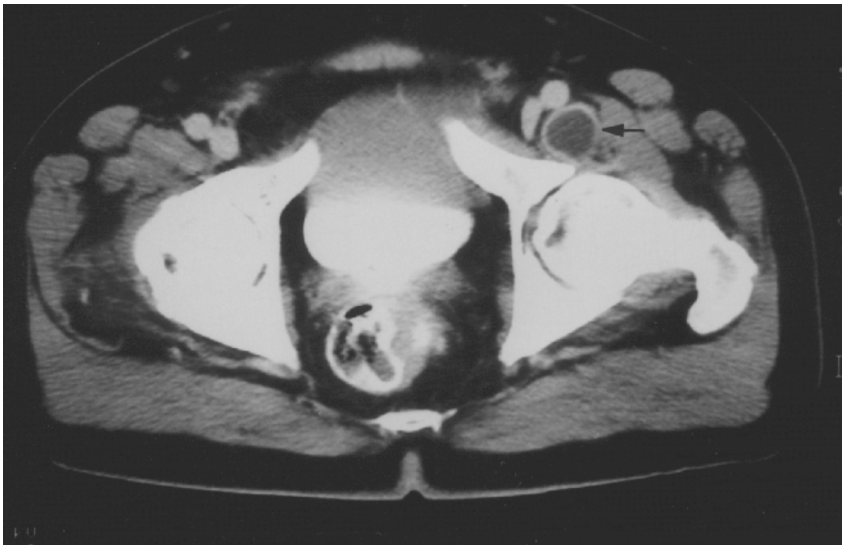
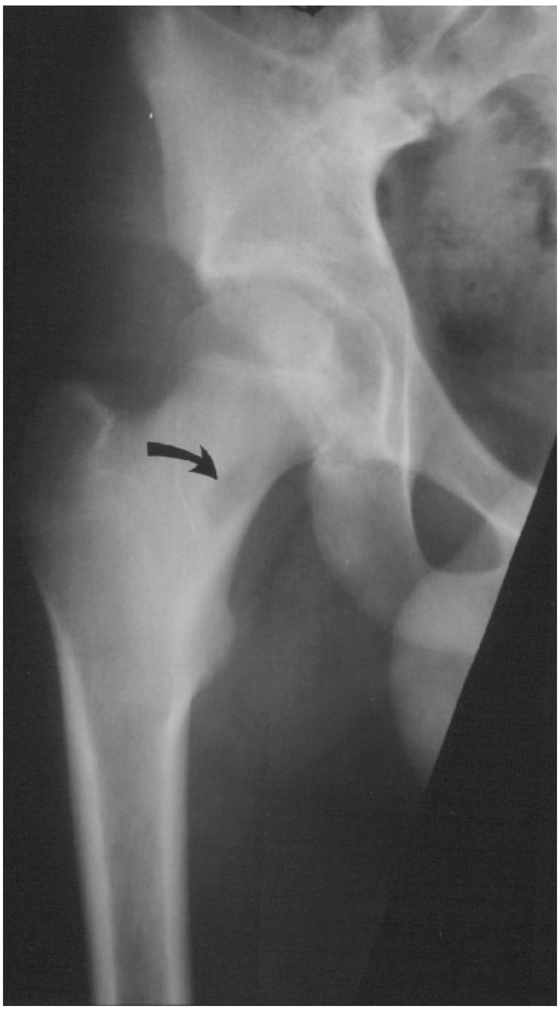


FIGURE 3.14. An iliopsoas bursa is demonstrated (arrow) anterior to the left hip joint. The mass is lower in attenuation than the surrounding soft tissue structures.

Osteoid Osteoma

In young adults, osteoid osteoma of the hip can cause pain and is difficult to diagnose because intra-articular osteoid osteomas may not evoke bony sclerosis or periosteal reaction. In the appendicular skeleton, these benign tumors are usually cortical, but intracapsular osteoid osteomas are either medullary or periosteal. (Figure 3.15) In one series, 5% of these tumors were intracapsular, and the hip is one of the most common intra-articular sites. Intracapsular lesions are often difficult to identify radiographically, and the clinical picture is confusing. These lesions are associated with nonspecific symptoms, and physical examination may reveal a joint effusion synovitis, the latter histologically characterized as lymphofollicular. Limitation of joint motion, stiffness, weakness, flexion deformity, atrophy, contracture, and epiphyseal overgrowth have also been reported in cases of intracapsular osteoid osteoma. The two most common radiographic findings are juxta-articular osteoporosis and widening of the medial joint space.

Thin-section CT is the best imaging technique for the identification and localization of the nidus of an osteoid osteoma.[13] CT is more accurate than MR imaging in the detection of the nidus. MR may be misleading due to the marked bone marrow edema or soft tissue mass which may accompany this lesion.[14,15] (Figure 3.16) In this setting, an osteoid osteoma could be falsely mistaken for a more aggressive pathologic process.



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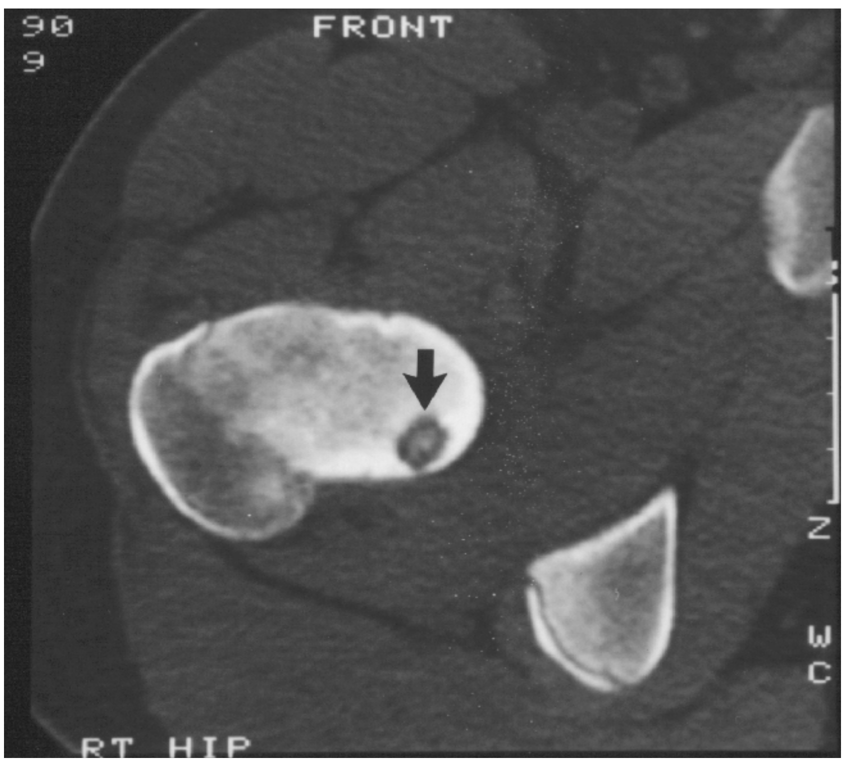


B

FIGURE 3.15. (A) Anteroposterior radiograph of the right hip in a 14-year-old boy demonstrates an ovoid radiolucency in the medial aspect of the right femoral neck (arrow). (B) Thin-section axial CT image demonstrates an osteoid osteoma of the posteromedial right femoral neck. There is some mineralization in the center of the radiolucent nidus (arrow).

FIGURE 3.16. (A) Coronal STIR MR image demonstrates bone marrow edema of the proximal left femur (arrow), as well as soft tissue reaction. MR did not demonstrate the nidus in this 14-year-old boy. (B) Axial CT image demonstrates the classic appearance of an osteoid osteoma. The radiolucent nidus is surrounded by minimal reactive sclerosis (arrow).

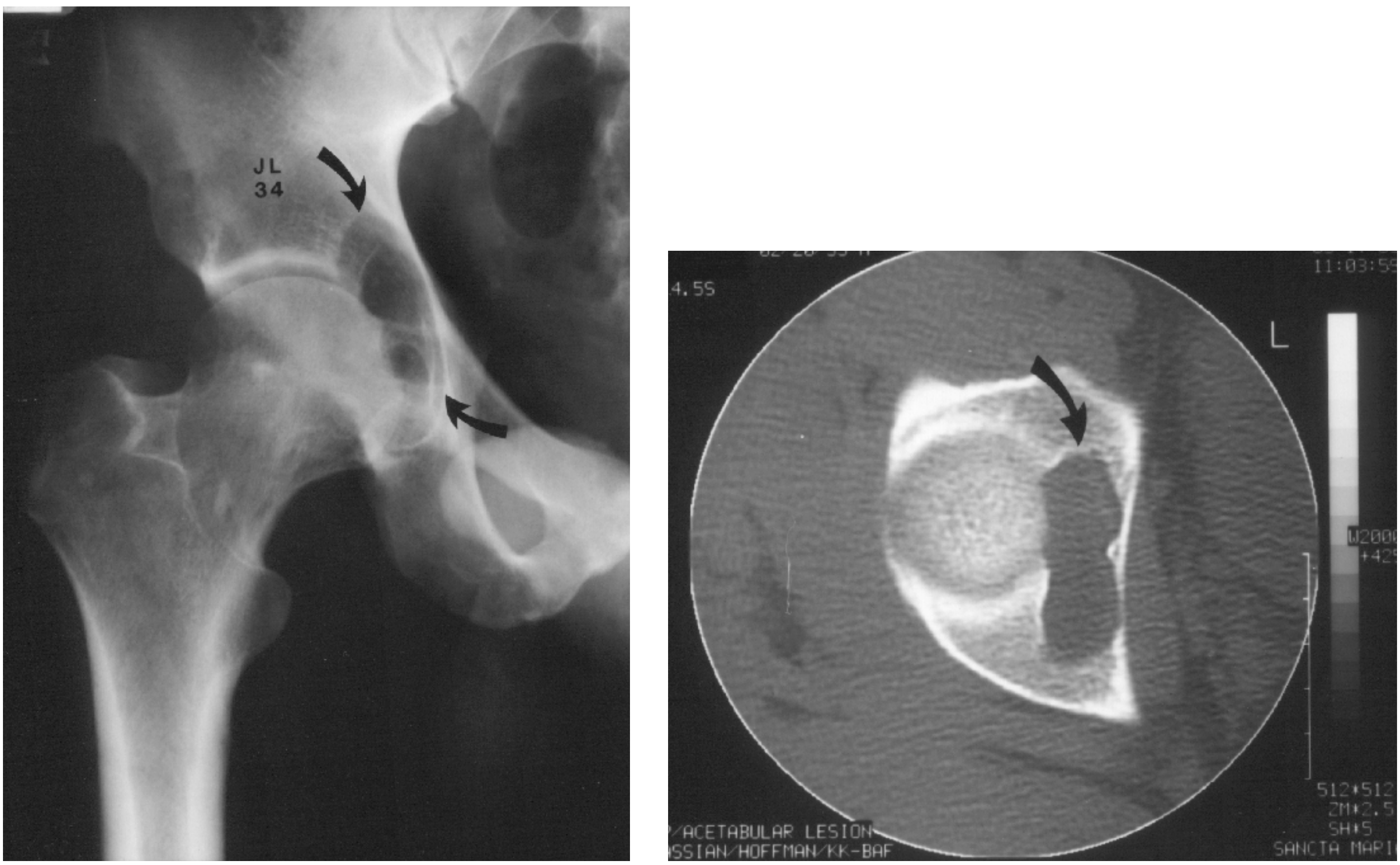
A

B

Pigmented Villonodular Synovitis

Pigmented villonodular synovitis (PVNS) is a localized monarticular neoplastic process characterized by a proliferation of synovial fibroblasts and histiocytes. It usually presents in adults between the ages of 20 and 50. There is often pain, swelling, and a limp, and the hip is the second most common site affected after the knee. The lesion is characterized by either a focal nodular or diffuse pattern characterized by multinucleate giant cells with pigmentation due to intra- and extracellular hemosiderin deposition. The lesion is highly vascular and may invade both sides of the joint, causing well-defined erosions with sclerotic margins in both the femur and acetabulum. (Figure 3.17)

The addition of MRI has improved the diagnostic accuracy, preoperative assessment, and postoperative follow-up in these patients. MRI of the hip in these patient demonstrates characteristic foci of low signal intensity on T1 and T2 imaging sequences related to the hemosiderin deposition. These patients are treated with synovectomy. However, in the hip there may be recurrence in up to half the patients.



A B

FIGURE 3.17. (A) Anteroposterior radiograph of the right hip in a 34-year-old man with right hip pain. There is a lytic, destructive lesion of the right acetabulum (arrows) with preservation of the joint space. This patient has pigmented villonodular synovitis. (B) Axial CT image demonstrates a well-defined, lytic, benign-appearing lesion of the acetabulum (arrow).

Synovial Osteochondromatosis

This benign entity manifests as multiple small osteocartilaginous loose bodies in the hip joint. Usually these calcific densities are all of the same approximate size being either small and punctate, or pea-sized. Any patient with more than five or six loose bodies in the hip joint should be considered for having synovial osteochondromatosis. This condition represents a metaplasia of the synovial lining. Despite the benign nature of this condition, the myriad ossific densities within the joint capsule can cause damage to the articular surfaces if left untreated. The sheer number of these loose bodies may cause bone erosion while still preserving the joint space and the bone density of the hip. (Figure 3.18) There have been several sporadic case reports of degeneration into chondrosarcoma.

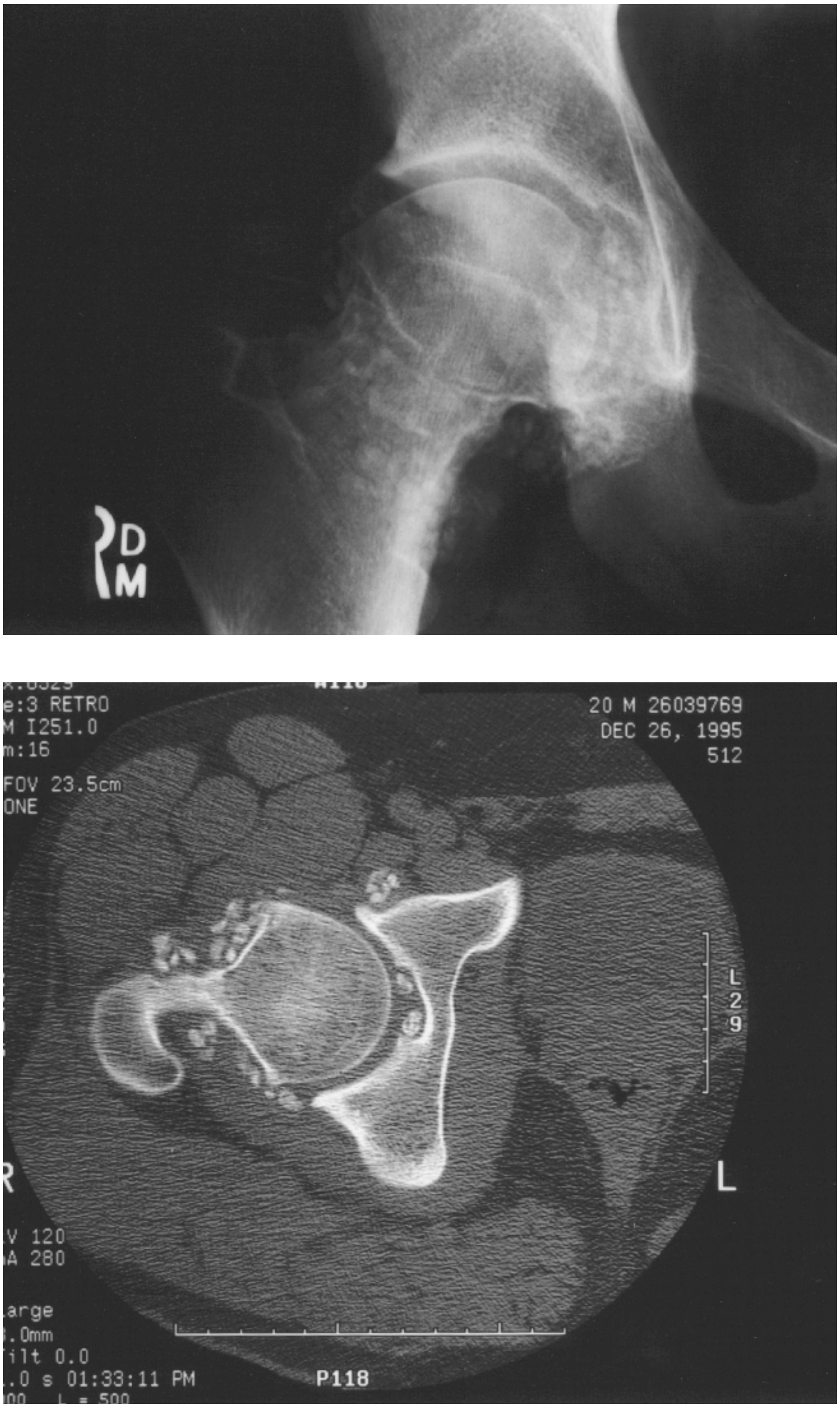


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FIGURE 3.18. (A) Anteroposterior radiograph of the hip in a 20-year-old patient with synovial osteochondromatosis. There are multiple, small osteochondral bodies in the hip joint. (B) Axial CT image demonstrates numerous intra-articular osteochondral densities. There is smooth, extrinsic erosion of the femoral neck.

MR Arthrography

Tears of the acetabular labrum may cause a patient disabling mechanical symptoms limiting the daily activities of individuals or the competitive participation in athletes. A labral tear may be a starting point for degenerative disease. The importance of early diagnosis and treatment of these labral abnormalities may prevent the onset of osteoarthritis and may also provide significant relief for those patients with debilitating hip pain.[16] Unfortunately, tears remain an elusive clinical diagnosis. Symptoms are often vague and nonspecific. The history and findings may suggest such other etiologies as osteoarthritis, synovitis, juxta-articular soft tissue abnormalities, osteonecrosis, or stress fracture.

Conventional MRI is limited in evaluating the labrum due to the variability in labral size and shape. Its evaluation is severely limited in most cases by the collapsed joint capsule against the acetabular rim and by the difficulty in distinguishing tears from pseudotears.[17] Magnetic resonance arthrography should be reserved for the preoperative assessment of patients with chronic hip symptoms and negative results from conventional imaging studies. This procedure converts MRI from a noninvasive examination to an invasive procedure requiring an injection into the hip under fluoroscopic guidance. The principle of the procedure relies upon capsular distension, thereby outlining the labrum with contrast and filling any tears that may be present. The acetabular labrum creates a fibrocartilaginous rim that effectively deepens the hip socket and increases the surface area of the hip articulation. (Figure 3.19) The acetabular labrum is usually triangular but can be rounded or flattened along its free margin.[17] Normal recesses occur at the junction between the labrum and the articular cartilage. It can be difficult to differentiate a labral sulcus from a true labral tear. The iliofemoral ligament is a normal structure that is one of the major hip stabilizers originating from the anterosuperior acetabular rim and then coursing inferolaterally in the anterior hip capsule to insert onto the intertrochanteric ridge.

A labral tear may lead to the formation of a labral or extra-articular cyst allowing communication with the joint, and such cysts may fill with contrast after an intra-articular injection. Patients with acetabular dysplasia commonly develop labral disorders and present with symptoms that collectively are known as the acetabular rim syndrome. These patients often have recurrent episodes of groin pain. Hip dysplasia patients are susceptible to the development of labral tears because the femoral head translocates superolaterally and impinges on the acetabular rim.[17] (Figure 3.20) The articular cartilage is more difficult to evaluate in the hip than in other arthrographically studied joints, because it is difficult to get maximum capsular distension of the hip. Without the use of traction, the opposing femoral head and acetabulum are in tight apposition. In patients with labral tears, cartilage lesions are common and first develop adjacent to the torn labral fragment.[17]

FIGURE 3.19. Coronal T1W1 with fat suppression post intra-articular gadolinium demonstrates a normal superior acetabular labrum (arrow) and iliofemoral ligament (white arrow).

A
B


FIGURE 3.20. (A) Fluoroscopic image of a patient with DDH. There is contrast material and gadolinium in the hip joint. Note the shallow acetabulum and diminished CE angle. (B) Coronal T1 fat-suppressed image demonstrates developmental dysplasia of the hip. The femoral head is uncovered by the acetabulum.

MR Arthrography Technique

In order to avoid excessive synovial resorption of fluid, the MRI study should begin no later than 30–45 minutes following completion of the injection. Some investigators advocate instilling approximately 0.3 cc of epinephrine (1:1000) into the fluid mixture in order to slow resorption. We generally find this unnecessary. MRI arthrography may be performed with dilute gadolinium solution in sterile saline, or with saline alone. In general, gadolinium MRI is preferable by virtue of the fact that the injected fluid is bright on T1 weighted images, allowing differentiation from noncommunicating cysts, bursae, and other preexisting extra-articular fluid collections.

With the patient in the supine position on the fluoroscopy table, the hip joint is localized. The hip is maintained in neutral position, the puncture site is selected, the overlying skin is marked and cleansed with an iodine solution, and sterile drapes applied. Superficial and deep local anesthetic (1% Lidocaine mixed with sodium bicarbonate) is infiltrated along the expected needle course. The anterior joint capsule extends down to the trochanteric ridge. In order to avoid the femoral vessels, the capsule is punctured overlying the outer half of the femoral neck. In many cases, a needle course directly perpendicular to the skin is possible. With some patients, particularly if obese, an oblique approach from a more laterally positioned skin entry site is necessary.

A 9 cm, 20 gauge spinal needle is advanced down to the cortical surface of the femoral neck, and intracapsular location is confirmed with the injection of 2 cc of iodinated, nonionic contrast material. Approximately 8 cc of a very dilute solution of gadolinium in nonbacteriostatic sterile saline (1:150–1:200) is then instilled into the hip joint. The procedure is performed under direct fluoroscopic control in order to assure that there is no inadvertent extracapsular injection. A spot radiograph is obtained at the completion of the procedure, documenting intracapsular contrast material. The patient is then transferred to the MRI scanner. In order to optimize detail, a small phased-array coil is placed directly over the symptomatic hip. Imaging is performed in the coronal, sagittal, oblique sagittal, and axial planes. The oblique sagittal plane is of particular value in evaluating the anterior acetabular labrum. This sequence is obtained in an axis roughly parallel to the superior labrum and lateral femoral neck. (Figure 3.21) On fat-saturated, T1-weighted images, the gadolinium solution will be intensely bright while the adjacent soft tissue signal will be suppressed. This heightens the conspicuity of labral tears. Extracapsular fluid collections, including noncommunicating bursitis as well as soft tissue and bone marrow edema, muscle injury, etc will not be visible on the T1 weighted, fat-suppressed images. Therefore, at least one proton density or T2 weighted sequence is necessary in order to identify bone and extracapsular soft tissue pathology.

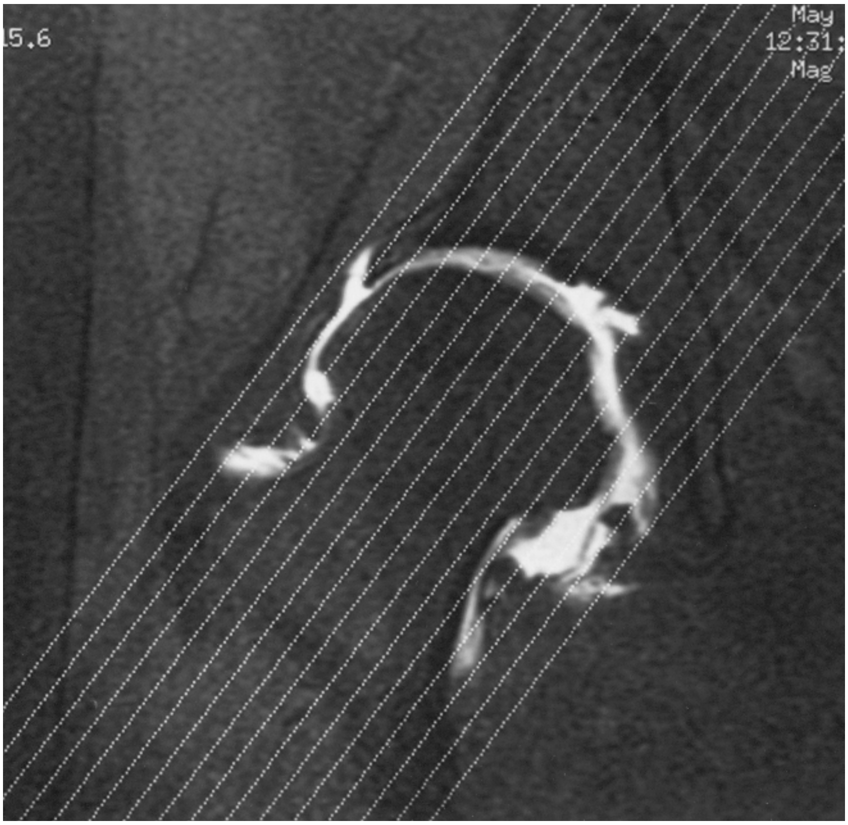


FIGURE 3.21. This scout view of the hip demonstrates the image plane for the oblique sagittal sequence. Imaging along this plane best shows the acetabular labrum.

On MR arthrography, labral tears manifest as an abnormal, linear extension of high-signal-intensity gadolinium solution into the labrum, labral blunting, or detachment of the labrum from the underlying bone. (Figures 3.22 and 3.23) Paralabral cysts may accompany labral tears. The normal labrum has a uniform, very low signal intensity, appearing black on MRI. (Figure 3.24) With labral degeneration, there is abnormal intermediate (gray) signal within the labrum, but labral contours are preserved, and there is no imbibing of gadolinium into the substance of the labrum. (Figure 3.25) Normal hyaline cartilage manifests intermediate to bright signal on MRI, although typically less intense than that of gadolinium solution. The articular cartilage should be carefully evaluated on all imaging planes. The gadolinium solution will outline the articular margins, defining any cartilage defects. (Figure 3.26) Other features of osteoarthritis, such as subchondral cysts, will also be depicted. Osteochondral bodies are represented by low-signal-intensity filling defects within the gadolinium solution. (Figures 3.27 and 3.28)

The ultimate value of MRI arthrography will depend on the success and accuracy of hip arthroscopy and its use as a treatment modality to alleviate the patient's signs and symptoms. Presumably, early detection and treatment of labral abnormalities might also delay the onset of osteoarthritis. Although many patients with acetabular labral tears, chondral flaps, or loose bodies experience improvement following arthroscopic treatment, the long-term benefits of this treatment modality have not yet been proven.

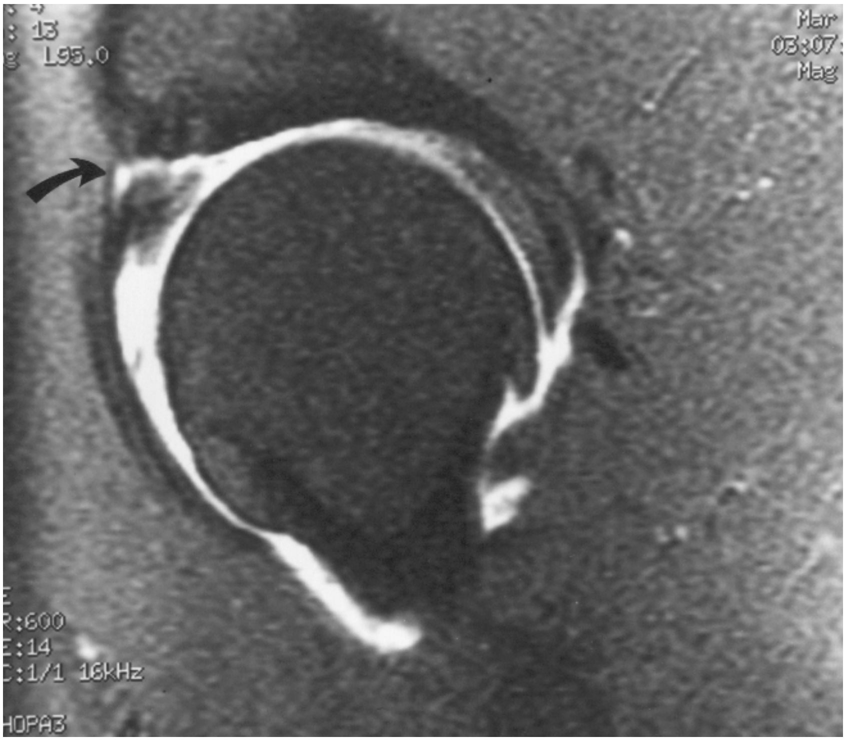


FIGURE 3.22. Sagittal T1 weighted, fat-suppressed image from a gadolinium MR arthrogram demonstrates a large tear of the anterior labrum. (arrow) In addition, there are degenerative changes of the hip joint.

FIGURE 3.23. Oblique sagittal T1W1 with fat suppression demonstrates a torn anterior labrum (arrow). Note a normal posterior labrum (arrowhead).

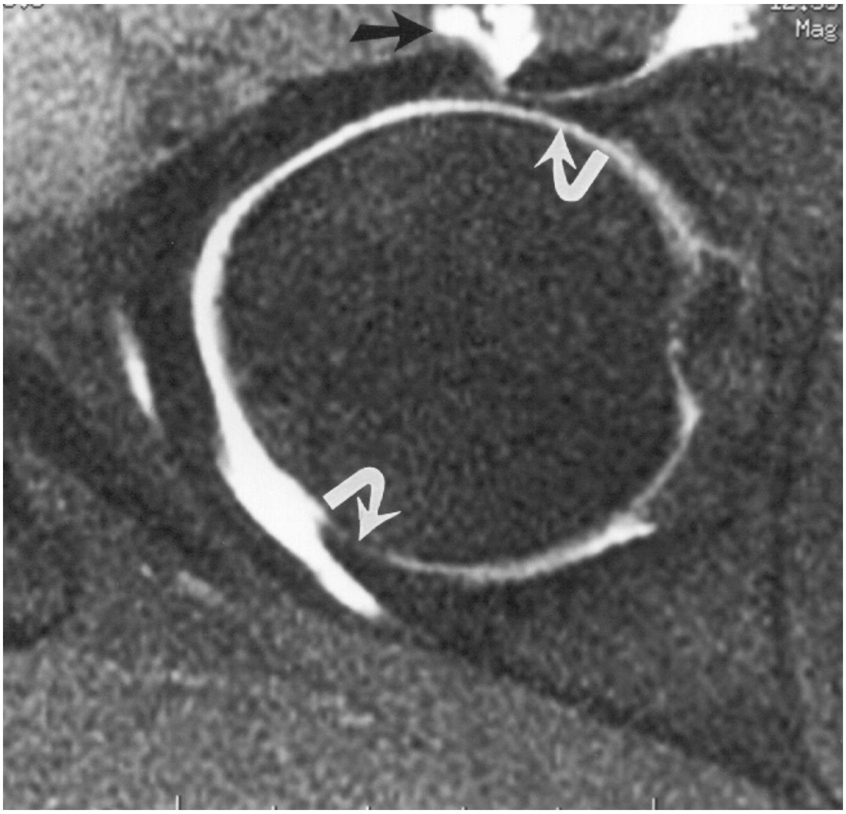
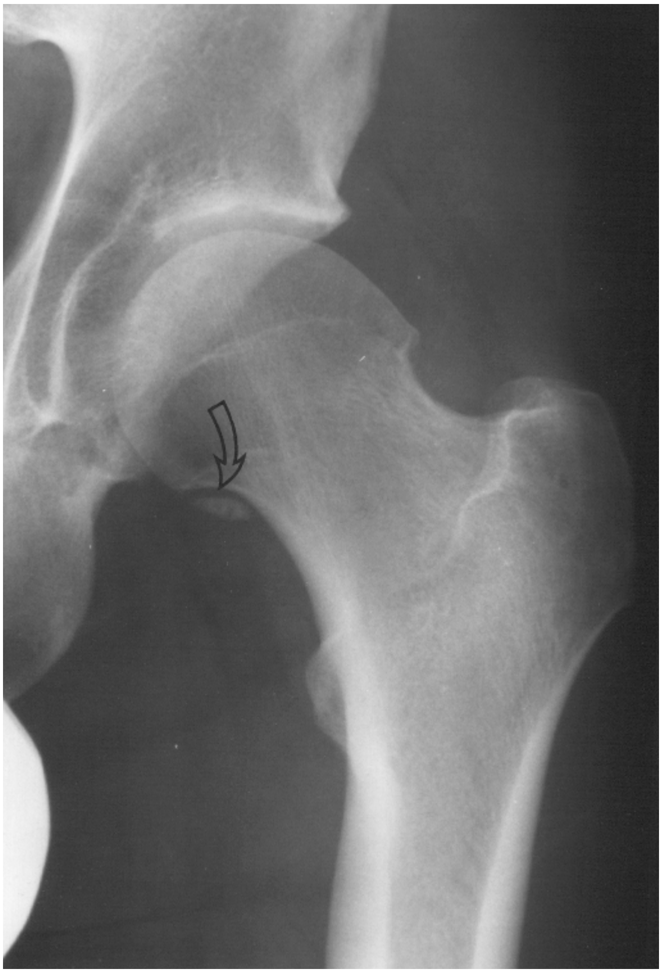


FIGURE 3.24. Axial T1W1 with fat suppression post instillation of gadolinium demonstrates normal anterior and posterior labrum (curved arrows). The contrast material enters a communicating iliopsoas bursa (straight arrow).

FIGURE 3.25. Coronal fat-suppressed T1W1 post intra-articular gadolinium administration demonstrates an enlarged, swollen, degenerated superior labrum (arrow) characterized by abnormal signal and morphology of the labrum. Gadolinium has been imbibed into the labral substance.

FIGURE 3.26. Coronal fat-suppressed image from a MR arthrogram demonstrates loss of femoral head and acetabulum articular cartilage (arrows). A small osteophyte is seen on the superolateral femoral head.



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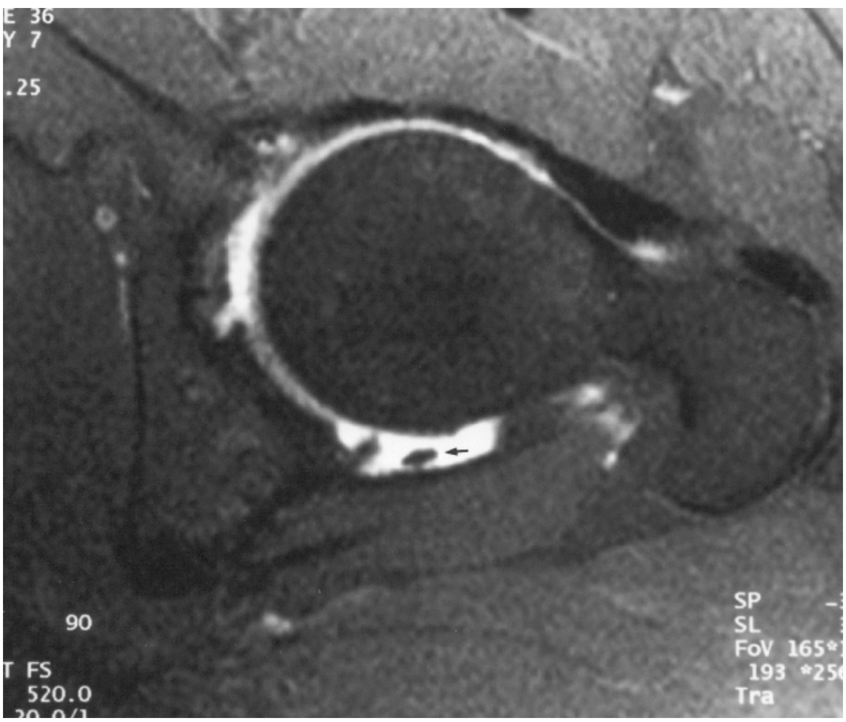

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FIGURE 3.27. (A) Anteroposterior radiograph of the left hip demonstrates a loose body (arrow), as well as early degenerative change of the femoral head. (B) Axial T1 weighted, fat-suppressed image with gadolinium in the left hip joint demonstrates a loose body (arrow) in the posterior aspect of the joint. Several other loose bodies were identified on other images.

FIGURE 3.28. Coronal fat-suppressed T1W1 post gadolinium demonstrates a distended left hip joint capsule with multiple filling defects (arrows) in a patient with synovial osteochondromatosis.

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4
Treatment Algorithms

Christian P. Christensen, Joseph C. McCarthy, and Jo-ann Lee

During the history and physical, the clinician should note whether the hip pain is primarily in the anterior groin, in the buttocks or posterior thigh, or in the lateral aspect of the hip and thigh. Though there is some overlap, each of these regions has particular etiologies of pain associated with it.

Anterior Pain

If patients with acute anterior groin pain following injury have negative radiographs and are able to ambulate and bear some weight, they deserve a trial of analgesics and rehabilitation, as the majority of them will improve. If they do not demonstrate some improvement within 2 weeks, the physical examination and radiographs should be repeated. Radiographs can demonstrate a stress fracture, osteonecrosis, or even cancer that was not evident on previous films. If radiographs continue to be normal, strong consideration should be given to an MRI, which can demonstrate bone edema due to an impending stress fracture or stage I osteonecrosis.

Patients thought to have chronic anterior hip pain can generally be divided into those who are tender and those who have mechanical symptoms. Rarely, disc or nerve root pathology in the upper lumbar levels can refer causalgic pain via the L2–L3 dermatomes.[1] Many patients with anterior groin or thigh pain are "weekend warriors" who present with a chronic strain of the rectus femoris or the iliopsoas musculature. Usually, such patients have made the diagnosis but seek medical attention because they are not getting well as quickly as they think they should. These patients generally require reassurance, and should be instructed in stretching and strengthening exercises. Rarely, some patients who think they have a "pulled muscle" will have an avulsion fracture noted on plain films at the rectus femoris origin, ie the anterior inferior iliac spine or at the insertion of the iliopsoas on the lesser trochanter. These patients do well with conservative therapy.

Patients with adductor tendinitis will often have anterior and medial pain and tenderness at the muscle's origin on the pubis, and will often have increased pain with resisted active adduction of the lower extremity. These patients often have a history consistent with overuse or muscle strain and can typically be treated successfully with analgesics and rehabilitation. Tenotomy of the adductor longus tendon may result in good long-term functional outcomes in patients who are not helped with conservative management.[2]

Iliopectineal bursitis, or iliopsoas bursitis, can also be responsible for pain due to inflammation of the bursa that lies beneath the iliopsoas muscle and tendon as they pass over the pelvic brim. Patients typically present with the hip flexed, externally rotated, and abducted in order to minimize symptoms. This condition typically responds to rest and local heat. Cortisone injections can sometimes work on this condition as well.[1]

Osteitis pubis and athletic pubalgia are conditions in the lower abdomen that can result in groin pain. Patients with osteitis pubis will have pain in the lower abdomen or groin that is greatly increased by resisted adduction of the lower extremity. This overuse injury often occurs in high-level athletes and is initially treated conservatively with ice and analgesics. Later, the patient is treated with stretching exercises. Only rarely do cases not improve with conservative treatment. (See Chapter 2.) Instability of the pubic symphysis demonstrated radiographically by flamingo views has been documented in recalcitrant cases.[3]

Abnormalities of the abdominal wall, including small inguinal hernias or microtears of the internal oblique muscle, can result in "athletic pubalgia" and be an overlooked source of groin pain in athletes. The evaluation of these patients is difficult, and radiographs are typically normal. Treatment includes NSAIDs, rest, and avoidance of provocative activities. Cases that do not improve with conservative management may be successfully treated with a modified Bassini herniorrhaphy.[4]

Pubic instability associated with pain and sometimes clicking can be due to excess motion at the pubic symphysis. This instability is usually secondary to trauma during childbirth, but can also be due to repetitive microtrauma in the athlete. Flamingo view radiographs can confirm this diagnosis when alternating weightbearing views demonstrate 2 mm or more

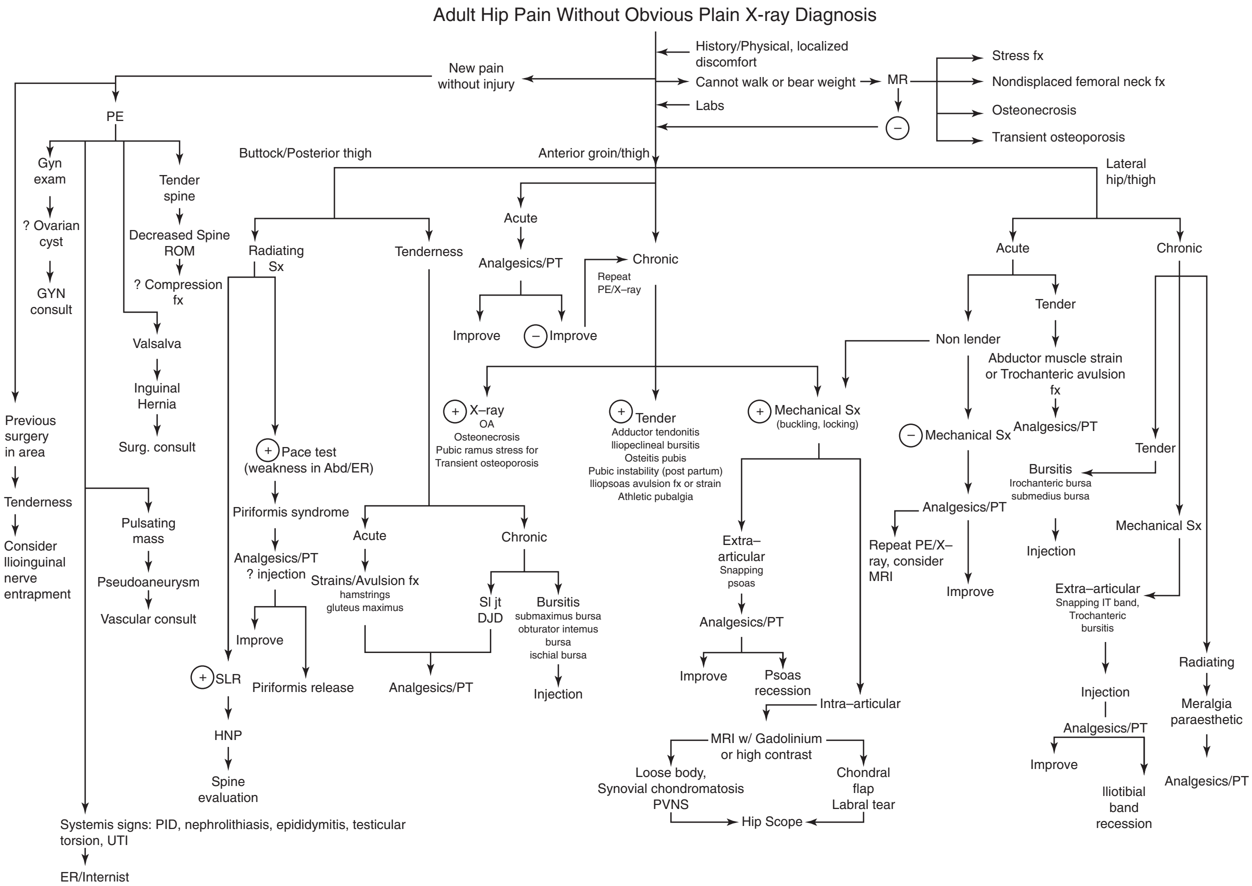

FIGURE 4.1. An algorithm for the evaluation and treatment of non-arthritic hip pain in young patients.

displacement of the symphysis. NSAIDs and compression shorts can often help alleviate symptoms, but surgical intervention is occasionally required to treat the instability.[5]

Mechanical symptoms such as buckling, locking, and giving way are frequent in patients with chronic anterior groin pain. An effort must be made during the physical examination to decide whether the mechanical symptoms are intra- or extra-articular. The chief extra-articular cause is "snapping hip syndrome." (See Chapters 1 & 2.) The snapping psoas can be confirmed by placing the patient in the supine position and having him or her recreate the "snapping" by moving the hip from a flexed and abducted position to an extended and adducted position. The examiner can then corroborate the diagnosis by asking the patient to repeat the maneuver and successfully blocking the iliopsoas from "snapping" with digital pressure over the femoral head. Iliopsoas bursography followed by fluoroscopic examination of the hip has been described, but is rarely required for diagnosis.[6]

Typically, this condition responds to NSAIDs and avoidance of the activities that cause the snapping. For chronic, painful snapping, stretching exercises and cortisone injections usually help. Rarely, lengthening of the iliopsoas tendon through an anterior approach is required for recalcitrant cases. A similar clinical picture can be created by a bony prominence at the iliopectineal ridge, an exostosis of the lesser trochanter, or by a chronically inflamed iliopsoas bursa. These conditions generally respond to similar conservative modalities.[6]

Patients who complain of clicking, locking, or giving way tend to have labral tears or loose bodies. Additionally, a positive Thomas flexion to extension test on preoperative exam correlates positively with acetabular labral tear noted at arthroscopy.[7] Intra-articular sources of mechanical symptoms are generally evaluated with an MRI with gadolinium or high-contrast material in the joint. Marcaine or lidocaine injected intra-articularly with the contrast can often provide temporary relief, confirming that the source of discomfort is within the joint. High-quality MRIs with specialized sequences can frequently demonstrate chondral flaps, labral tears, loose bodies, synovial chondromatosis, or pigmented villonodular synovitis (PVNS). In general, these conditions respond poorly to conservative management and can be confirmed and simultaneously treated by hip arthroscopy.

Posterior Pain

Patients with buttock and/or posterior thigh pain can often be divided into those with radiating symptoms and others with tenderness. Patients with radiating symptoms often have a positive straight leg raise, indicating a possible herniated disc requiring a consult from a spine surgeon. Radiating symptoms can also be caused by a piriformis syndrome.[8] These patients will complain of buttock pain and/or sciatica that can increase with physical activity, including simple adduction and internal rotation. Sitting on hard surfaces can predispose to piriformis pain, causing a "hip pocket neuropathy" or "wallet neuritis." A positive Pace sign, demonstrated by weakness in resisted abduction and external rotation, confirms the diagnosis. Rectal examination also reveals tenderness over the piriformis tendon. This condition is typically treated with analgesics and stretching the piriformis muscle with hip internal rotation, adduction, and flexion. Corticosteroid injections have been described medially,[9] laterally,[10] and caudally[11] and can provide diagnostic data and simultaneous therapeutic benefit. Using CT scan guidance to perform these injections is a good idea for those who are less experienced. Cases refractory to conservative management require piriformis release to relieve the pressure on the underlying sciatic nerve.[12]

Tenderness about the buttock or the posterior thigh should be divided into acute and chronic cases. Acute cases are often caused by avulsion fractures or myotendinous strains of the hamstrings or gluteus maximus. Avulsion fractures can generally be seen on plain radiographs. Strains can often be delineated only by tenderness about the region with an appropriate history. Both avulsion fractures and strains can generally be treated with analgesics and rehabilitation. Hamstring tears are high-energy injuries that are not be confused with strains. These patients are very debilitated, have diffuse ecchymosis and pain in the posterior thigh, and often require repair of the hamstrings.

Chronic tenderness in the buttock and posterior thigh is often due to either bursitis or sacroiliac degenerative joint disease. Sacroiliac degenerative joint disease should be confirmed with a Ferguson view demonstrating arthritis in the joint. This condition can generally be treated with NSAIDS, steroid injections, and rehabilitation. Septic sacroilititis is an uncommon entity but should be kept in mind, and a hip pyarthrosis has to be ruled out. Patients will generally be immunocompromised, have a history of drug abuse, a recent respiratory or genitourinary infection, or will have had some seemingly insignificant trauma in the region, eg acupuncture, tattoo, or intramuscular injection.[13]

Ischial gluteal bursitis is frequently noted on the underside of the ischium where the patient sits. Obturator internus bursitis is located posteriorly on the lateral aspect of the obturator foramen. The submaximus bursa is located beneath the gluteus maximus on top of the short external rotators just behind the greater trochanter, and this too can become inflamed and cause pain. All of these bursae can be diagnosed and cured simultaneously with a lidocaine and corticosteroid injection.[14]

Lateral Pain

Lateral hip and thigh pain should initially be classified into acute and chronic injuries. Acute injuries are notable for tenderness or mechanical symptoms. The tender region is usually on or around the greater trochanter, and an accurate history should help delineate whether the injury was caused by a direct or indirect mechanism. If the region of maximal tenderness is right over the proximal portion of the greater trochanter, the AP radiograph should be evaluated closely in order to rule out a trochanteric avulsion fracture. If the radiograph is negative, the patient likely has a strain or tear of the gluteus medius at its insertion on the greater trochanter. Both of these injuries can be treated conservatively with crutches or a cane in order to minimize the resultant limp from this sort of injury. Acute injuries can often have mechanical symptoms, such as buckling or locking, associated with them. These mechanical symptoms are due to intra-articular lesions, though extra-articular causes, such as a snapping iliotibial band, should be ruled out. Conditions suspicious for intra-articular etiologies warrant an MRI with gadolinium with lidocaine or marcaine. Positive intra-articular findings demonstrated on MRI and temporary pain relief due to the anesthetic agents injected are generally managed using hip arthroscopy.

Patients with chronic lateral hip and thigh pain should be divided into those with radiating symptoms, those with mechanical symptoms, and those with tenderness over the lateral aspect of the hip. Patients with radiating symptoms may have myalgia paresthetica due to pressure or damage to the lateral femoral cutaneous nerve. These patients are typically handled with analgesics and rehabilitation. Rarely, injections can benefit people with this condition.

Patients with chronic mechanical symptoms should be examined carefully in order to delineate whether the source is intra- or extra-articular. Patients with intra-articular causes are typically managed with an MRI, followed by hip arthroscopy if intra-articular pathology is identified. A snapping iliotibial band is the primary case of extra-articular mechanical symptoms on the lateral aspect of the hip. (See Chapters 1 and 2.) Patients with a snapping iliotibial band often improve with a corticosteroid injection to decrease the inflammation in the bursa underlying the iliotibial band. This often improves the patient's symptoms, with concurrent rehabilitation aimed at stretching and strengthening the iliotibial band. Avoiding provocative activities is imperative for these patients. Rarely, the patient fails to improve with conservative management. In these cases, possible operative intervention includes trochanteric bursa excision and iliotibial band recession.[6]

Most patients with lateral hip and thigh pain have tenderness due to trochanteric bursitis. In this case, the bursa underlying the iliotibial band on top of the greater trochanter becomes chronically inflamed, causing pain and sometimes crepitus on hip flexion and extension. The condition can be diagnosed and treated with a lidocaine and corticosteroid injection. The lidocaine injection within the bursa anesthetizes the bursa and relieves the patient's symptoms and discomfort. The steroid helps control the inflammation long term. Patients will occasionally require a reinjection, and very rarely will go on to open debridement of the bursa in the operating room.

Rarely, tenderness on the lateral aspect of the hip just proximal to the greater trochanter can be due to inflammation of the submedius bursa. This bursa is generally located deep to the gluteus medius tendinous insertion on the greater trochanter, and also responds well to injection. More commonly, tenderness just proximal to the greater trochanter occurs secondary to a tendinopathy of the gluteus medius. This conditon generally responds to therapy and nonsteroidals.

Conclusion

Most hip pain in skeletally mature patients without an obvious radiographic diagnosis is due to musculotendinous injury and resolves with conservative treatment. The first step in management is an accurate history and physical. Usually, this is followed by a standard radiographic series and occasionally by laboratory studies. Most patients with intra-articular pathology will have anterior groin pain. Patients with mechanical symptoms should be treated aggressively by an orthopedic surgeon. Patients with intra-articular sources of buckling and locking should be imaged with a specialized MRI with gadolinum or high contrast in order to rule out intra-articular pathology. Many hip surgeons will add Marcaine or lidocaine to the dye if they are not sure if the source of pain is inside the joint or outside. These patients are the most likely to be helped by hip arthroscopy and should be treated aggressively. Patients with new anterior hip pain without obvious injury should be queried and closely examined to rule out general surgical, gynecological, urological, or vascular sources. Patients with posterior thigh and buttock pain should be evaluated closely to rule out spine etiologies. Patients with lateral hip and thigh pain generally have symptoms due to problems associated with the greater trochanter or iliotibial band, and generally respond to conservative measures. In all, it is important to evaluate these patients with care initially and to reevaluate them if they are not better within 2–3 weeks. One must follow a stepwise progression in the management of these complicated patients in order to better utilize health care dollars and to prevent excessive long-term disability and pain.

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Section II
Operative Preparation

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5 Anatomy

Brian D. Busconi

The pelvis is formed from the fusion of three separate centers of ossification: the pubis, ischium, and ilium. All fuse into a single bone by early adolescence. The site of convergence and fusion of all three centers of ossification is the triradiate cartilage, which eventually fuses and forms the mature acetabulum. In addition to these primary centers of ossification, the adolescent has seven other centers of secondary ossification, which include the iliac crest, ischial apophysis, anterior inferior iliac spine, pubic tubercle, angle of pubis, ischial spine, and the lateral wing of the sacrum. These secondary centers of ossification must be recognized on x-ray, and knowledge of fusion is mandatory for a diagnosis of fracture or avulsion to be made.

Proximal femoral development occurs as a result of the fusion of three separate centers of ossification: the femoral head, the greater tuberosity, and the lesser tuberosity.[1] Staheli has documented the changes of the proximal femur from the neonate to the adult.[2] The neck shaft angle, which begins at 155 degrees in the neonate, decreases to 130 degrees, and the anteversion of the femoral neck, which begins at 40 degrees in the neonate, decreases to 10 degrees in the adult. These developmental changes can affect the biomechanics of the proximal femur, increasing vulnerability to injury from either trauma or repetitive stresses. Similar to the glenoid cavity of the shoulder, the acetabulum has a fibrocartilaginous labrum attached to its margins. Contrary to the shoulder, the acetabular labrum increases the depth of the joint rather than increasing its diameter. The labrum does not form a complete circle and is continued inferolaterally as the transverse ligament across the acetabular notch. The acetabular fossa lies in the inferomedial portion of the acetabulum and is filled with the triangular-shaped ligamentum teres and the pulvinar (fat and connective tissue). The fovea capitus (bare area) is a small depression on the medial femoral head, which is the insertion site for the ligamentum teres. (Figure 5.1) The fibrous capsule of the hip joint is reinforced by three prominent thickenings of the joint capsule: the iliofemoral, the pubofemoral, and the ischiofemoral ligaments. The iliofemoral ligament (ligament of Bigelow) is the thickest and strongest. This ligament inserts on the intertrochanteric line, resulting in more than 95% of the femoral neck being intracapsular. The zona orbicularis, the name given to the deep circular fibers of the iliofemoral ligament, may be mistaken arthroscopically for the acetabular labrum. The iliopsoas bursa, directly anterior to the hip joint, communicates with the joint in 15% of normal anatomic specimens. It is often not shown arthrographically, but it may be seen in chronic joint distention with synovitis (Figure 5.2).

Because of its ball-and-socket configuration, the hip joint has a unique degree of internal stability. Despite this, there is great mobility between the femoral head and the acetabulum. The motion in the hip joint is in three planes, sagittal, frontal, and transverse, with the greatest motion in the sagittal plane. To perform activities of daily living, flexion of a least 120 degrees, abduction of 20 degrees, and rotation of 20 degrees are requested, but to participate in sports a significantly greater range of motion is often necessary. During slow walking, the maximum force that is transmitted across the hip joint is about 1.6 times body weight. In running, the force increases to 5 times body weight during the stance phase.

The blood supply to the hip joint is profuse, but the blood supply to the femoral head itself is more tenuous.[3–5] Until physeal closure (14–17 years of age), metaphyseal and epiphyseal blood supplies are separate. Throughout childhood and into adolescence, femoral blood supply is primarily provided by the terminal branches of the medial femoral circumflex artery. These terminal branches form two retinacular vascular systems, posterior–superior and posterior–inferior. The lateral circumflex system is significant until 5 or 6 years of age and supplies blood only to the anterior half of the femoral head.[4,6] This specific arrangement of medial blood supply and poor anastomosis makes the femoral head highly susceptible to avascular necrosis from injury to the physis or femoral neck (Figure 5.3). Numerous short and long muscles control the hip joint. The main function of the musculature is to meet the requirements of efficient walking—to maintain stability of the weightbearing leg despite continued change in limb and body position, and to move the body for-

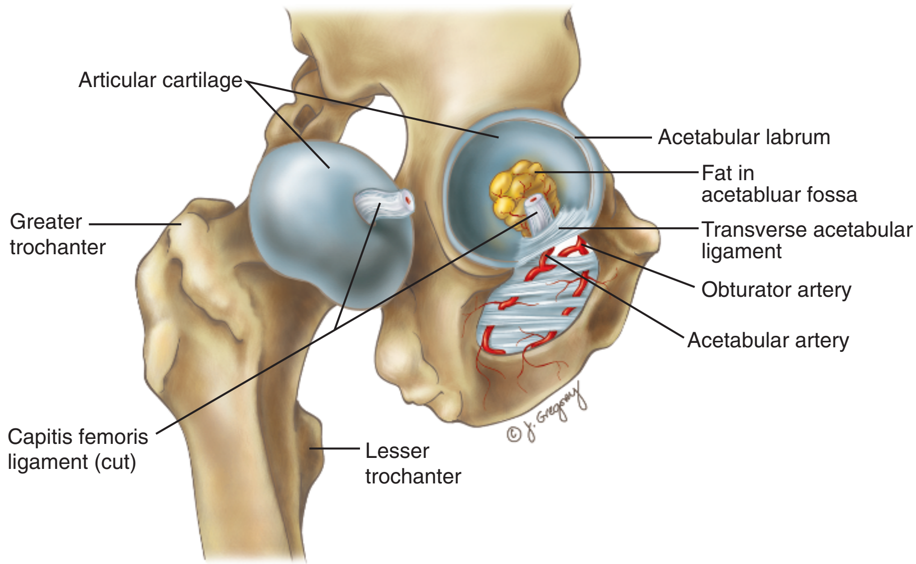

FIGURE 5.1. Drawing of the intra-articular structures of the hip.

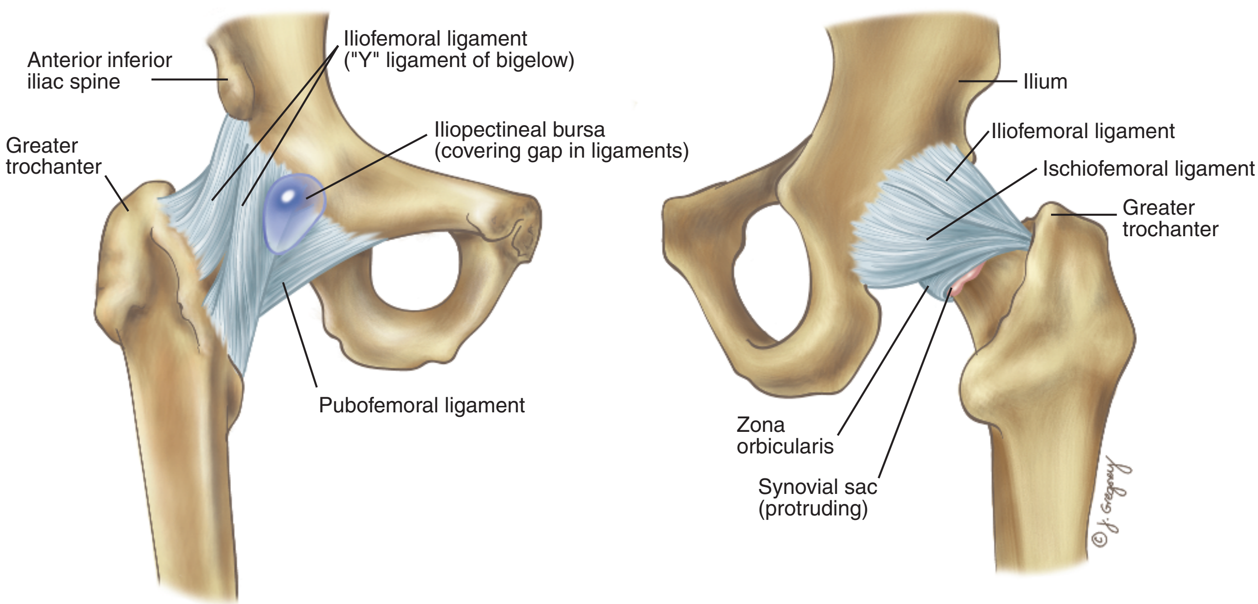

FIGURE 5.2. Drawing of the ligaments as they are attached to the hip.

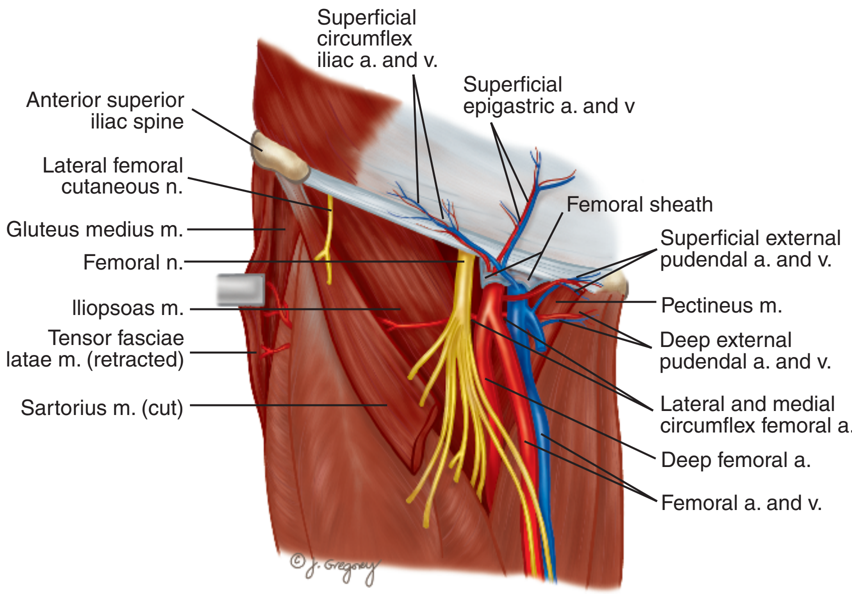

FIGURE 5.3. Drawing of the major blood vessels that supply the hip.

ward. Stability is gained by muscle action to resist the force of gravity, which acts to pull the body downward. Because the human frame is top-heavy, with much of its mass above the pelvis, large muscular forces are required to maintain stability. Also, because the center of gravity must move from behind the supporting stance-phase foot to ahead of the stance-phase foot to move the body forward, the demands on the muscles are constantly changing. The force to propel the body forward is derived from accelerating the swing-phase limb during the gait cycle and positioning the stance-phase limb to allow the body to fall forward. Hip muscles participate in both these functions. The gait cycle presents complex and progressively changing demands on the hip musculature. Abnormalities of these muscles that cause weakness or pain distort the gait cycle, producing a limp. It is convenient to think of the muscles in functional groups when describing muscular control; however, an individual muscle may contribute to more than one functional movement. These groups are described as the abductors, flexors, adductors, extensors, and rotators. The innervation of these muscles will be noted so that the physician can interpret the effect of neurologic disorder on hip function.

The tensor fascia lata extends its tendinous fibers with the fibers of the gluteus maximus to form the iliotibial tract on the lateral aspect of the thigh. Muscles of this group are innervated by the superior gluteal nerve, which is composed mainly of fibers from the fourth and fifth lumbar nerve roots. The muscles of this group are required to maintain pelvic stability during of the stance phase of gait. During stance phase, body weight forces the bearing hip into adduction. Unless the abductors contract with normal strength, there is an excessive pelvic tilt. With deficient abductor function, the individual will compensate by leaning the trunk over the stance-phase limb. This compensatory gait pattern is called an abductor lurch and reduces forces across the hip.

The primary flexors of the hip are the iliopsoas, rectus femoris, and sartorius. The pectineus and tensor fascia lata also function as flexors. The strongest flexor is the double-bellied iliopsoas muscle. The iliopsoas is innervated by the femoral nerve, which is composed of fibers originating from the second through fourth lumbar segments. The sartorius and rectus femoris muscles are less powerful flexors and are innervated by the femoral nerve. During gait, hip flexors are important as swing phase is initiated. These muscles contract to accelerate the leg forward. A patient with weak hip flexors circumducts the leg and compensates further by pivoting the body about the opposite stance-phase foot, giving the characteristic circumduction limp. The hip flexors are also important in elevating the limb during stair climbing and in such activities as kicking. With kicking, the rectus femoris contracts strongly. Its origin through an apophysis at the anterior inferior iliac spine may be avulsed in adolescence (Figure 5.4).

The adductor group is comprised of five muscles: the adductors longus, brevis, and magnus; the gracilis; and the pectineus. The adductor longus and brevis muscles, the gracilis, and much of the adductor magnus are innervated by the obturator nerve. The posterior portion of the adductor magnus, which is predominantly an extensor of the hip, is innervated by the sciatic nerve, whereas the pectineus is innervated

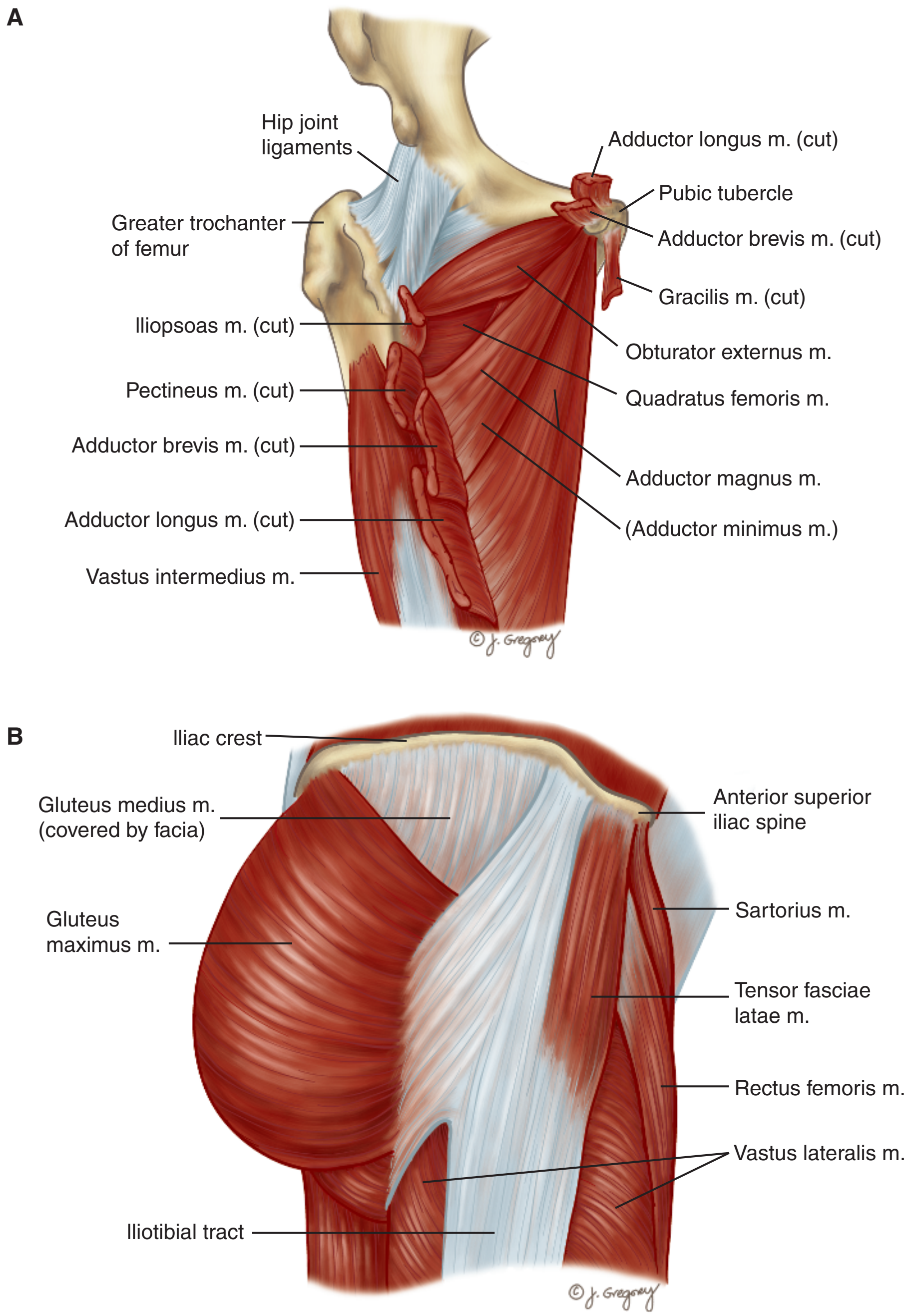

FIGURE 5.4. Drawing of the major muscle groups of the hip.

mainly by the femoral nerve. Like the hip flexors, these muscles are largely controlled by the second through fourth lumbar segments.

The adductor group has a varied role during gait. At the beginning of stance phase, the adductor magnus is important in assisting the hip extensors to resist flexion of the hip. The adductor longus acts as a hip flexor at the end of the stance phase, and as an extensor at the end of the swing phase.

The extensors consist of the gluteus maximus and hamstring muscles, including the long head of the biceps femoris, the semitendinosus, and the semimembranosus. Also an extensor is the posterior portion of the adductor magnus. The gluteus maximus is innervated by the inferior gluteal nerve, which is predominantly composed of fibers from the fifth lumbar and first sacral segments. The hamstrings are all innervated by the sciatic nerve, with fibers originating from the fifth lumbar through second sacral segments.

Primarily, the hip extensors are responsible for preventing hip and trunk flexion during gait, especially during the early stance phase of gait. The extensors are also responsible for slowing down the accelerating swing-phase leg at the end of swing phase. If these muscles fail to function properly, gait becomes unsteady. The gluteus maximus, along with the adductor magnus, is also responsible for climbing and rising from a sitting position.

Extending across the posterior aspect of the hip are the short external rotators, including the piriformis, superior and inferior gemelli, obturator externus and internus, and the quadratus femoris. Except for the obturator externus, which is innervated by the obturator nerve, the short rotators are innervated by a branch of the sacral plexus.

There are no purely internal rotators of the hip. A number of muscles provide internal rotation as well as other functions. For example, the anterior fibers of the gluteus minimus may rotate the hip internally.

Branches of the lumbar and sacral plexus innervate the hip joint. These nerves derive from the second through fifth lumbar segments. Several of the branches originate from the obturator nerve. The other branches of the obturator nerve innervate the anterior portion of the knee joint, which helps explain why patients with hip disorders may have anterior knee pain in the absence of significant pain about the hip. Occasionally, knee pain may be referred from the hip.

The sciatic nerve emerges from the sacral plexus through the greater sciatic notch between the piriformis and the obturator internus. In the sciatic notch, the sciatic nerve is vulnerable to injury from pelvis fractures and, distal to the notch, vulnerable to injury from posterior dislocation of the femoral head. The femoral artery, vein, and nerve enter the thigh lying on the iliopsoas and pectineus muscles. They are cushioned by these muscles and are not likely to be injured by hip dislocation or pelvic fractures.

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6
Surgical Indications

Joseph C. McCarthy and Jo-ann Lee

Despite the anatomic constraints of the hip joint, minimally invasive techniques to access this joint continue to evolve. As noted earlier, these efforts have paralleled an increased understanding of hip anatomy, improvements in joint distraction techniques whether the patient is in the lateral or supine position, as well as instrumentation developed specifically for the hip. In addition, developing clinical and radiographic expertise in diagnosing intra-articular lesions has resulted in an increasing necessity for accessing the joint.

Until recently, radiographic demonstration of loose bodies within the hip joint required an open arthrotomy for treatment. The open procedure, however, carried with it a plethora of potential risks. These risks included avascular necrosis of the femoral head (especially if the hip was dislocated or a posterior approach was utilized), neurovascular injury (especially if a lengthy split was made in the gluteus medius during a direct lateral approach), and thromboembolic disease. In addition, open arthrotomy of the hip necessitated an inpatient hospitalization, was costly, and had a protracted rehabilitation period. For each of the above reasons, open hip surgery was performed with reluctance and only for the most compelling of reasons. Rarely was an arthrotomy performed for diagnostic reasons.

Current Indications

The advent of hip arthroscopy has facilitated both comprehensive access to and treatment of an evolving series of conditions that affect the hip joint. These conditions include:

- Loose bodies
- Synovial chondromatosis
- Labral tears
- Chondral flap lesions of the acetabular or femoral head
- Osteonecrosis of the femoral head
- Ruptured or impinging ligamentum teres
- Collagen disease (RA, SLE, etc.) with impinging synovitis
- Foreign body removal
- Crystalline hip arthropathy (gout, pseudogout, etc.)
- Capsular shrinkage (Ehler Danlos, etc.)
- Post trauma (dislocation, Pipkin fracture, bullet, etc.)
- Post total hip arthroplasty (diagnosis of occult sepsis, removal of intra-articular wire or cement)
- Intractable pain (with positive physical findings)
- Extra-articular conditions (bursa, soft tissue release)
- Osteoarthritis

Loose Bodies

Loose bodies may be ossified or not. When calcium is present they are readily identified by radiographic studies. If not evident on plain films, CT scanning with or without contrast is highly sensitive to visualize these structures. (See Chapter 3.) When symptomatically present, arthroscopy provides a minimally invasive technique for removal of these bodies.

When the loose bodies are not calcified, however, they may be extremely difficult to visualize. McCarthy et al showed that up to 67% of loose bodies may not be evident on radiographic studies.[1] When the bodies produce locking or catching symptoms, arthroscopy becomes a means to establish the diagnosis and corroborate the clinical suspicion. (Figure 6.1.) In addition, the procedure provides a means of simultaneous treatment.

Loose bodies may occur as an isolated fragment, such as post dislocation, or may be associated with osteochondritis dissecans. Or, alternatively they may be multiple (2–300) as seen in synovial chondromatosis. In this condition some bodies may aggregate together in grapelike clusters 1–4 centimeters in diameter. (Figure 6.2.) Often these bodies adhere to the synovium about the fovea and must be morcellated in order to be removed arthroscopically. (See Chapter 11.)

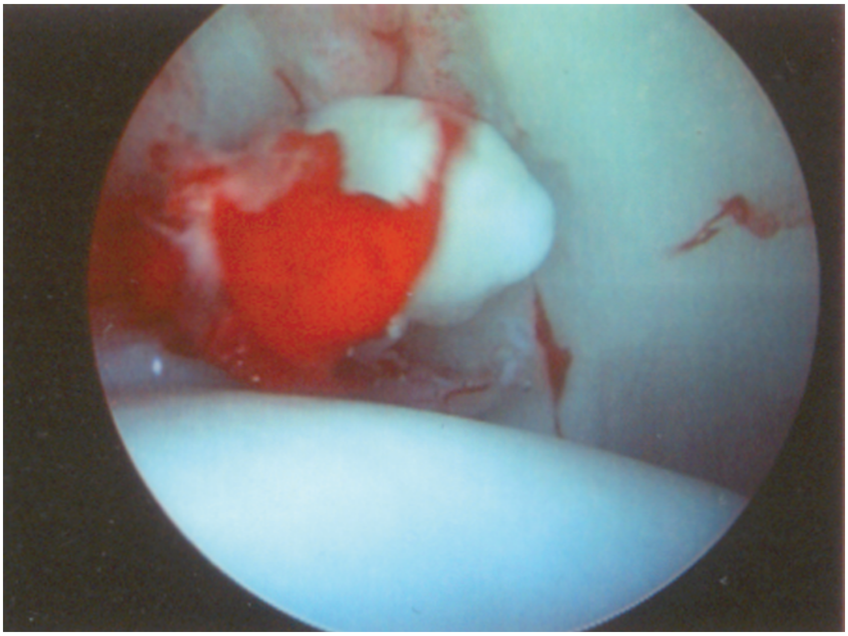


FIGURE 6.1. Intra-articular loose body in the fovea.

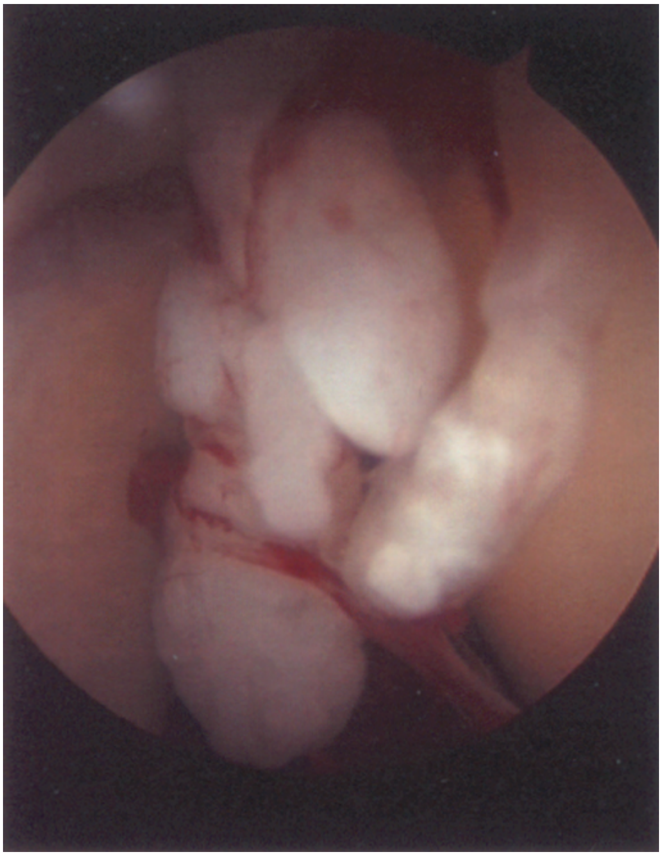


FIGURE 6.2. Intra-articular loose bodies seen in synovial chondromatosis.

Labral Tears

The diagnosis of labral tear remains largely clinical. These lesions often present with mechanical symptoms, including buckling, catching and painful, restricted range of joint motion. Evolving radiographic studies, including high-contrast or gadolinium-enhanced arthro MRI scanning, have improved the diagnostic sensitivity for labral injuries. (See Chapter 3.) Hip arthroscopy allows a comprehensive evaluation of labral anatomy. Visual inspection is possible for all quadrants of the joint. In addition, long probes can be used to evaluate subtle or suspected lesion areas, either on the articular surface or at the capsular margin. Most important, hip arthroscopy provides a means for treatment of labral lesions. The optical enhancement of the lenses and the microsurgical tools developed for treatment provide the least intrusive means of resecting or stabilizing a labral tear. It should be emphasized that the labrum is an important anatomic structure in the hip joint with many functions, especially in dysplasia. Overresection of labral tissue, more commonly seen with open arthrotomy, should be avoided. (See Chapter 12.)

Labral tears not only produce functionally limiting symptoms, but also occur most commonly on the articular, nonvascular edge of that tissue.(Figure 6.3.) For this reason they will not heal with conservative treatment. The most compelling rationale for hip arthroscopy is underscored by this biologic fact.

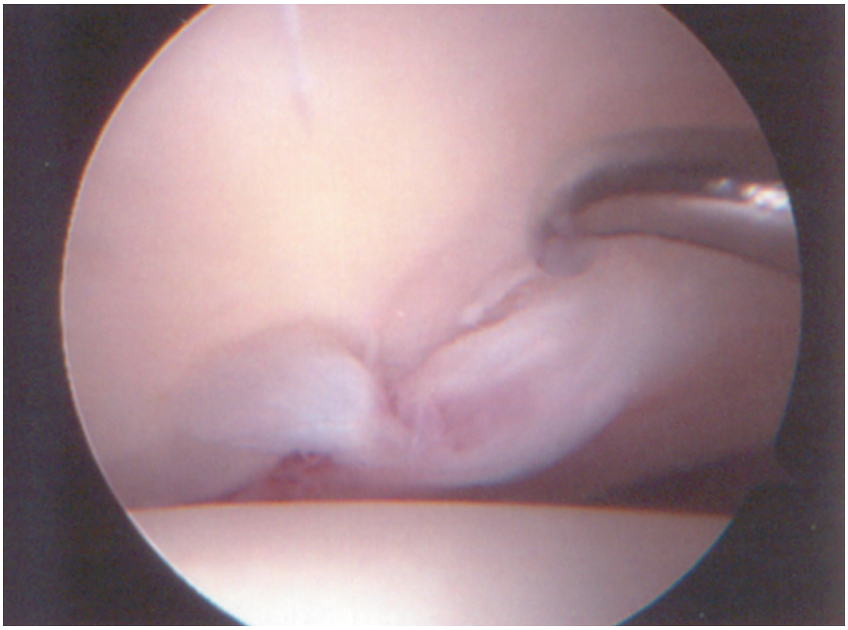


FIGURE 6.3. Labral tear on the articular nonvascular edge of the labrum.

Chondral Lesions of the Acetabulum or Femoral Head

Chondral lesions are among the most elusive sources of hip joint pain. Because of the more constrained anatomy of the hip compared to the shoulder, until recently these lesions were not believed to exist. Furthering the consternation of both patient and clinician, no currently available radiographic test reliably diagnoses the presence or extent of these lesions.[1]

Even gadolinium-enhanced arthro MRI scanning has limitations in elucidating chondral injuries. This lack of sensitivity may be explained in part by its static nature, as well as the lack of distraction during the study. And yet chondral lesions do occur with frequency. In the senior author's experience of 457 hip arthroscopies during a 6-year period, chondral injuries occurred in the anterior acetabulum in 269 cases (59%), the superior acetabulum in 110 cases (24%), and the posterior acetabulum in 114 cases (25%). Although these lesions were seen most frequently in association with a labral tear, most disturbing was the unstable flap nature and extent of the full-thickness cartilage injury. Seventy percent of the anterior, 27% of the superior, and 36% of the posterior chondral injuries were grade III or IV by Outerbridge criteria.[2] In addition, the senior author's classification of labral tears demonstrates a clear decrement in outcome once an associated chondral acetabular lesion of greater than 1 cm occurs.[3] (See Chapter 12.)

Chondral injuries may occur in association with a multitude of hip conditions, including labral tears, loose bodies, posterior dislocation, osteonecrosis, SCFE dysplasia, and degenerative arthritis. The difficulty in diagnosing these lesions as well as their effect on outcome provides a cogent rationale for arthroscopic hip surgery.

Osteonecrosis

There is a limited role for arthroscopy in this condition. The focus of most diagnostic and treatment efforts to date has been directed at the subchondral bone, to prevent its collapse. Revascularization, especially free-vascularized fibular grafting, has altered the natural history of this disease favorably.

However, because of the limitations of MR and CT scanning in thoroughly evaluating the chondral joint surfaces, some unstable lesions have been missed. Arthroscopy allows a comprehensive mapping of the femoral head and acetabular joint surfaces, as well as the labrum and the synovium. (Figure 6.4.) In addition, the authors have on several occasions endoscoped the intraosseous femoral head core tract and witnessed the clear-cut demarcation of the avascular zone. Arthroscopy has no role in end-stage disease with a collapsed femoral head.

Thus the current rationale for arthroscopy in osteonecrosis is narrowly focused. It may facilitate staging of patients, especially prior to free fibular grafting.[4–6]

In the author's experience it should be reserved for those patients with evident mechanical symptoms such as locking, buckling, and catching. In addition arthroscopy may have a role in the patient who fares poorly following revascularization, perhaps because of a chondral lesion. As noted above, arthroscopy can be performed simultaneously with a core decompression.

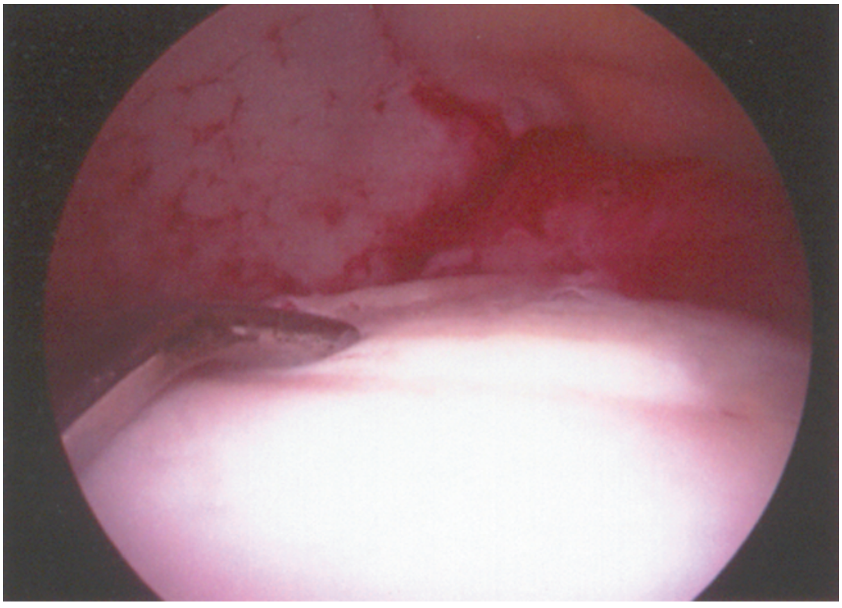


FIGURE 6.4. Femoral head, acetabular joint surfaces, labrum, and synovium in osteonecrosis. (Probe is balloting the involved chondral surface.)

Ruptured or Impinging Ligamentum Teres

This lesion, albeit infrequent, may occur as a result of trauma, such as posterior dislocation or Pipkin fracture. In addition it may occur in association with degenerative arthritis. Isolated lesions of the ligamentum teres have been occasionally reported.[7–9] (See Chapter 13.)

Gray and Villar have described this condition as a source of hip pain either alone or in conjunction with other articular pathology.[10]

Dysplasia

Dysplasia may also produce morphologic abnormality. As noted by Salter, the limbus is enlarged in dysplasia.[11] By adult life repetitive stretching of this structure may result in elongation and/or hypertrophic impingement. (Figure 6.5.) In the author's experience one such patient with Crowe I dysplasia presented with recurrent buckling, falling, and pain. Following arthroscopic debridement of the ligament these symptoms were alleviated. Six years later the identical symptoms in the opposite hip were also eliminated, again by arthroscopic intervention.

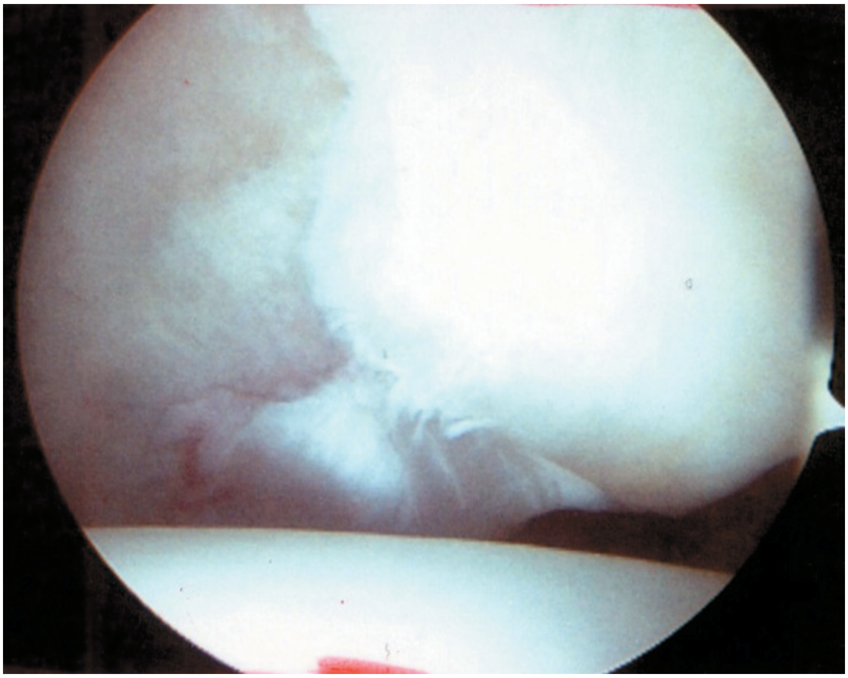


FIGURE 6.5. Enlarged labrum in moderate dysplasia. An elongated ligamentum teres may also occur.

Synovial Abnormalities

The synovium can be the genesis of deep-seated and unremitting hip joint pain. A diverse number of etiologies may initiate synovial irritation. These conditions may be of inflammatory, hematologic, crystalline, collagen disease, mechanical, viral, or tumorous origin. Specific treatment is based upon whether the condition is focal or diffuse, and self-limiting or unremitting in nature. Crystalline diseases such as gout or pseudogout can produce extreme hip joint pain. A joint effusion, best seen on T2 weighted MR scanning, can be accompanied by an elevated or normal serum uric acid level. Joint fluid analysis with polarized-light microscopic verification clinches the diagnosis. At arthroscopy the senior author has witnessed high concentrations of crystals diffusely distributed throughout the synovium as well as embedded within the articular cartilage of the acetabulum. (Figure 6.6.) Arthroscopic treatment consists of copious lavage, mechanical removal of crystals, and synovial biopsy if necessary.

Collagen diseases such as JRA, rheumatoid arthritis, lupus erythematosus and Ehler-Danlos not only occur in the hip, but this may be the presenting symptomatic joint. Rheumatoid arthritis may present with an effusion, dense synovitis synchiae, and synovial cysts, as well as articular surface damage. Intense joint pain unresponsive to extensive conservative measures is the rationale for arthroscopic intervention. The senior author has observed synovitis so hypertrophic and hyperemic that it obscured initial visualization of the femoral head and acetabulum. Arthroscopic treatment consists of synovial biopsy and/or synovectomy, evaluation and treatment of accompanying articular cartilage damage, and lavage. Procedural results are directly dependent on the stage of articular surface involvement.

Ehler-Danlos syndrome, as in the shoulder joint, may present with pain and instability. In combination with medical diagnosis, arthroscopic treatment has consisted of skin and synovial biopsy to further define the disease classification. In addition, thermal capsular shrinkage has been performed judiciously. The senior author's experience to date has been uniformly favorable. Longer-term follow-up is requisite to define this procedure's ultimate utility.

Synovial chondromatosis is a metaplastic synovial condition that results in the production of numerous loose bodies. Although benign, this tumorous entity may be recurrent. The loose bodies, when non-ossified, can make diagnosis of this disease extremely difficult. The senior author has reported in 20 cases preoperative diagnosis by all radiographic means was established in only 50% of patients, and all of these hips had calcified bodies present. None of the cases with non-ossified bodies were evident before surgery, even with MR scanning.[12] Arthroscopic treatment in 20 cases to date has consisted of classification of diagnosis, removal of between 5 and 300 loose bodies especially those clustered within the fovea, treatment of articular damage, and synovectomy. (Figure 6.7.) Although recurrence may occur despite intervention—in the author's experience the rate is 10%—a second arthroscopy may be performed without intercedent scarring. In addition arthroscopy, in contrast to open arthrotomy, has been executed without the attendant risks of osteonecrosis, heterotopic bone, deep vein thrombophlebitis, neurovascular injury, or infection. (See Chapter 14.)

Hematologic disorders such as sickle cell anemia, hemophilia, and pigmented villonodular synovitis can produce significant joint symptoms. Although medical management is usually effective, arthroscopic intervention may be warranted when dysfunction becomes protracted. This minimally inva-

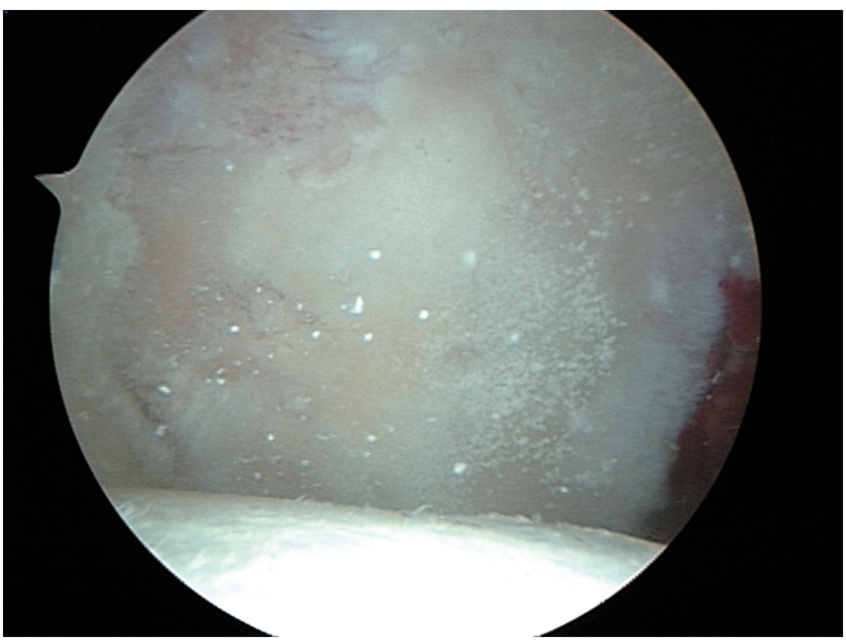
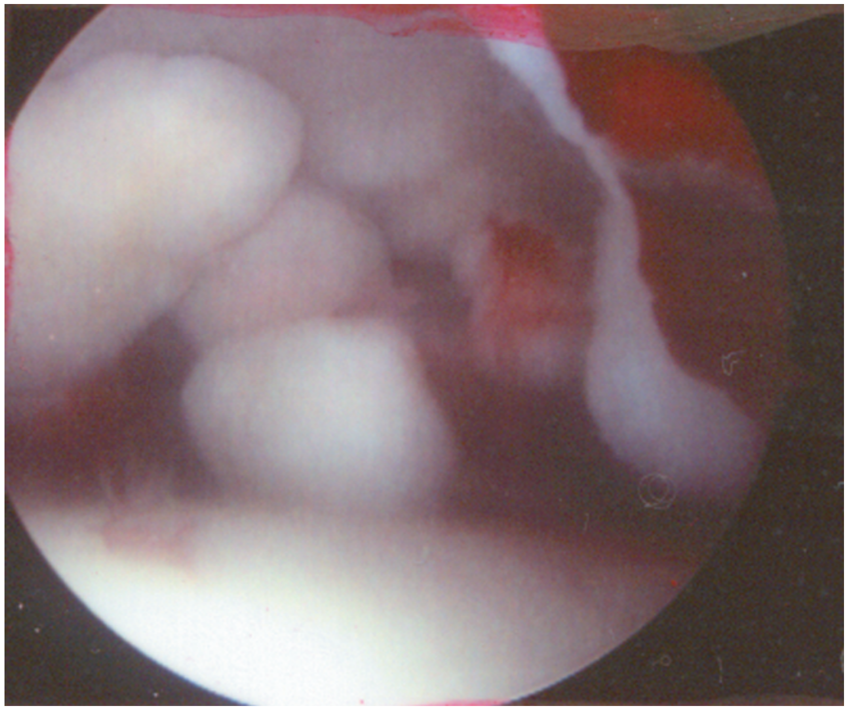


FIGURE 6.6. Crystals diffusely distributed throughout the joint in chondrocalcinosis.

FIGURE 6.7. Chondral loose bodies clustered within the fovea in synovial chondromatosis.



sive approach has much less bleeding risk than open arthrotomy. Surgical treatment includes evacuation of hematoma, removal of synechiae, copious lavage, and synovectomy as necessary. There is no outcome data on this procedure, however symptomatically beneficial, to date.

Infection

Arthroscopy has a limited though important role in sepsis, particularly in the pediatric population.[13] Acute bacterial joint involvement can be decompressed, lavaged, and drains left in the joint with minimal morbidity. In addition, for those cases where joint aspiration is negative or equivocal, arthroscopy can provide a definitive diagnosis, not only through joint fluid analysis but also synovial biopsy. Simultaneously, joint irrigation and articular surface assessment and treatment can be performed.

Arthroscopy Following Total Hip Replacement

Most patients with painful total hip replacement do not require arthroscopic evaluation. The etiologies that generate symptoms following arthroplasty can usually be diagnosed by conventional means: clinical (leg length discrepancy, abductor weakness, etc); radiographic (component loosening, malposition, trochanteric nonunion, etc); or by special studies such as a bone scan or aspiration arthrogram to detect subtle loosening or sepsis.

When unexplained symptoms persist despite appropriate conservative treatment, arthroscopy can be efficacious. The senior author has arthroscoped two patients with suspected sepsis but repeatedly negative joint aspirations. On both occasions low-virulent organisms were recovered, not just by fluid analysis but by synovial biopsy. At the same time debridement of exudates and impinging granulation tissue is performed along with copious lavage and installation of a drainage catheter. On one occasion the patient's advanced liver disease and coagulopathy precluded an open procedure, yet following successful arthroscopic intervention he was ambulatory within 24 hours.

Another indication for a minimally invasive surgical approach is an intra-articular third body. The senior author has recently removed a broken trochanteric wire (16 gauge by $1^3/_4$ in. long) from the joint. The metallic fragment had migrated to within 5mm of the prosthetic interface. (Figure 6.8) In addition, 2 migrated porous beads have been removed on an outpatient basis. A 68-year-old woman with a revision right total hip replacement was evaluated for a 9-year follow-up. She had placement of a porous ingrowth acetabular component, which showed evidence of good ingrowth, but on successive films she had progressive loosening of one of the peripheral screws on the cup. The screw was within the joint at the posterior margin and was successfully removed arthroscopically. (Figure 6.9.)

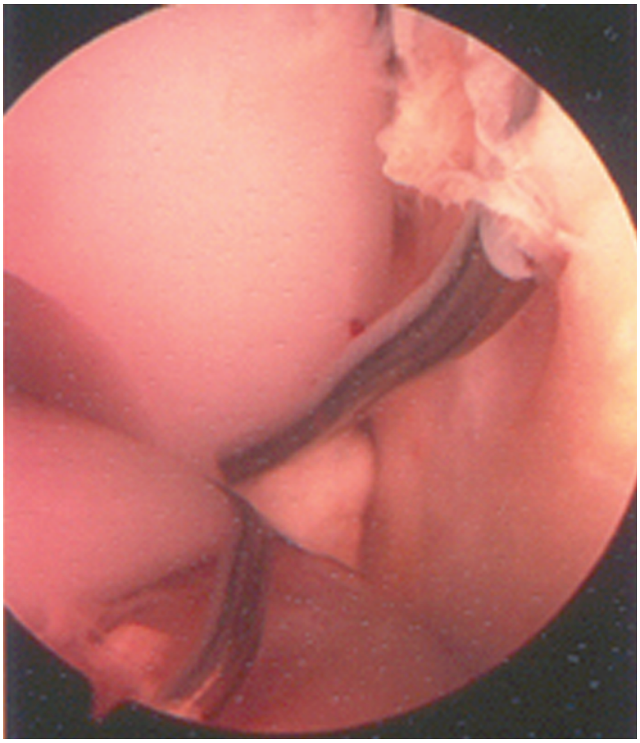


FIGURE 6.8. Post-total hip replacement metallic fragment that had migrated to within 5 mm of the prosthetic interface.

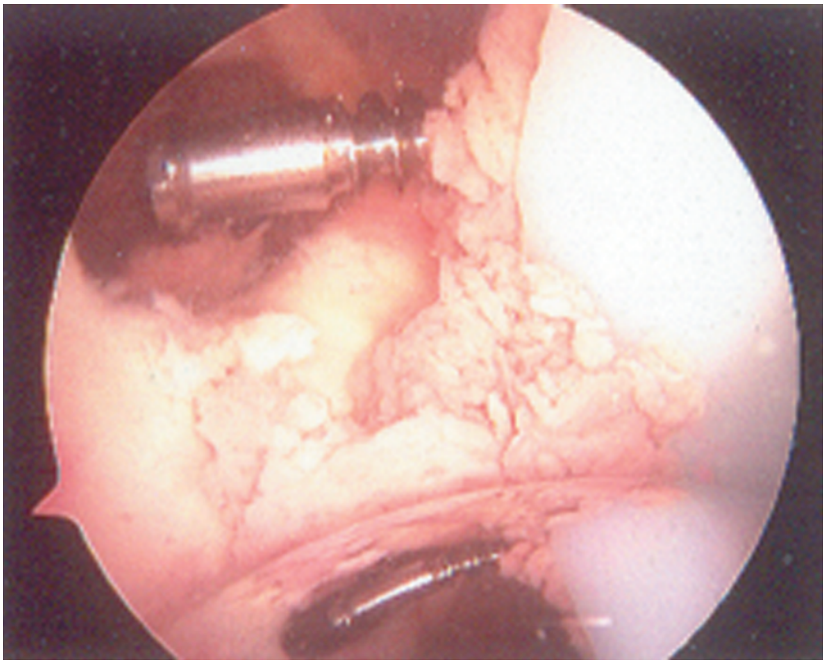


FIGURE 6.9. Post-total hip replacement acetabular component peripheral screw that had backed out within the joint at the posterior margin.

A potential use of arthroscopy may be to reverse symptomatically tight or impinging tendinous periarticular structures such as the iliopsoas. Although attractive, arthroscopy to lavage the joint of wear-related enzymes does not address the primary implant-related cause of potential osteolysis. It should be noted that neither of these applications has sufficient clinical data to warrant anything other than scrupulous judgment.

Trauma

Traumatic events about the hip joint are a frequent occurrence. While most fractures of the femoral neck or acetabulum are successfully treated by reconstituting the bony architecture, articular injuries can and do occur. Epstein reported that the high incidence of chondral damage present following a fracture dislocation of the hip warranted an arthrotomy in every case.[14] The high risks associated with open surgery in the early post-trauma period (infection, contracture, deep vein thrombosis, pulmonary emobolus, heterotopic bone, and neuromuscular dysfunction) have limited enthusiasm for that approach. The minimally invasive nature of arthroscopy, however, significantly reduces these risks. The senior author has treated a patient who, 5 days following a dislocation, had excruciating hip pain. At surgery a large hematoma was evacuated, two chondral loose bodies were removed, and a torn posterior labrum was repaired. The patient was ambulatory the next morning.

Dislocations and fracture dislocations can produce, in addition to loose bodies and labral injuries, shear damage to the chondral surfaces of the femoral head or acetabulum. This is not often seen by MRI scanning. Pipkin fractures can result in displaced bone or cartilage from the femoral head or a ruptured ligamentum teres. Although each presents special difficulties, the author has successfully treated both these conditions.

Intra-articular foreign bodies, such as bullet fragments, can affect the hip with or without an associated fracture. The senior author has removed a bullet that migrated into the joint 7 years after the patient's initial trauma. Most recently, a patient developed hip pain 2 years following attempted removal of a femoral intramedullary rod. A metallic fragment had migrated into the joint, embedding itself, like a piece of glass, into the superior lateral aspect of the acetabulum. At surgery the femoral head had already been scratched by this metallic shard. (Figure 6.10.) It was successfully removed endoscopically.

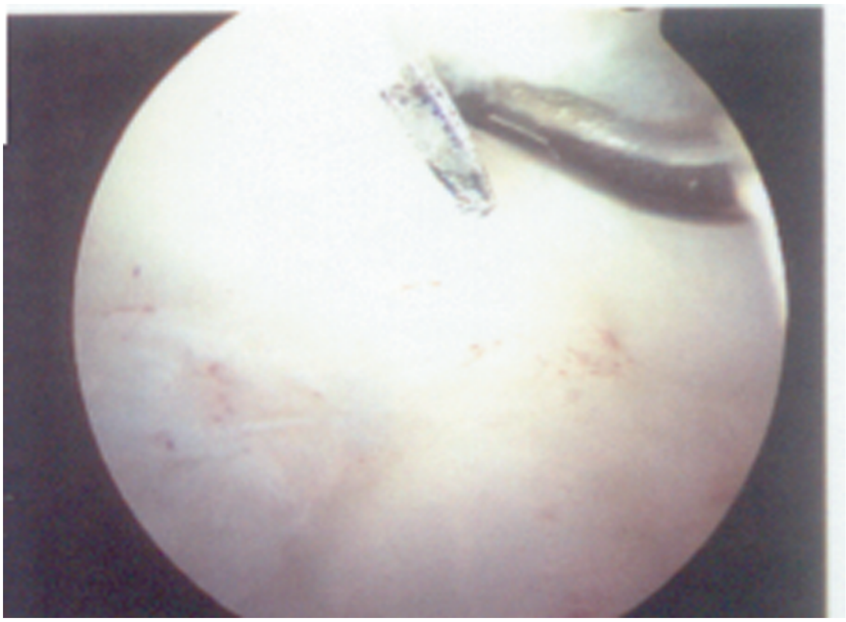


FIGURE 6.10. Femoral head that had been scratched by a metallic shard.

Osteoarthritis

Hip joint pain and stiffness accompany osteoarthrosis. Osteophytes are readily visible on radiographic studies. These impinging bony excrescences may contribute to the limited motion present in this disease. While technically possible and appealing, removal of osteophytes per se is not an indication for arthroscopy. These rim protuberances are but the late, bony expression of diffuse joint disease. Articular cartilage involvement that accompanies osteophyte formation is usually full-thickness and exhibits diffuse lesions. McCarthy and Glick have reported a direct correlation between the stage of cartilage loss, especially on the acetabular side, and poor outcome following arthroscopy.[3,15]

Despite this cautionary note, two situations may warrant surgical consideration. One is a patient who, with a previously normal joint, sustains an avulsion fracture resulting in periarticular ossification that limits motion. The other is a patient with known mild to moderate radiographic signs of arthritis but who was functioning well without symptoms until an injury occurred, producing mechanical dysfunction. Arthroscopic treatment of a labral tear or chondral loose body can eliminate the buckling, catching, or locking symptoms. The clinician should be judicious in considering surgery in these conditions.

Extra-Articular Conditions

The efficacy of arthroscopy in treating pathologic conditions in encapsulated environments (joints, bladder, etc) has spawned interest in further applications. Advancements in general surgery to endoscope soft tissue cavities have allowed treatment of inguinal hernias and gallbladder disease. Similarly, orthopedic arthroscopic procedures have begun to extend to extra-articular areas. As mentioned above, posttraumatic periarticular impinging ossification has been resected via the arthroscope. Glick has also reported his experience with this technique for iliopsoas and iliotibial band release.[15] It should be emphasized that the results are preliminary; the recovery can be protracted, especially for the iliopsoas, and further study is necessary.

Intractable Hip Pain

Arthroscopy is not a substitute for clinical acumen. The myriad etiologies of inguinal and buttock pain include many extra-articular conditions. (See Chapters 1 and 2.) The vast majority of these cases are self-limited and will resolve with time and appropriate conservative management. Numerous psychological, emotional, and legal as well as physical issues can contribute to pain intensity, extent, and protractedness. Occasionally an intra-articular joint injection with Aristocort and Marcaine, done under fluoroscopic control, may help to clarify whether the source of pain is intracapsular.

It is when joint symptoms are unremitting, usually more than 6 months, and radiographic studies are nondiagnostic, that arthroscopic evaluation is considered. In these situations Villar has reported that arthroscopy facilitated a diagnosis in 40% of cases.[16]

The senior author rarely operated for pain symptoms alone. Conversely, the patient with protracted mechanical symptoms (buckling, catching, locking) and positive physical findings (McCarthy hip extension sign, ie hip flexion, adduction, and external rotation showing painful impingement and inguinal pain on resisted straight leg raising) represents an excellent candidate for surgery. Further evaluation of radiographic procedural sensitivity should diminish the number of hip diagnostic dilemmas.

Contraindications

As noted earlier arthroscopy is not a substitute for sound clinical judgment. Surgical intervention is proscribed for joint conditions amenable to medical management, such as the arthralgias associated with hepatitis or colitis. Similarly, hip pain referred from other sources precludes surgery, such as compression fracture of L1. (See Chapters 2 and 4.)

Periarticular conditions such as stress fractures of the femoral neck, insufficiency fractures of the pubic ischium, and transient osteoporosis are best treated by non-endoscopic means.

Certain joint conditions, in the absence of mechanical symptoms, do not warrant arthroscopy. These include osteonecrosis and synovitis.

Acute skin lesions or ulceration, especially in the vicinity of anterior or lateral portals, would proscribe arthroscopy. In addition, sepsis with accompanying osteomyelitis or abscess formation requires open surgery.

Conditions that limit the potential for hip distraction may also preclude arthroscopy. These include joint ankylosis, dense heterotopic bone formation, or significant protrusio.

Morbid obesity is a relative contraindication for arthroscopy, not only because of distraction limitations but also because of the requisite length of the instruments necessary to access and maneuver within the deeply receded joint. Finally, advanced osteoarthritis is, in the author's opinion, a contraindication for arthroscopy, as noted earlier.

Summary

Now that the technical challenges that previously limited hip joint access have been overcome, the indications for arthroscopic surgery continue to expand. The ability to visualize the chondral articular surfaces directly has already greatly increased our understanding of early hip disease. Further improvements in hip-specific instrumentation, safe distractors, and surgical expertise will facilitate this procedure's eventual role in the pathophysiology of hip disease. Further refinement in indications will await prospectively done outcome studies. The importance of this fact cannot be overemphasized.

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7
Anesthesia Considerations

Donald Foster and Robert Bode

Hip arthroscopy is proving to be a valuable diagnostic and therapeutic procedure. The technique has allowed successful surgical intervention with minimal invasiveness, especially in patients with chronic hip pain that has been refractory to conservative therapy. The anesthetic perioperative management for this procedure is relatively straightforward, but there are some challenging factors to consider and address.

Perioperative Management

Hip arthroscopy as performed at the New England Baptist Hospital is generally an outpatient surgery procedure. The majority of patients undergoing hip arthroscopy are categorized as ASA I and II. Although in one series patient ages ranged from 17 to 69 years,[1] most are young adults. They have few serious comorbid conditions and usually require minimal preanesthetic testing. Some patients present with severe chronic hip pain and are narcotic tolerant due to long-term analgesic use. Despite their increased narcotic requirements during and after the procedure, they seldom require postoperative hospital admission for pain control.

A basic requirement of anesthesia for hip arthroscopy is satisfactory muscle relaxation at the hip. This allows distraction of the joint and permits adequate arthroscopic visualization. Regional techniques such as spinal or epidural anesthesia will provide the required muscle relaxation, but often require intravenous adjuncts for patient comfort. Although hip arthroscopy may be accomplished with patients in the supine position on a fracture table,[2] the preferred method at our institution is to place the patient in the lateral decubitus position.[3] (See Chapter 9.) After surgical prep and draping, the patient is seldom able to watch the procedure on a video monitor due to obstructed vision. Thus, the advantages of regional anesthetics are lost on two counts: The patient's position may be quite uncomfortable during extended cases, and can require substantial amounts of supplemental intravenous medications. Furthermore, patient expectations to remain awake and watch the procedure on a video monitor are impeded by obstructions to viewing.

General anesthesia utilizing an endotracheal tube is the preferred anesthetic technique for this procedure. Patient comfort and profound muscle relaxation are easily attained with this approach. Anesthesia is induced and the airway secured with the patient in the supine position. The use of a laryngeal mask airway (LMA) is not appropriate for this procedure due to the use of muscle relaxants and controlled positive pressure ventilation. After anesthetic induction, short-duration neuromuscular blockade is accomplished, and the patient is carefully turned to the lateral ducubitus position. Attention to detail is important during this positioning procedure. Proper pelvic and chest stabilization is of significant importance in relation to distraction and optimal arthroscopic visualization of the hip.

A peg board is the preferred operating room fixture to secure the patient in the lateral decubitus position. (Figure 7.1.) The board is sized to accommodate the dimensions of a standard operating room table and is attached to the table using special metal latches. A full-length silicone gel pad is then used to cover the pegboard and protect the patient's skin from injury. Pegs are placed in juxtaposition to the patient's lower thorax and pelvis to immobilize the patient in the lateral position. (Figure 7.2.) Placement of additional pegs may be necessary with exceedingly tall or obese patients. Each peg is then covered with additional gel padding to prevent skin abrasion.

Additional precautions should also be used to protect the patient in the lateral decubitus position. An axillary roll, placed caudad to the dependent axilla, will lift the thorax and relieve pressure on the brachial plexus and vessels there. (Figure 7.3.) The head and neck should be positioned properly to insure the protection of eyes, ears, and cervical spine from compressive injury. The dependent arm is placed on a padded armrest, with additional foam padding placed to protect the ulnar and radial nerves. The upper arm is also positioned so as to avoid compressive injury. (Figure 7.3.) It is placed on a Mayo stand, which has been padded with a pillow and a

FIGURE 7.1. A pegboard covered with a full-length gel pad secures the patient in the lateral decubitus position, and an axillary role protects nerves on the downside.

FIGURE 7.2. Pegs are placed in juxtaposition to the patient's lower thorax and pelvis to immobilize the patient in the lateral position.

FIGURE 7.3. The dependent arm is placed on a padded armrest while the upper arm is placed on a Mayo stand, which has been padded with a pillow and foam arm cushion.

foam arm cushion. The dependent (nonoperative) lower extremity is secured in a traction binding, with the lower leg wrapped with either compression bandages or pneumatic intermittent compression leggings to minimize venous stasis there.

Substantial respiratory changes may also occur after the patient is placed in this lateral position. Decreased chest wall compliance, combined with differences in perfusion to the lower and upper lungs, can lead to clinically evident ventilation–perfusion mismatch.[4] Dead space may increase, and marked differences between arterial and end tidal carbon dioxide tension may develop.[5] Any such clinically significant respiratory alteration should be evaluated as soon as possible after lateral positioning is accomplished, and modifications should be made prior to surgical preparation and draping. Often, enriching the level of inspired oxygen and adjusting mechanical ventilation settings are necessary to remedy these changes, especially for patients with significant pulmonary disease.

Anesthetic and Analgesic Medications

Due to the ambulatory nature of this surgical procedure, the choice of anesthetic medications is directed toward those with short-duration profiles of action. Midazolam is frequently used as a premedicant. Propent, an agent consisting of equal volumes of propofol and pentathol, has proven to be a valuable anesthetic induction agent for short-duration cases. The mixture provides excellent cardiovascular stability during induction, and we have noted no delays in recovery or discharge compared to the use of propofol alone. The balanced anesthetic technique incorporates volatile anesthetics in oxygen or air with or without the combination of nitrous oxide. A short-acting narcotic such as fentanyl is used, and muscle relaxation accomplished with vecuronium or rocuronium. Succinylcholine is regularly administered for intubation of the trachea. The initial distraction process requires the deepest level of neuromuscular blockade and causes intense surgical stimulation. After fluid distention and arthroscope placement, surgical stimulation tends to stabilize. Neuromuscular blockade for the remainder of the procedure may be maintained at moderate levels until reversal and emergence, which is performed after the patient is turned supine.

Hip arthroscopy is an evolving technique and has been employed for acute processes such as bullet fragment extraction[6] and bone fragment removal following acetabular fracture repair. In one such case, involving the removal of intra-articular bone fragments, intra-abdominal extravasation of arthroscopic irrigant occurred, leading to cardiac arrest.[7] This was successfully resuscitated after emergent laparotomy to decompress the abdomen. It is therefore recommended that hip arthroscopy not be undertaken after acute or healing acetabular fractures. Fluid may extravasate under normal circumstances as well.[8] It has been hypothesized that fluid may escape from the hip joint and enter the retroperitoneum, or cause distention via subcutaneous propagation, causing severe abdominal pain. Since it is theorized that this irrigation fluid is quickly resorbed, postoperative complaints of this pain are seldom encountered. Some practitioners therefore refrain from performing hip arthroscopy under regional anesthesia, where premature termination of the procedure may be required due to this complaint. Fluid overload due to extravasation of irrigant may cause serious electrolyte disturbances as well. This problem should be considered during any evaluation of intraoperative and postoperative complications for this procedure.

The surgeon usually injects intra-articular morphine combined with bupivacaine and epinephrine at the end of the procedure. Most reports concerning the efficacy of this approach stem from arthroscopic procedures at the knee,[9,10] and its use at the hip is extrapolated from these accounts. Intra-articular morphine may act at peripheral opiate receptors and mediate antinociceptive effects there. Although ample evidence exists that peripheral receptors such as these exist,[11] there is uneven validation of the method,[12] and the intra-articular route may be no more effective than a single dose of parenteral narcotic.[13] However, patients appear to benefit from intra-articular narcotic administration. Most require only small doses of parenteral or oral analgesics prior to discharge home. There is anecdotal evidence that the incidence of postoperative nausea and vomiting is increased after the administration of intra-articular morphine. (Typically, 5 mg of morphine is used.) When susceptible individuals are identified preoperatively, antiemesis prophylaxis is customarily employed. Metoclopramide and the 5-HT^3 receptor antagonists ondansetron or dolasetron are frequently utilized in this situation.

The parenteral nonsteroidal anti-inflammatory medication ketorolac is often administered in the postanesthetic care unit setting. This is used as a one-time-only analgesic, and is typically given via the intravenous or intramuscular route. Theoretical concerns related to postoperative bleeding complications, such as hemarthrosis, have not been realized, and ketorolac has been a remarkably effective analgesic for outpatient hip arthroscopy. These concerns should not be disregarded, however, and ketorolac use is reserved as a rescue therapy for patients with large analgesic requirements.

The performance of anesthesia for hip arthroscopy is relatively forthright, provided several factors are considered. General anesthesia is the preferred method, as patient discomfort due to positioning negates the advantages of regional techniques. Muscle relaxation facilitated by deep neuromuscular blockade is key to providing surgical visualization of the hip. Care in positioning and properly padding pressure points is essential in the prevention of complications. Considerable success can be achieved in utilizing this procedure on an outpatient basis, provided patients are allowed to benefit from short-duration anesthetic medications and techniques.

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8
Patient Positioning and Distraction

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Brian D. Busconi, Brett D. Owens, and Jo-ann Lee

The Lateral Approach

The last decade has seen an evolution in the understanding of the benefits of hip arthroscopy. The technique for lateral positioning was pioneered by Dr James Glick, who became frustrated with difficulties in visualization and instrumentation, particularly in the posterior aspects of the hip joint, using the supine position and anterolateral portal placements.[1] Indeed, he experienced several cases in which loose bodies could not be removed from the posterior inferior aspect of the hip joint via the supine approach.

Since the introduction of the lateral approach, this surgical approach has gained widespread acceptance by arthroscopists.[1–6] It allows a direct lateral approach to the hip joint, provides reproducible bony landmarks for orientation, and facilitates access and instrumentation of most areas within the hip joint.[7]

The indications for hip arthroscopy via the lateral approach are essentially the same as those via the supine approach and include synovitis, septic arthritis, removal of loose bodies, management of labral pathology, and synovial lesions. Relative indications for the lateral approach in preference to the supine approach include anterior labral pathology, posterior loose bodies, and obesity.

Positioning

The lateral approach requires that the patient be positioned in the lateral decubitus position with the affected hip up. Most surgeons use a modified fracture table. The positioning is similar to that used for lateral femoral nailing. Some centers still have access to a specially modified distraction device produced by Arthronix Corporation (the Hip Distraktor), which can be fitted to a regular fluoroscopic surgery bed; however, this apparatus is no longer in commercial production. Commercially available modifications to the OSI fracture table (Orthopedic Systems Inc, Union City, California) include an adjustable, well-padded lateral peroneal post and tensiometer, which allow positioning and distraction capabilities. Similar modifications are available through other fracture table manufacturers and are usually packaged with the acetabular reconstruction or lateral femoral nailing attachments. A more recent distractor is now available through Innomed of Savannah, GA. This device can be positioned on a regular operating room table and is adjustable. (Figure 8.1.)

It is quite important to pad a patient adequately in the lateral position to protect against neuropraxia and pressure. We generally place a patient on a pegboard with an axillary roll. (Figure 7.1.) The lower, unaffected limb is padded and placed in neutral position with a fluoroscopically transparent support. Direct pressure over the fibular head is avoided with the use of blankets or pillows, which suspend this area. A strap is placed across the upper torso as a measure of safety. If traction is suddenly lost in the midst of the case, without a strap the patient may rebound and potentially could roll off the operating table.

To adequately visualize the inner aspects of the acetabulum and access intra-articular pathology, the femoral head needs to be distracted from the acetabulum. Without sufficient distraction, the spherical nature of the femoral head prevents the passage of instruments into the recesses of the acetabulum and consequently limits the usefulness of this technique to management of peripheral synovial and soft tissue lesions.

The orientation of the traction must effect a resultant force parallel to the femoral neck in order to lift the femoral head from the acetabulum. The position of the extremity and the traction forces are paramount in achieving this resultant force vector. (Figure 8.2.) The axial distraction is applied with the leg abducted between 0 and 20 degrees, depending on the patient's neck shaft angle and the depth of the acetabulum. (Figure 8.3.) A more varus neck orientation is managed with a slight increase in hip abduction. Conversely, a more valgus neck angulation requires less lateral orientation of the distraction force.

The hip is then placed in slight forward flexion of approximately 10–20 degrees. The foot is maintained in neutral to slightly externally rotated position. (Figure 8.4.) The forward flexion of the hip relaxes the tension within the Y ligament

FIGURE 8.1. Hip distractor demonstrating customized padded foot boot and distraction unit (Innomed Corp, Savannah, GA) positioned on a regular operating room table. The lower unaffected limb is padded and placed in neutral position with a padded gel support, while the fibular head is protected with blankets or pillows.

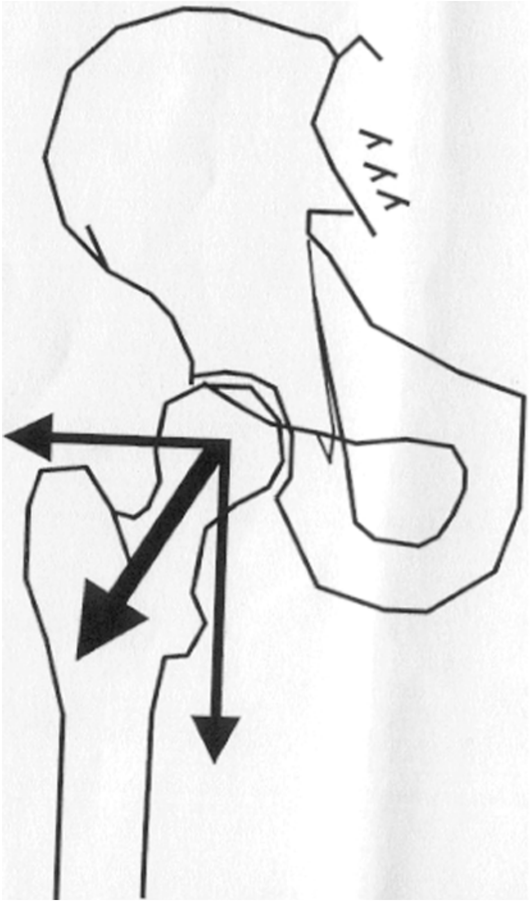

FIGURE 8.2. The vector is in line with the femoral neck.

FIGURE 8.3. Axial traction is accompanied by lateral traction via the perineal post.

FIGURE 8.4. Hip in slight forward flexion with the foot in neutral to slight externally rotated position.

of Bigelow in the anterior aspect of the hip capsule, potentiating the distraction maneuver.

Prior to the application of the longitudinal traction, the well-padded lateral peroneal post is positioned and adjusted for the abduction force. The exact positioning of this lateral peroneal post is paramount in achieving the abduction movement necessary to lift the femoral head up from the medial wall of the acetabulum and over the transverse acetabular ligament. A static lateral peroneal post must be set and adjusted at the beginning of the case. An adjustable peroneal post, as with the OSI fracture table, can allow intraoperative adjustments if necessary. The post is placed transverse to the long axis of the torso approximately 10–15 centimeters distal to the ischial tuberosity. The reason for this more distal placement is twofold. First, it avoids pressure on the pudendal nerve, which may result in pudendal neuropraxia. Second, the more distal placement allows a cantilever effect on the proximal femur when longitudinal traction is applied. If the lateral peroneal post is placed deep within the groin, the post will abut the femur in the region of the lesser trochanter and essentially block axial distraction.

Distraction

Although some authors have described successful arthroscopic evaluation of the hip joint without the use of distraction, we have found distraction essential to visualize the intra-articular structures and allow management with arthroscopic techniques.[1,5,6,8] There is, however, significant individual variation in the force required to achieve adequate distraction of the femoral head from the acetabulum. Eriksson et al.[9] reported a force variation of 300–500 Newtons required in anesthetized patients to distract the hip adequately. Other authors have reported variance in the force necessary to distract the hip joint between approximately 100 Newtons (approximately 25 pounds) and 900 Newtons (250 pounds in non-anesthetized volunteer patients).[6] For this reason, it is our practice to perform hip arthroscopy under general anesthesia and with adequate skeletal muscle relaxation, which reduces the force required to distract the hip joint. Although general, spinal, and epidural anesthetics can be used, the patient must achieve complete relaxation of the lower extremity muscle force so that the amount of traction can be minimized. The need to perform a reliable neurological exam postoperatively to assess for traction-related neuropraxia makes the quick reversal of anesthesia desirable. For this reason, either general or epidural agents are generally chosen. With this technique, the majority of hip arthroscopies can be performed with distraction forces between 25 and 100 pounds of direct axial traction.[6] In addition to muscle relaxation, release of the resting negative intra-articular pressure can also reduce the traction force necessary for joint separation. When the joint capsule is punctured with a spinal needle, either air or saline can be injected into the joint. When one observes this process under image, the joint will usually increase the femoral–acetabular separation without change in distraction force. In fact, Eriksson et al[9] estimated that as much as half of the total resistance to hip distraction in nonanesthetized patients was related to the negative pressure and resultant vacuum effect. The relative contribution of the vacuum force within the hip joint is greater with adequate muscle relaxation.

Although skeletal traction has been utilized in some centers, we have not found it necessary. Distraction of the hip for arthroscopy requires countertraction provided by a perineal post. This introduces the potential for compression injury to the perineum, especially transient neuropraxia of the pudendal nerve, an uncommon but disturbing complication. Taking care to ensure that the perineal post and entire traction apparatus are heavily padded can lessen this concern. Attention to the details of the distraction apparatus setup is essential to ensure appropriate protection of the structures at risk. The perineal post is lateralized to the operative side, providing the proper vector to distract the hip while minimizing pressure on the pudendal nerve. A tensiometer on the hip distraction device may be of significant help in preventing neuropraxia. We typically apply axial traction via a foot boot. (Figure 8.5) Care must be taken to pad the ankle adequately and to seat the heel firmly within the foot distraction piece. This allows the foot to stay in a plantar/grade position. The traction device is adjusted so that the foot can be maintained in neutral position with regard to eversion/inversion of the hindfoot, thereby avoiding undue stress to the ligamentous structures on one side or the other of the ankle. To ensure that

FIGURE 8.5. Axial traction is applied via a padded foot boot.

FIGURE 8.6. Before prepping and draping, fluoroscopic images determine the relative distraction of the femoral head from the acetabulum.

the heel does not lift out of the footplate during the course of the procedure, we have had success overwrapping the footpiece with wide tape or Coban®.

Generally, we try to limit the continuous application of traction to less than two hours, recording the time the traction is initially applied. The anesthesia personnel monitor the traction time, and the surgeon is informed at regular intervals, similar to tourniquet times. It is helpful to train an unscrubbed assistant to manage the traction apparatus prior to draping or application of traction. Inadvertent loss of traction while instruments are in the joint may result in harm to the articular cartilage or breakage of an instrument within the joint. The unscrubbed assistant may adjust additional traction or reduce the traction as indicated throughout the course of the procedure as necessity dictates. The footplate can be rotated internally and externally to assist with visualization of the femoral head articular surfaces.

Before prepping and draping, fluoroscopic images projected in the anteroposterior plane are used to determine the relative distraction of the femoral head from the acetabulum. (Figure 8.6.) Initial distraction of the femoral head should be 8–10 mm of distal articular cartilage displacement prior to surgical prepping. (Figure 8.7.) Distraction of the femoral head from the acetabulum creates a negative intra-articular pressure gradient, which results in a linear increase of the force required to distract the hip.

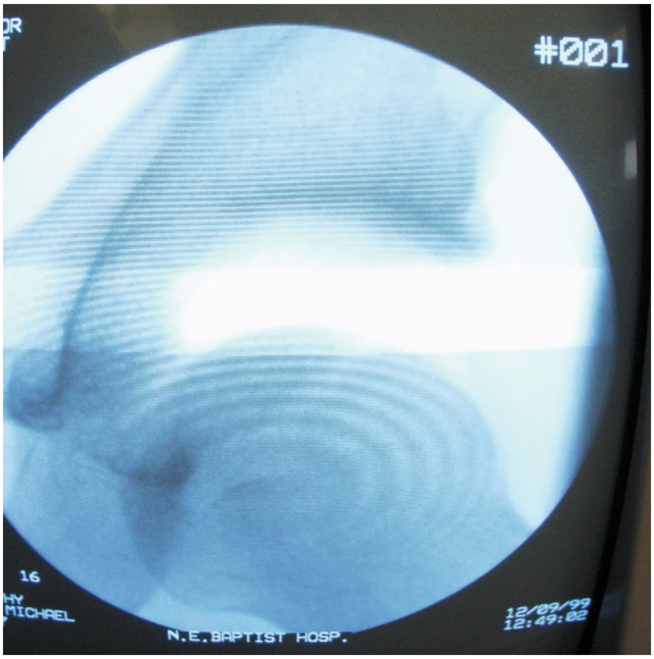

FIGURE 8.7. Fluoroscopic image projected in the anteroposterior plane showing distraction of the femoral head

The negative intra-articular pressure gradient is released with a 6-inch, 18-gauge spinal needle placed superior to the greater trochanter and inclined cephalad to the acetabulum. (Figure 8.8.) This needle is advanced into the hip joint. The image intensifier can be used for this step, if necessary. As the spinal needle is advanced across the hip capsule, a decided "give" sensation is felt. Similarly, a second 6-in., 18 gauge spinal needle is advanced into the hip capsule. The orientation of these initial spinal needles is dictated by the surgeon's selection of operative portals. The trocars of the spinal needles are removed. The joint is then injected with approximately 30–60 cc of normal saline. Flow from the second spinal needle confirms intra-articular placement of both needles. Eriksson has estimated that half of the resistance to hip distraction in nonanesthestized patients is due to the vacuum effect within the joint.[9] Often after the negative intra-articular pressure is released, the hip distraction increases by 2–4 mm. Adequate distraction of the hip is important not only to visualize the confines between the femoral head and acetabulum but also to prevent scuffing. The arthroscope and the arthroscopic instruments can easily be brushed against the chondral surfaces, resulting in scuff marks if the hip is not distracted sufficiently. Adequate distraction should be 8–10 mm for ease of entrance. In our experience, instrument breakage occurred once, and the piece was removed arthroscopically.

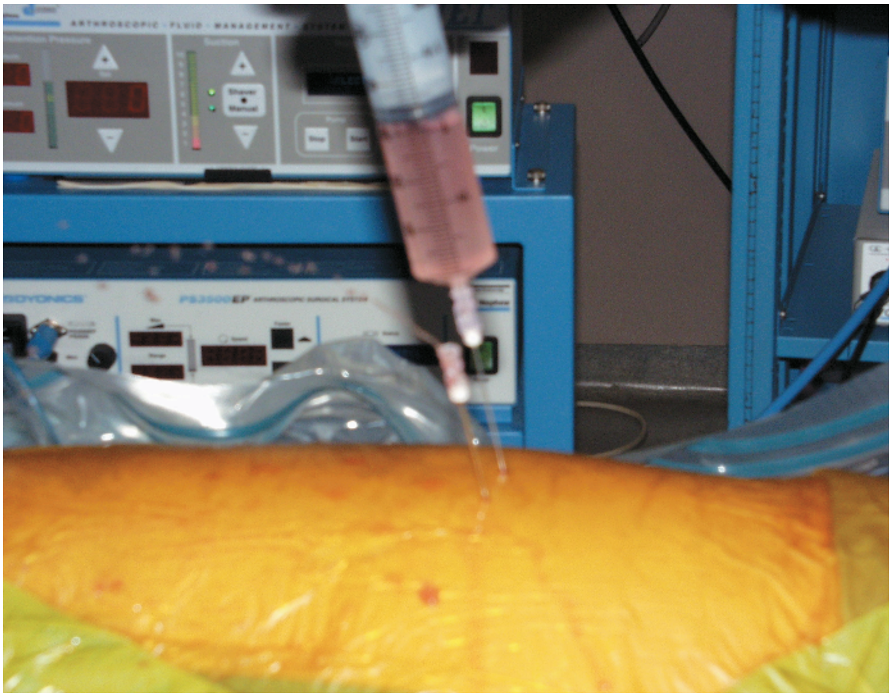

FIGURE 8.8. A 6-in., 18-gauge spinal needle placed superior to the greater trochanter and inclined cephalad to the acetabulum.

Advantages of the Lateral Approach

There are several technical advantages to lateral positioning for hip arthroscopy. The entire weightbearing articular surface of the acetabulum and femoral head can be visualized with a 30-degree scope via the paratrochanteric portals. The posterior and inferior aspects of the hip joint not only can be visualized, but also instrumented when the patient is positioned laterally. The orientation is quite familiar to the surgeon who performs total hip arthroplasty. The paratrochanteric portals puncture the superior hip capsule, which is slightly thinner, thereby facilitating cannula placement. Utilizing the primary portals with lateral positioning, the cannula passes through fewer muscle planes, and the potential injury to the lateral femoral cutaneous nerve is minimized. Pathology in the anterior superior quadrant of the hip is often encountered, and can be easily managed via the primary portals of the lateral approach.

When the scope instruments are placed within the hip joint, their cantilever movement is minimized, thereby minimizing the risk of instruments slipping out of the joint. Finally, we have found this approach more manageable for obese patients, as the adipose tissues tend to fall both anteriorly and posteriorly away from the greater trochanter, allowing better orientation and thinner tissue planes.

Supine

Hip arthroscopy in the supine position has proven effective for approaching and correcting various sources of hip joint pathology. This position provides ease of distraction for access to the space above the femoral head, good x-ray control of the initial steps for hip joint penetration, and satisfactory capacity to maneuver instruments for the correction of pathologic conditions encountered.

The patient is placed on the fracture table for the initiation of any of the several types of anesthesia capable of providing complete muscle relaxation. (See Chapter 7.) A large, well-padded perineal post is essential to minimize the likelihood of pudendal nerve denervation. The involved limb is secured to the traction foot stirrup, and initial gentle traction is established. (Figure 8.9.) The contralateral limb can be abducted and restrained in a second foot stirrup or supported in the 90–90 position of hip and knee flexion, with moderate abduction and internal rotation of the hip.

Prepping and draping is accomplished per routine, including sterile drapes on the C-arm for fluoroscopic imaging. The applied drapes must allow free access to the involved hip for placement of any of the several portals needed (ie anterior, lateral, or posterior). Once the drapes are in place, the C-arm can be brought in just medial to the uninvolved limb and positioned above the involved hip for initial imaging. (Figure 8.10.) A spinal needle laid on the anterior aspect of the hip aids in identifying the ideal point of entry for both the insufflation needle and later for the arthroscopy instruments. Using x-ray control, the spinal needle, with IV tubing extension and syringe, can be advanced into the capsule using approaches identical to those used for hip aspiration and injection. Longitudinal traction can be increased by the unscrubbed personnel while injection is made, using the C-arm image to assure appropriate femoral head migration from the depths of the acetabulum. Considerable variability is encountered in the ease with which femoral movement can be accomplished, depending on the mechanical response of the hip joint. Femoral head displacement of 7–10 mm is desired.

FIGURE 8.9. The involved limb is secured to the traction foot stirrup to establish initial gentle traction.

FIGURE 8.10. The C-arm is brought in medial to the uninvolved limb and positioned above the involved hip.

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9
Surgical Approaches

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Traditional Surgical Approaches

Any discussion regarding minimally invasive approaches to the hip joint is predicated by the context in which it developed. The hip joint is the most deeply recessed joint in the body. Because of the many musculotendinous investing structures surrounding it, a number of open surgical approaches were developed. Each of these methods, importantly, passes through fascial planes between muscles supplied by major nerves. These planes are well detailed by Henry.[1] Indications for hip surgery have historically been confined to regularly identified pathological entities. In the pediatric population these pathologies include: joint sepsis, calcified loose bodies, treatment of joint instability, and tumors. In skeletally mature adults, joint arthrotomy has been utilized for osteonecrosis, osteotomy, cheilectomy, sepsis, removal of loose or foreign bodies, synovectomy, fracture management, and prosthetic replacement. This chapter will review the seminal features of the principal surgical approaches to the hip.

Posterolateral Approach

The posterolateral approach provides excellent exposure of the acetabulum and proximal femur for primary or revisional total hip replacement. Because the abductor muscle group is preserved, there is minimal muscle stripping or damage in this approach. Rehabilitation of the patient following surgery is shortened because of this muscle preservation. If necessary, this approach can also be converted to become more extensile (iliofemoral, trochanteric slide, or osteotomy). In addition, the posterolateral approach minimizes the likelihood of gluteal nerve injury or heterotopic bone formation. When performed for prosthetic replacement, the posterolateral approach has historically been associated with a higher incidence of posterior dislocation than other approaches.[2] However, recent modifications in the surgical technique have significantly reduced this likelihood. Pellicci, Poss, and Goldstein have all published rates less than 1%.[3,4]

Surgical Technique

The patient is placed in the direct lateral decubitus position. The pelvis is securely fixed with a pegboard device or its equivalent, carefully padding the contralateral peroneal nerve and proximal chest wall structures. The operative leg is draped free, and the perineum protected out of the operative field. The skin incision is centered over the greater trochanter. Distally it parallels the femoral shaft and proximally it is extended, in slightly curvilinear fashion, posteriorly. The iliotibial band and gluteus maximus fascia are then split in line with the skin incision. The leg is then extended and internally rotated. The trochanteric bursa is incised and the short external rotators identified. The sciatic nerve is palpated, adjacent to the ischium, and protected throughout. The posterior border of the abductors (gluteus medius and minimus) is then identified and retracted anteriorly. (Figure 9.1.) This maneuver allows visualization of the piriformis, gemelli, obturators, and quadratus. These short rotators are then sequentially incised from their femoral attachments. With retraction above and below the femoral neck, the posterior capsule is then incised. Commencing proximally near 12 o'clock, the incision extends to the intertrochanteric line and then distally at 7 o'clock, creating a trapezoid-shaped flap that is posteriorly based. This capsular flap is carefully protected for later reattachment. Following capsulotomy, the hip is further internally rotated until the femoral head is dislocated. Further mobilization of the femur can be accomplished by incising the inferior capsule along the iliopsoas sheath. The anterior capsule is preserved, unless contracted. Acetabular exposure can be facilitated by displacing the femur anteriorly and this may require judicious capsular incision, gluteus maximus tendon release, and appropriate retraction.

Once the intra-articular procedure has been accomplished, closure is begun. The posterior capsular flap is reapproximated to the greater trochanter with #5 nonabsorbable sutures through drill holes. The leg remains in neutral rotation during this stitching. The short rotators are reattached to the posterior tendinous border of the abductors, carefully avoiding

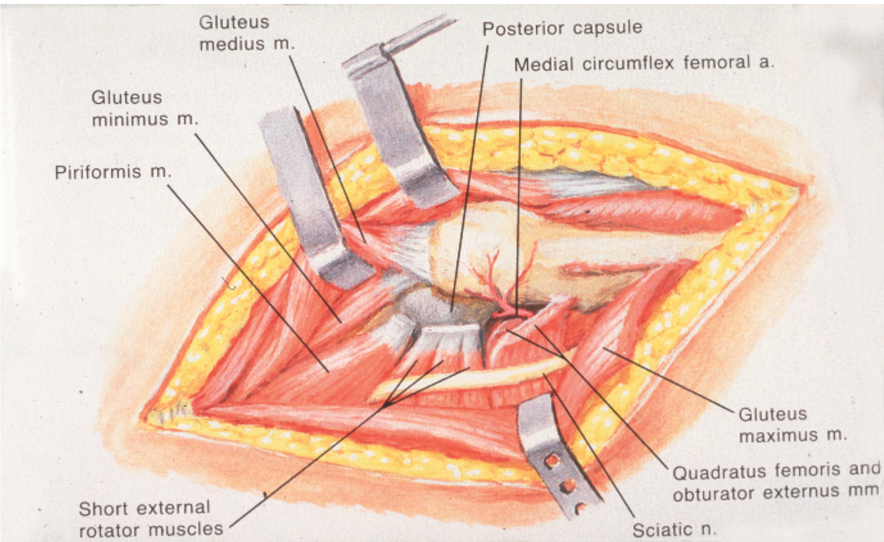


FIGURE 9.1. Identifying landmarks for posterolateral approach.

overtightening. Sciatic nerve integrity is again confirmed by palpation. The fascia and subcutaneous tissues are then closed in sequential layers. Following skin closure, a sterile bandage is applied and the patient is carefully transferred to the recovery room.

Trochanteric Osteotomy

Conventional trochanteric osteotomy was initially described by Charnley in England in association with total joint replacement.[5] This approach is utilitarian and can be combined with other approaches if necessary. This approach has been utilized for primary and revision total hip replacement; for preservation of the femoral head blood supply when arthroplasty is not planned; for extensile exposure in markedly obese patients; for lateral iliac exposure during pelvic osteotomy or acetabular cage placement; for distorted anatomy such as developmental dysplasia of the hip; for mobilization of joint ankylosis from protrusio collagen disease or fusion; for fracture plating of the anterior or posterior columns; and for distal transplantation for joint instability or leg length adjustment.

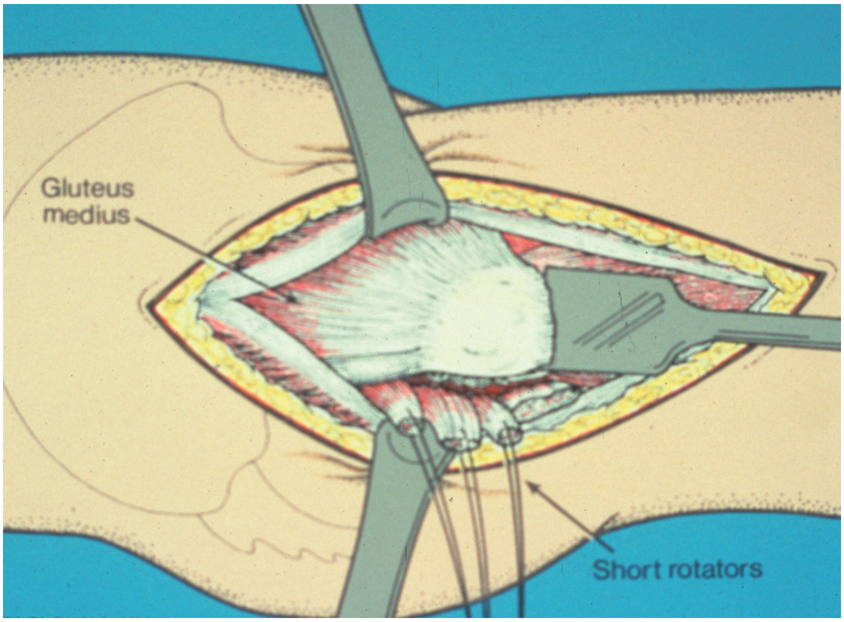
While advantageous in many situations, trochanteric osteotomy has drawbacks. Nonunion of the osteotomized fragment may occur in up to 37% of cases.[6–15] The fixation wires or cables may irritate surrounding structures, causing bursitis or iliotibial band tendonitis. In addition these wires may break and, if migration occurs, may provoke third-body wear in the joint.[16] Heterotopic bone formation may also occur and potentially limit hip motion. On rare occasions sciatic nerve injury has occurred from trochanteric wiring.[17]

Surgical Technique

With the patient in the lateral decubitus position an incision is made, centered over the greater trochanter. The fascia is incised in line with the skin. The vastus lateralis fascia is then incised in L fashion 0.5 cm distal to the vastus tubercle. The transverse extent of the fascial incision is to the anterior border of the trochanter. A joker or wing-tipped elevator is then placed beneath the gluteus minimus tendon above the hip capsule to direct the saw blade. The osteotomy encompasses the sulcus between the lateral portion of the origin of the vastus intermedius muscle and the insertions of the gluteus medius and minimus. The short external rotators may be preserved or released, depending on soft tissue tension. (Figure 9.2.) Following osteotomy, the trochanter is retracted proximally. The capsular attachments of the gluteus minimus and psoas are carefully freed up using blunt elevators. Once exposed, the joint capsule can be excised if contracted or incised in T-like fashion for later reapproximation.

Following completion of the intra-articular procedure, the trochanter is reattached. Numerous methods have been described. Charnley's two-wire technique and Harris's 3- and 4-wire techniques remain popular. (Figure 9.3.) On occasion, bolts and screws have been utilized, though breakage and pullout have occurred with these methods. More recently, multifilament cable in association with a trochanteric grip has become available to increase mechanical advantage, reduce wire breakage, and minimize the likelihood of trochanteric bursitis. Although fixation reliability has increased[15] there are reports of cable debris migration into the prosthetic joint.[18] Thus, even though trochanteric osteotomy provides excellent extensile exposure of the hip, concern regarding complications proscribes its routine use.

FIGURE 9.2. Surgical technique approach to trochanteric osteotomy.



Anterolateral Approach

An alternative approach for hip joint exposure is the anterolateral approach. This technique can be performed with the patient either in the lateral decubitus or supine position. The approach obviates the concern of those surgeons who feel that the posterolateral approach gives insufficient acetabular exposure. It also avoids the complications associated with trochanteric osteotomy. Described early by McFarland, the approach is muscle splitting and may be extended distally via a myofascial sleeve into the quadriceps.[19] This approach can be extensive for procedures involving the acetabulum and/or femur. It is advantageous for those situations where preservation of the femoral head blood supply is necessary, or for prosthetic revision surgery.

There are limitations to the anterolateral approach. If the abductor muscle split is incorrectly performed or carried too far proximally, neurovascular injury can occur or permanent muscle weakness ensue.[20] In addition, an increased incidence of heterotopic bone formation has been described.[21] Conversely, because the posterior capsule is preserved, the incidence of prosthetic dislocation is remarkably low.[22] This approach is not indicated for situations where leg length readjustment is required.

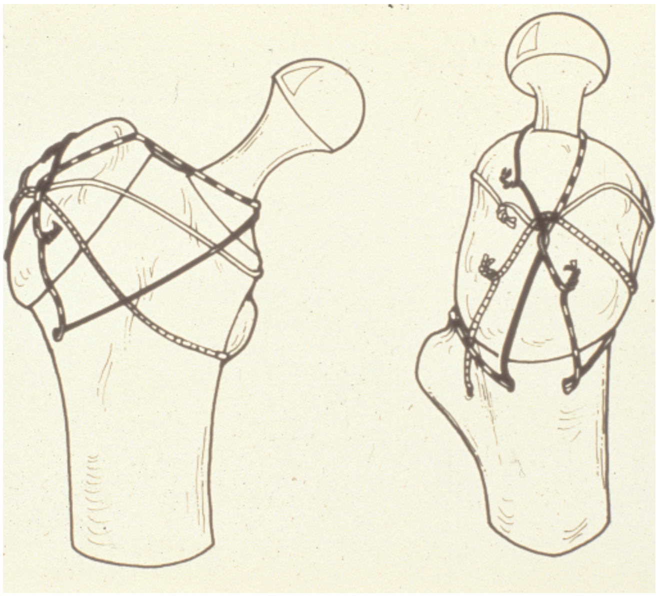


FIGURE 9.3. Repair of trochanteric osteotomy.

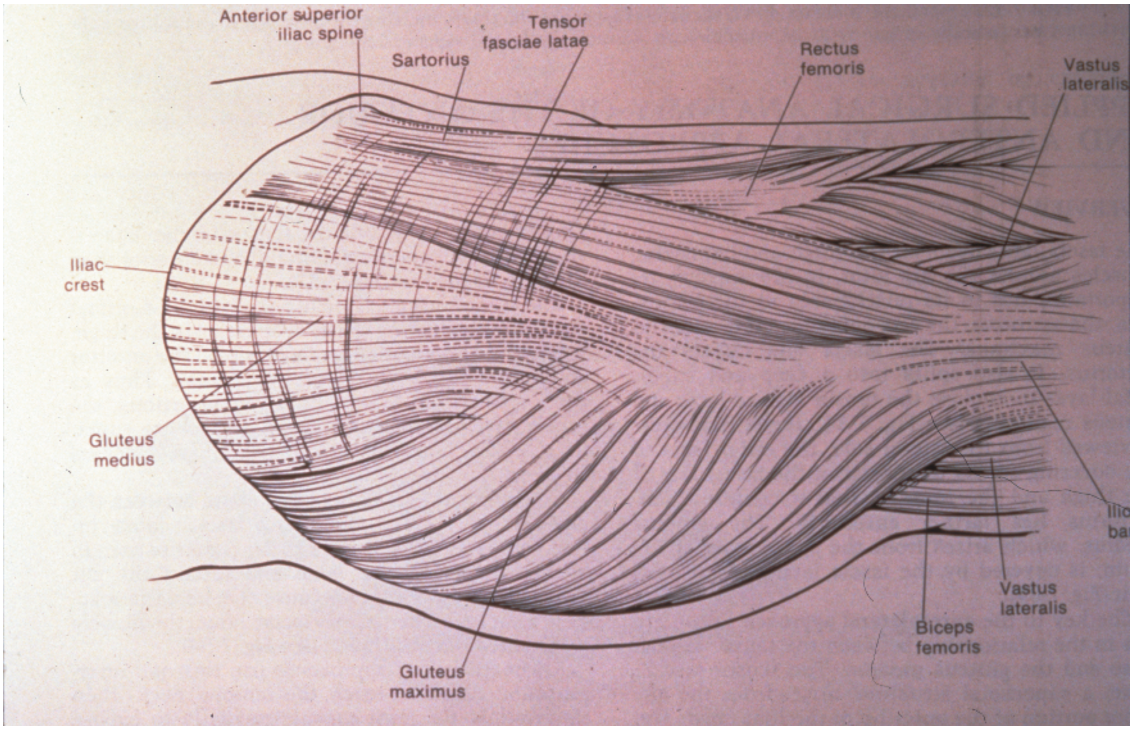


FIGURE 9.4. Identifying landmarks for the anterolateral approach.

Surgical Technique

When performed in the lateral position, the procedure is advantaged when the patient is inclined slightly posteriorly. Following prepping, the surgical field should be draped so that the superior, anterior, and posterior iliac spines are exposed along with the iliac crest proximally, and the greater trochanter and femoral shaft distally. The incision extends proximally from the greater trochanter to the level of the iliac spines.

Distally, the incision parallels the anterior border of the femoral shaft. The fascia is incised in line with the skin incision, between the posterior border of the tensor fascia lata and anterior to the insertion of the tendon of the gluteus maximus. The abductor muscles are then identified. (Figure 9.4.) A muscle split is then performed anterior to the tendinous portion of the abductors and extended proximally less than 4 cm above the tip of the greater trochanter to avoid injury to the inferior branch of the superior gluteal nerve and artery.[22] Distally, the muscle split is carried along the anterior border of the greater trochanter and into the vastus fascia. Should femoral shaft exposure be necessary, the fascial incision can be carried posteriorly just below the vastus tubercle and then distally along the linea aspera. The vastus lateralis muscle can then be reflected anteriorly, and the shaft is now accessible.

Once the intra-articular procedure has been completed, closure is begun. The abductor muscle mass should be secured to the greater trochanter via multiple drill holes and #5 nonabsorbable sutures. Secure anatomic anchorage is paramount. The vastus lateralis fascia is then reapproximated to the linea aspera, and the iliotibial band fascia restored with interrupted sutures.

The anterolateral approach is adaptable to many different surgical situations. The utility of its potential for proximal and distal extension, shortened operative time, and minimized blood loss make it an attractive option as long as secure abductor reattachment can be assured.

Trochanteric Slide

The trochanteric slide approach incorporates some of the advantages of the two previously described exposures. This technique involves removal of the greater trochanter from posterior to anterior while maintaining the integrity of the abductor muscles and the vastus lateralis muscle in continuity. Trochanteric osteotomy ensures extensile exposure of the acetabulum and pelvis. Reflection of the vastus lateralis allows the surgeon to address femoral pathology. In contrast to conventional trochanteric osteotomy, the trochanteric slide is a myosseous sleeve and, should bony nonunion occur, superior migration of the trochanteric fragment is much less likely. Thus abductor function is more reliably preserved. Avulsion of the abductor muscles from the trochanter, as has been reported with the anterolateral approach,[23] does not occur due to the myosseous sleeve continuity.

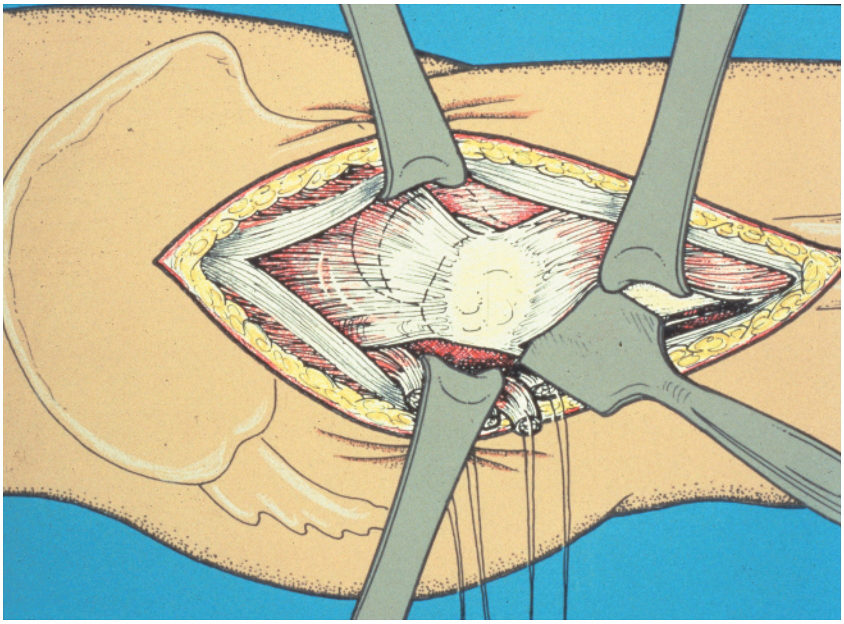


FIGURE 9.5. Surgical approach for trochanteric slide.

There are many potential applications for the trochanteric slide. These include revision total hip replacement with or without leg length adjustment; periprosthetic femoral fracture; access to and treatment of femoral cortical deficiency; removal of extraosseous bone cement; osteotomy of the femur to correct varus, valgus, or rotational malalignment; and trochanteric repositioning or rotational, length, or offset improvement. On the acetabular side, the slide approach facilitates bone grafting; insertion of bilobed cups; vertical relocation of the high hip center for developmental dysplasia, or girdlestone conversion; and removal of heterotopic bone or excessive scarring.

Despite the considerable utility of the trochanteric slide approach, there are some potential drawbacks. Trochanteric osteotomy can result in delayed union or nonunion, resulting in abductor muscle weakness. Fixation of the osteotomized bone, whether with wire or cables, can break, unravel, or even migrate into the articulation. In addition, the fixation may provoke trochanteric bursitis. To avoid tethering of the inferior branch of the superior gluteal nerve, certain extensive acetabular reconstructions (whole acetabular allograft, or insertion of an acetabular cage device) are more safely accomplished by conventional trochanteric osteotomy.

Surgical Technique

With the patient secured in the lateral decubitus position, the skin and fascia are incised in a manner similar to that used for the posterolateral approach. Distally the vastus lateralis fascia is then incised 1 cm anterior to the linea aspera. The entire lateralis muscle is then reflected anteriorly, exposing the femoral shaft. The vertical length of the fascial incision is unlimited, but should be commensurate with the index procedure. Perforator vessels are carefully identified and ligated.

Proximally, the posterior border of the abductor tendon is identified and retracted anteriorly. A blunt-tipped elevator is then placed beneath the gluteus minimus and above the joint capsule from posterior to anterior.

The patient's leg is then slightly rotated internally, and the trochanteric osteotomy initiated just deep to the abductor tendons, the depth guided by the elevator. The oscillating saw is directed from posterior to anterior, maintaining the abductors and lateralis in continuity. (Figure 9.5.) The patient's leg is then progressively rotated externally to complete the anterior extent of the cut. With the lower leg now positioned perpendicular to the floor and protected in a sterile leg bag, the surgeon retracts the trochanter and muscle mass anteriorly. A complete capsulotomy or capsulectomy can now be readily accomplished.

Following completion of the intra-articular reconstruction, the trochanter is reapproximated. Holes are drilled in the lesser trochanter for placement of cerclage wires or cables. A trochanteric grip can be incorporated if necessary. The vastus lateralis fascia is then closed with absorbable suture.

The trochanteric slide approach provides extensile exposure for a wide variety of hip conditions. When necessary, this versatile approach can provide the surgeon with anatomic femoral procedural orientation, access to the anterior and posterior columns of the pelvis, and myosseous continuity to facilitate postoperative function.

Direct Lateral and Modified Dall Approach

Another variant for hip joint arthrotomy is the direct lateral approach. In 1954, McFarland and Osborne described a laterally based technique for hip joint entry.[19] In 1982, Hardinge modified the approach such that the muscular posterior of the gluteus medius and minimus, the anterior capsule, and the anterior portion of the vastus lateralis are reflected anteriorly, thus exposing the femoral neck.[24] The advantages of this approach are the preservation of the greater trochanter and the tendinous portion of the gluteus medius, the expedient joint entry, and the remarkable reduction in posterior prosthetic implant dislocation.[25] Conversely, the limitations of this approach include increased potential for heterotopic bone formation.[26] Neurovascular injury may also occur with this procedure. Baker found a 15% incidence of abductor denervation,[27] but Ramesh found 11% of patients had electromyographic evidence of damage to the superior gluteal nerve.[28] Persistent limp and/or avulsion of the reattached abductor muscles have also been described with this approach. In addition, access to the posterior column of the pelvis is limited, should plating be required. Superior iliac exposure for allografting or cage insertion should not be performed through this approach, to avoid injury to the superior gluteal nerve or artery.

Surgical Technique

The direct lateral approach can be performed with the patient in either the supine position, as favored by Hardinge, or the lateral decubitus position as popularized by Chandler. The skin incision is positioned over the interval between the tensor fascia lata and the gluteus maximus. From 5 cm proximal to the greater trochanter the incision is carried distally for 15 cm over the midline of the femoral shaft. The fascial incision, commencing distally, is extended proximally between the tensor fascia lata and the gluteus maximus. The tendinous fibers of the gluteus medius are identified after dividing the trochanteric bursa. The muscle splitting of the abductor is done parallel to the anterior border of the greater trochanter, thus preserving abductor function. The proximal extent of the muscle split should be less than 4 to 5 cm above the greater trochanter. Beneath the gluteus medius the intervening fat is reflected, and the gluteus minimus split 1 cm anterior to its posterior border. The inferior extent of the gluteus medius split is extended distally just anterior to the vastus tubercle using cutting cautery. (Figure 9.6.) It is paramount to leave a strong cuff of fascia on the trochanter for later repair. Distal to the trochanter the anterior fascia of the quadriceps is incised for 6 cm. Beneath the muscle the transverse branch of the lateral circumflex vessel is identified and ligated. The leg is then progressively rotated externally while the anterior aspect of the femur is subperiosteally dissected. The entire cuff of gluteus medius, minimus, anterior capsule, and quadriceps can then be retracted anteriorly, allowing anterior dislocation of the hip.

A modification of this technique involves an oblique partial trochanteric osteotomy contouring the above-noted muscles. This method, described by Dall, allows postprocedure bone-to-bone trochanteric coaptation rather than soft tissue-to-bone healing. (Figure 9.7.) Some authors have diminished enthusiasm for this approach because of bone nonunion and trochanteric bursitis.[29]

With the femoral head resected and the femur translated posteriorly, a complete capsulectomy is possible. Following completion of the intra-articular reconstruction, closure is begun. The capsule is reapproximated from proximal to distal. If a Dall anterior trochanteric osteotomy has been performed, the anterior bone segment is reduced and held with three #5 nonabsorbable sutures or #16 gauge wire through drill holes. (Figure 9.8.) When a direct lateral approach has been utilized, the abductor soft tissues are secured to the decorticated greater trochanter via multiple drill holes and nonabsorbable #5 suture. Secure anchorage is requisite. (Figure 9.9.) The anterior

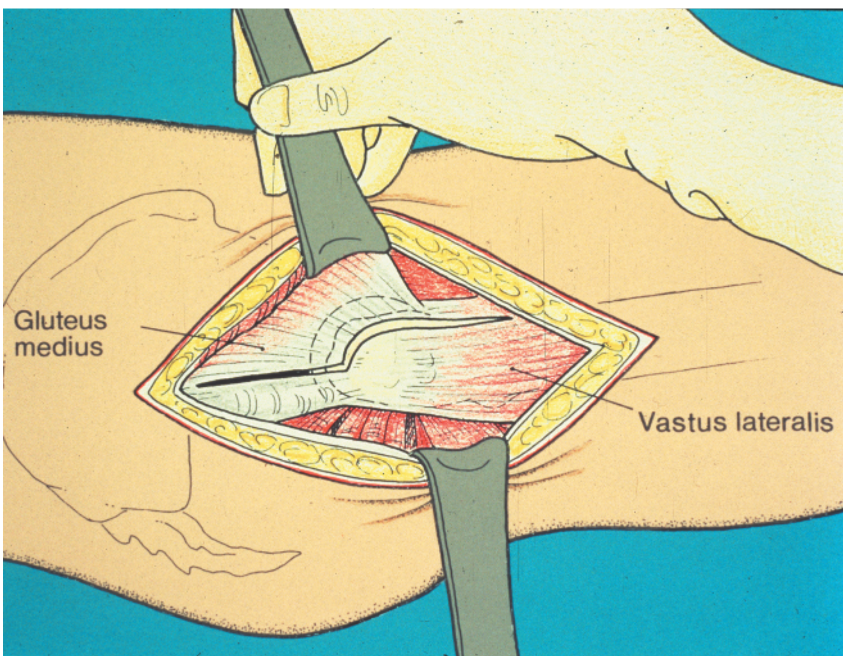


FIGURE 9.6. Identifying landmarks for direct lateral approach.

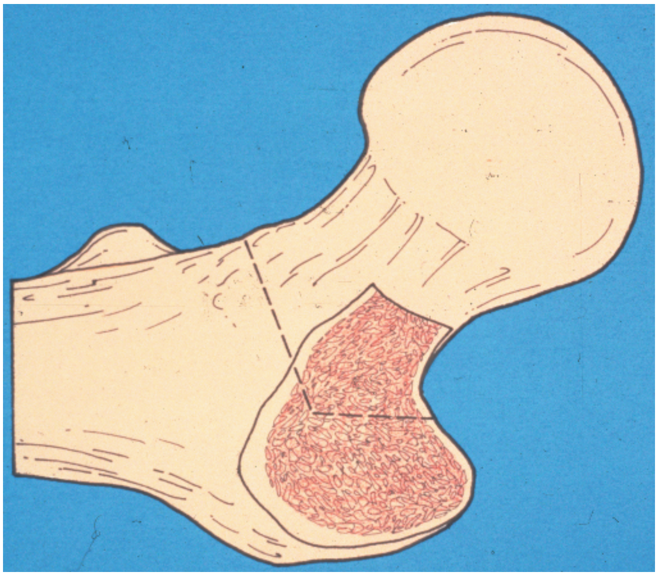


FIGURE 9.7. Osteotomized trochanter using the modified Dall approach.

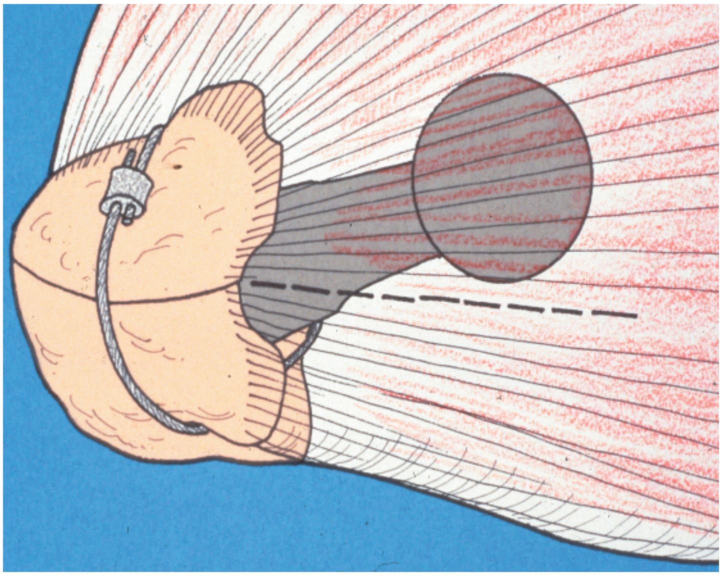


FIGURE 9.8. Surgical repair of modified Dall approach.

cuff of gluteus medius is reapproximated with #1 resorbable suture, as is the vastus lateralis fascia.

The direct lateral and Dall oblique trochanteric osteotomy approaches provide excellent exposure of the acetabulum and femur for primary and simple revision procedures. Preservation of the posterior soft tissues greatly reduces the potential for posterior prosthetic dislocation, and early postoperative flexion range of motion is facilitated.

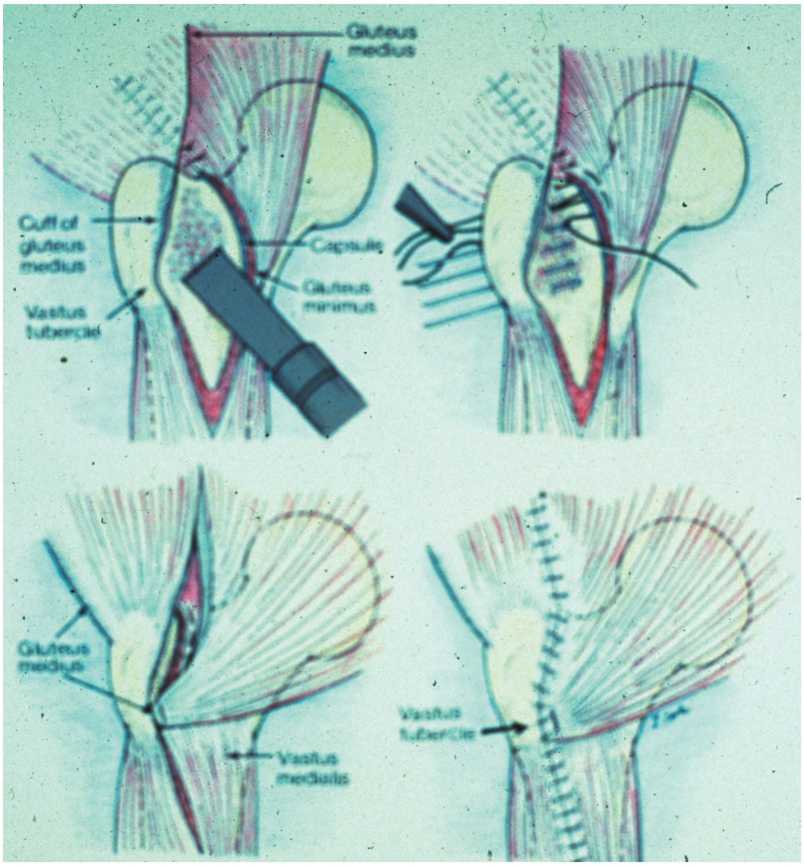


FIGURE 9.9. Surgical repair of direct lateral approach.

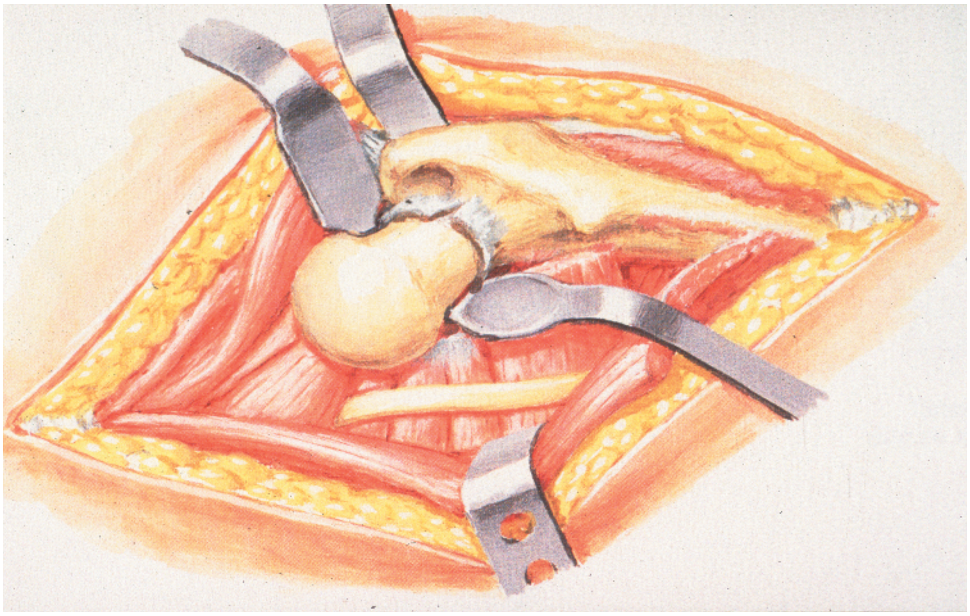


FIGURE 9.10. Surgical dislocation of the femoral head.

Conclusion

Each of the previously noted approaches is intended to achieve joint arthrotomy. Most of the procedures for which they are performed involve femoral head dislocation. (Figure 9.10.) For those surgeries not involving prosthetic replacement there is an attendant risk of developing osteonecrosis. Arthrotomy of the joint requires an inpatient hospital stay and a potentially extended rehabilitation course. For major joint reconstruction or bone grafting these postoperative sequelae are readily justified. For the patient with a symptomatic loose body or labral tear, however, these open techniques are less advantageous. It is for this reason that, however difficult, minimally invasive approaches to the hip joint have been developed.

Minimally Invasive Surgical Approaches

The surgical approach in any operative procedure, arthroscopic or open, is the foundation for success and safety. Hip arthroscopy has evolved significantly over the last 15 years, and the accurate anatomic mapping and delineation of safe entry points or portals to the hip joint has been a major factor in this evolution. The depth of the hip joint from the skin, the intervening muscle and capsule, and the proximity of major neurovascular structures make the arthroscopic approach in the hip significantly more difficult than it is in other, more superficial and less confined joints. In choosing portals for hip arthroscopy one must be familiar with the landmarks, local anatomy, and the relationship of these portals to vital structures which include the sciatic nerve and gluteal vessels posteriorly; the lateral femoral cutaneous nerve anterolaterally; and the femoral nerve and artery anteriorly. Refinements in positioning and hip joint distraction have improved our ability to utilize the portals in various combinations successfully to carry out a number of surgical procedures. Proper preoperative clinical evaluation and radiographic studies are important in planning the selection of appropriate portals to address the suspected pathology. The combination and sequence of portals used for a diagnostic hip arthroscopy may be very different from those used for removal of a foreign body or some other therapeutic intervention, and may also differ based on the operative position preferred by the surgeon. To make such a decision, specific knowledge and understanding of each portal is mandatory. The following chapter will describe in detail the most commonly applied hip arthroscopy portals, including superficial landmarks, relevant periportal anatomy, and the utility of the portal in certain diagnostic and operative situations.

Portal placement begins with palpation, identification, and marking of the anatomic landmarks on the skin. Palpation and marking of the femoral pulse and neurovascular bundle should be done in every case prior to and after the application of distraction, even when an anterior portal is not planned. Once these are marked, localization of the joint and portal pathway is achieved with long (typically 6-in. or 15 cm) 18-gauge spinal needles under image intensification. (Figure 9.11.) After the joint and proper trajectory have been localized, superficial skin incisions, not penetrating deeper than the subcutaneous adipose tissue, can be made to initiate creation of

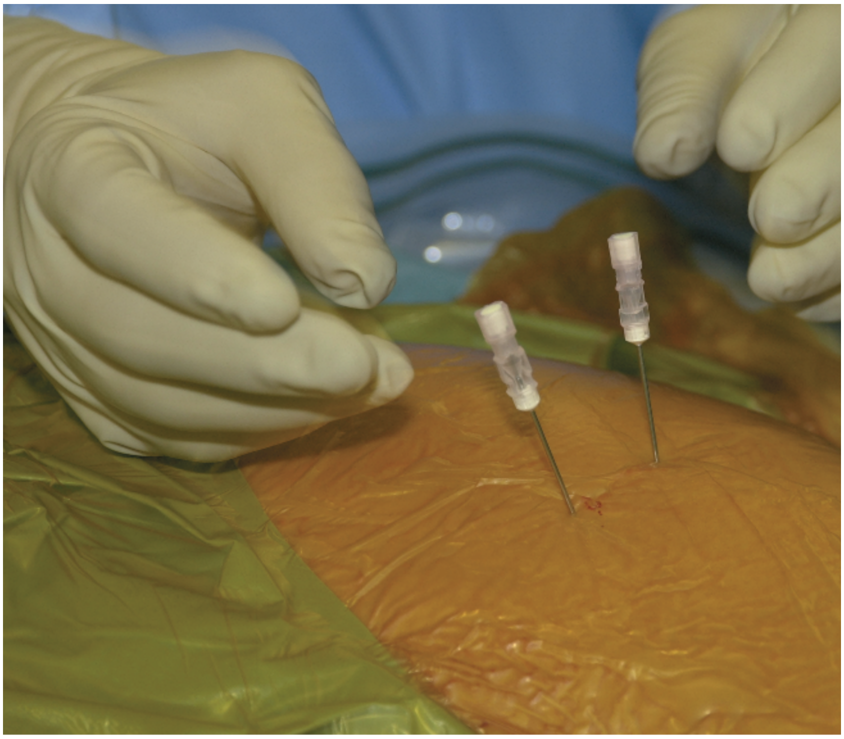


FIGURE 9.11. Two 6-in. spinal needles advanced into the hip joint via the superior trochanteric portals.

the portal. After skin penetration, sheathed blunt trocars are used to pass through the intervening adipose, fascia, and muscle tissue until the hip capsule becomes palpable as a firm but not solid structure. This basic method protects all interceding neurovascular structures and muscle from sharp equipment and repetitive trauma during the exchange of instruments and scopes. Penetration of the capsule, once identified, can then be performed safely through the sheath using trocars (sharp or blunt) or an arthroscopic scalpel. Blunt trocars are preferred over sharp to avoid transection of neurovascular structures and damage to the labrum and articular cartilage upon joint penetration. When using blunt trocars, significant pressure must be exerted to penetrate the thick periarticular capsule. The pressure required varies by patient and by capsular location, with the lateral capsule being thinnest and easiest to traverse. When entering the joint, a firm but gentle "pop" should be encountered. If this sensation is not followed by easy advancement of the trocar and sheath, the labrum may be interposed and damaged. Redirection of the trocar and/or confirmation of positioning with image intensification should then be carried out. After entering the capsule, the trocar in a properly placed portal will advance over the femoral head and into the fovea of the acetabulum. If a firm, bony endpoint is not met after advancement of a few centimeters, the cannula is likely not in the joint. Proper intra-articular needle or cannula placement can be confirmed by aspiration of joint fluid, injection of saline through one port with egress of fluid from the other, or by fluoroscopic imaging. (Figure 9.12.) Once the first portal is established, the others can be performed with intra-articular arthroscopic guidance. Placing the second portal as close to any identified pathology as possible allows for better control and maneuverability of the instruments during treatment. This is more frequently anterior than posterior. Once portals are established, there is little room to "reach" with the instruments to gain additional access. The preferences for initial portal creation, and the selection of working portals, will vary by surgeon and patient position.[30]

Arthroscopic approaches, or portals to the hip joint were actually described by Burman in a 1931 paper that obviously was far ahead of its time.[31] In the paper the paratrochanteric portals or "punctures" were described in detail. He concluded at that time, in the absence of distraction, that the anterior paratrochanteric puncture provided the best approach and visualization of a portion of the femoral head. Watanabe in 1960 reiterated and expanded on the arthroscopic approaches to the hip joint, and in 1985 published them in a textbook of arthroscopy.[32] Gross, working in the pediatric population, published the first clinical application for hip arthroscopy in 1977; he used the anterior portal without distraction, and described the use of an obturator portal.[33] As hip arthroscopy evolved, use of the anterior and anterior paratrochanteric portals became common as a result of the supine position that was initially favored.[34–36] Glick et al[37] later described the lateral approach, which commonly utilizes 2 working paratrochanteric portals; this approach has been further popularized by McCarthy and Villar.[30,38] Goldman et al[39] detailed a limited open posterior arthroscopic approach to the hip utilized in a special circumstance, for removal of a bullet. Although the commonly utilized hip arthroscopy portals had been described and utilized, details of the periarticular hip joint anatomy and

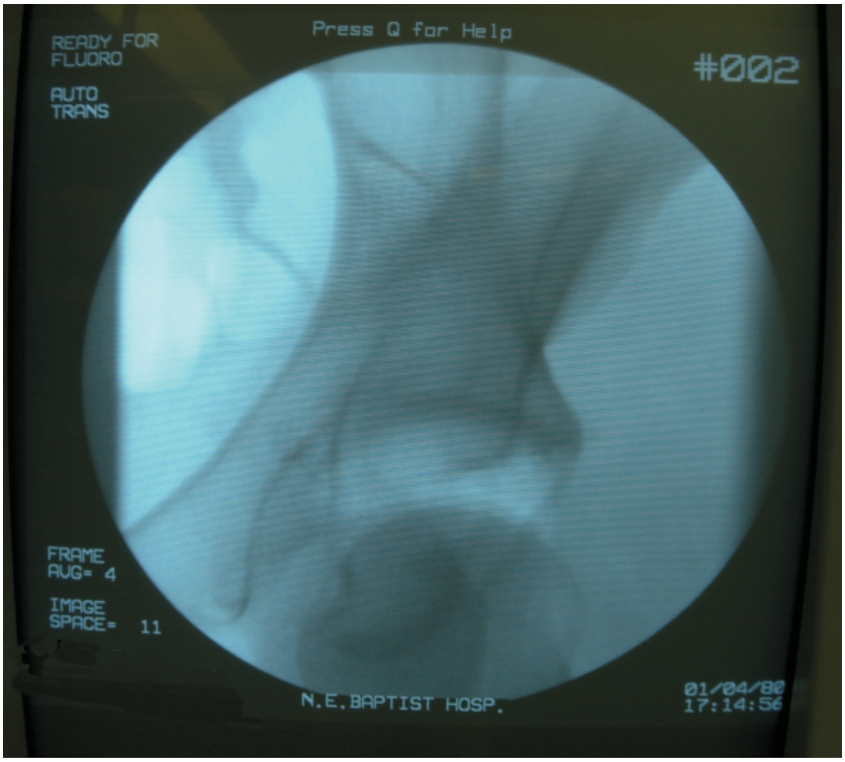


FIGURE 9.12. Proper intra-articular needle or cannula placement can be confirmed by fluoroscopic imaging.

portal relationships were not published until Day and Dvorak in 1990[40] and then further coordinated in 1995 by Byrd;[41] this information has been useful in standardizing the portal terminology and defining anatomically the safety and dangers of each particular approach. Thorough knowledge of the anatomic relationships of each of these portals is essential for the orthopedic surgeon planning to perform hip arthroscopy, and advanced education and training is available and recommended.

Five portals are commonly utilized when performing hip arthroscopy. These are the direct anterior, the anterior paratrochanteric or anterolateral, the proximal trochanteric, the posterior paratrochanteric or posterolateral, and the direct posterior portal. Unfortunately, the nomenclature and definitions regarding these portals or approaches are not consistent in the literature. Confusion arises when reference is made to an anterolateral portal. To some authors this nomenclature refers to the direct anterior portal as described below,[30,42] and to others it represents the anterior paratrochanteric portal also described below.[41,43] The lateral approach described by Glick may have influenced the use of the terms anterolateral and posterolateral in reference to the portals he described, but in recent presentations he refers to these portals with the more descriptive terms anterior and posterior paratrochanteric, as described by Burman in 1931.[31,44] As the procedure evolves and more studies are published, these semantics should resolve; for the purpose of this chapter the lateral specification will be mentioned but replaced by the paratrochanteric designation.

Proximal Trochanteric Portal

The entry point for the proximal trochanteric portal is just cephalad of the tip of the greater trochanter, equi-distant from the anterior and posterior margins of the greater trochanter. The cannula is directed towards the center of the acetabulum and is passed through the musculotendinous junction of the gluteus medius and gluteus minimus muscles before reaching the hip capsule. This route into the hip joint is relatively safe with regard to neurovascular structures. However, if the surgeon fails to maintain the cannula direction towards the center of the femoral head, there is a risk that the scope could deflect anteriorly and injure the femoral neurovascular structures. Because the trochanter is displaced distally due to the longitudinal traction, the direction in which the cannula is advanced is medial and slightly superior. If the portal is initiated too cephalad, the superior labrum is at risk of injury as the scope cannula penetrates the joint capsule. Conversely, if the portal is placed too caudad, and the cannula is not directed towards the gap between the femoral head and acetabulum, the femoral head is at risk for scuffing.

The proximal trochanteric portal provides excellent visualization of the femoral head, fovea, and anterior and posterior labral structures. It is generally used in combination with the anterior or posterior paratrochanteric portals for triangulation within the hip joint. For diagnostic arthroscopy, this is often the first portal of choice. Once the portal is established, the arthroscope can be inserted into the hip joint with inflow through the scope. If the arthroscope is located centrally within the acetabulum, an assessment of the intra-articular pathology may guide secondary portal placement. Modern cannulated scope instruments allow placement of subsequent portals either anteriorly or posteriorly via the trochanteric portals under direct visualization as they enter the hip joint.

Anterior Paratrochanteric Portal

The anterior paratrochanteric portal is perhaps the safest portal used in hip arthroscopy. It lies most centrally of all the portals in the "safe zone" of hip arthroscopy. This portal may also be used initially to introduce the scope into the hip joint, allowing creation of the direct anterior and posterior paratrochanteric portals under direct visualization.

The anterior paratrochanteric portal is located approximately 2 cm anterior to the anterior margin of the greater trochanter and essentially level with the tip of the greater trochanter. Care must be taken to maintain a slight posterior superior orientation when entering the hip capsule to avoid shaving off the thick anterior hip capsule and injuring the anterior femoral neurovascular structures. The neurovascular structure at significant risk with this portal is the superior gluteal nerve. This nerve innervates the gluteus medius, gluteus minimus, and the tensor fascia lata muscles. This nerve courses transversely across the deep side of the gluteus medius muscle in a posterior-to-anterior direction. Anatomic studies have shown that the nerve is an average of 4.4 cm superior to the needle or trocar. This portal transgresses the anterior musculotendinous junction of the gluteus medius, the tendinous region of the gluteus minimus, and the anterior hip capsule before entering the hip joint.

This portal allows visualization of the anterior synovium and the synovial fronds of the zona orbicularis, as well as the anterior labrum. It is an extremely useful portal for instrumentation and management of anterior labral and acetabular chondral pathology. In combination with the proximal trochanteric portal, the scope can be placed through the anterior paratrochanteric portal to visualize the superior acetabular labrum and allow instrumentation of the superior acetabular labrum via the proximal trochanteric portal.

Posterior Paratrochanteric Portal

The posterior paratrochanteric portal is established 2–3 cm posterior to the tip of the greater trochanter at the level of the tip of the greater trochanter, essentially mirroring the anterior paratrochanteric portal. Correct positioning of the posterior trochanteric portal passes through the posterior margin of the musculotendinous junction of the gluteus medius muscle. The cannula passes anterior to the tendinous portion of the piriformis, through the posterior margin of the gluteus minimus, and into the posterior hip capsule. Care should be taken to bias the initial trocar placement slightly superior and slightly anterior to avoid deflection posteriorly and potential injury to the sciatic nerve. Positioning of the hip in flexion greater than 20 degrees can translate the sciatic nerve anteriorly, bringing this structure into jeopardy. Likewise, external rotation of the femur posteriorly translates the greater trochanter and increases the likelihood of posterior deflection of the trocar, which may potentiate injury to the sciatic nerve. It is for this reason that the leg must be placed in neutral position or slight internal rotation when passing the needle or trocar for this portal.

In much the same way that the anterior paratrochanteric portal is key to instrumentation of anterior pathology, the posterior paratrochanteric portal is used to view the posterior capsule, posterior labrum, the ligament of Weitbrecht, and the posterior femoral head. In instances of instrument crowding, the posterior paratrochanteric portal can be used as the primary scope portal, while the anterior paratrochanteric portal is used for managing commonly found anterior acetabular pathology.

An important point with the posterolateral portal is that the "pop" that is encountered when entering the joint must be felt before bone. This signifies that the acetabular floor is encountered. If bone is felt without the sensation of traversing the capsule, one of two possibilities exists. If the needle or trocar is too high, the outer wall of the acetabulum may be encountered. If on the other hand it is too low, it may be the head of the femur that is encountered in lieu of the acetabular floor. Image intensification is helpful for altering the position of the portal pathway.

Cadaveric studies have shown that the course of the portal placement transgresses the gluteus medius and gluteus minimus muscles. It runs superior and anterior to the piriformis tendon. It has been shown that the course of the sciatic nerve brings it closest to the path of this portal at the level of the capsule. Its average distance is 2.9 cm posterior to the trocar capsular position.

The posterolateral portal is considered a very safe portal. Placing this portal under direct visualization frequently facilitates its intra-articular position. This is commonly done by placing the camera in the anterolateral portal first. Some have suggested slight flexion of the hip to promote ease of placement of the needle or trocar. Although no anatomic studies have looked at this idea, excessive hip flexion could potentially tent the sciatic nerve more anteriorly and place it at increased risk.

Direct Anterior

The anterior portal remains available to the arthroscopist when the patient is in the lateral position. This portal is located by the intersection of vertical lines from the anterior superior iliac spine and a horizontal line drawn from the superior aspect of the symphysis pubis laterally. An 18-gauge spinal needle is advanced toward the femoral head along a line 45 degrees medial and 45 degrees proximal to this point.[45] Following distention of the joint with normal saline, the arthroscope is positioned in the joint along the spinal needle pathway. The scope is inserted medial to the tensor fascia lata and lateral to the sartorius muscle. Structures at risk with this portal placement include the lateral femoral cutaneous nerve and the ascending branch of the lateral femoral circumflex artery. The femoral nerve and artery are within 3 to 4 cm and should not be at issue unless portal misplacement occurs. This approach allows visualization of the anterior femoral neck, the superior retinacular fold, and the ligamentum teres. A 70-degree arthroscope is a helpful adjuvant for visualization of posterior femoral and acetabular pathology. Some authors minimize the slight increase in neurovascular injury associated with the anterior portal by dissecting via a mini open incision down to the hip capsule.[46]

Posterior Portal

The posterior portal is used only in association with a miniarthrotomy. Its main purpose is to visualize the posterior aspect of the hip joint while avoiding a formal arthrotomy or more importantly dislocation of the joint. Due to the intimacy of the sciatic nerve and the superior gluteal vessels to the course of this portal, an open approach is made with an 8-cm incision along the posterior aspect of the greater trochanter to the posterior superior iliac spine. The gluteus maximus is split in line with its fibers in a blunt fashion. The short external rotators, including the gemmeli, the obturator internus, and the piriformis muscles are tagged and retracted. Care is taken to preserve the quadratus femoris muscle, which overlies the medial circumflex vessel, the vascular supply for the femoral head. At this point the posterior capsule is exposed, and the arthroscopy instruments may be passed. The scope is then advanced posterior to the posterior margin of the gluteus medius muscle. This approach has been useful for removal of posteriorly lodged foreign bodies, as well as access to the posterior inferior recesses of the hip joint.[16]

Portal Placement in the Supine Position

Direct Anterior Portal

The direct anterior portal is commonly used in hip arthroscopy performed in the supine position, and during extensive synovectomy and debridement when in the lateral position. As noted above, the entry point for the arthroscope is at the perpendicular intersection of a horizontal line directed laterally from the symphysis pubis and a vertical line extended inferiorly from the anterior superior iliac spine (ASIS). The superior margin of the greater trochanter has also been described as a landmark in lieu of the symphysis pubis for creation of the horizontal line, but its height is variable.[38,41] The direct anterior portal should not be created medial to the vertical line, and the femoral neurovascular bundle should always be palpated and marked prior to any instrumentation. Spinal needles and cannulas are then directed toward the femoral head along a trajectory 45 degrees from the horizontal and 30–45 degrees from the vertical midline.[30,41,45] Anatomic studies have placed the portal an average of 6.3 cm distal to the anterior superior iliac spine.[41] This portal directs the cannula sheath through the sartorius and rectus femoris muscle bellies, and enters the hip joint under the anterior margin of the acetabular labrum. This portal should be created after the arthroscope has been previously placed into the joint and direct visualization is possible. This portal can be established without the aid of the fluoroscope by placing the anterior stab wound in the same location as the initial point of entry for the spinal needle and moving down to the capsule bluntly with the switching stick. Visualizing the movement of the capsule anteriorly from the lateral portal has been sufficient to guide the placement of the switching stick, the sheath, and the electrocautery incising instrument. Once the anterior capsule has been penetrated with the switching stick, additional instruments can be passed into the hip joint, preferably through the cannula.

The structures best visualized through the direct anterior portal include the anterior femoral neck, the anterior aspect of the hip joint, the superior retinacular folds, the lateral acetabular labrum, the anterior aspect of the transverse acetabular ligament, and the ligamentum teres. A 70-degree arthroscope is necessary for visualization of pathologic changes along the anterior labrum or acetabulum.[30] As a working portal, anterior labral pathology, synovectomy, and retrieval of loose bodies can all be addressed through the direct anterior portal.

The neurovascular structure most at risk with this portal is the lateral femoral cutaneous nerve. Anatomic studies have shown that the nerve has usually divided into three branches in its course at the level of this portal, and branches can pass within 2–4 mm.[41] Damage to the nerve usually occurs secondary to a deep, aggressive skin incision, not with trocar insertion or manipulation of the working instruments when properly sheathed. The femoral nerve and artery are within 3–4 cm and should not be an issue unless portal misplacement occurs. The only vascular structure at real risk for an accurately placed anterior portal is the ascending branch of the lateral circumflex femoral artery, which can be 1–6 cm away.

Lateral Portal

The initial portal that is recommended is the straight lateral portal, which provides easy and accurate fluoroscopic guidance for initial insertion of the instrumentation. A 5-mm stab wound is made just above the tip of the greater trochanter. The location of the point of entry is made more serviceable if a switching stick or other radiopaque object, laid upon the surface so as to be superimposed on the hip joint's radiographic anatomy, is used to assess the track to be followed by the instruments accessing the lateral point of entry into the hip joint, to be inserted next. This assures that the approach to the joint arrives along the surface of the femoral head tangential to its surface to minimize the likelihood of impinging on the chondral surface itself. The stab wound allows passage of a blunt-ended switching stick to the lateral aspect of the hip joint, where the stick can be used to palpate the groove between the acetabular margin and the femoral head and be confirmed fluoroscopically. The same tool can be used to assure that the point of contact is at the most lateral aspect of the acetabular margin, approximately midway from the anterior to the posterior extreme of the hip joint.

With the switching stick held firmly in position, the appropriate sheath can be passed to the level of the lateral capsule and held firmly there as the switching stick is removed. A shielded, hook-pointed electrocautery tip can be used to incise the capsule to ease penetration of the switching stick if the hip joint capsule is very thick and resistant to penetration. This approach has proven less traumatic to the structures of the underlying joint than has forceful penetration with the sharp trocar. The incision in the lateral capsule can be monitored fluoroscopically as it is made. Once the capsule is penetrated or incised, the blunt nose of the switching stick can be passed through the same sheath, or the sheath can be removed, and the scope sheath with the blunt obturator can be passed through the lateral capsule into the joint, and confirmed radiographically. We have found it advantageous to place the switching stick through the same sheath used for the incision, to make finding the incision with the blunt instrument more assured. Once the blunt introducer passes into the joint toward the cotyloid fossa, the optical elements of the scope can be introduced and the joint insufflated, irrigated, and inspected. We have also found that irrigating fluid with epinephrine minimizes bleeding in the joint and helps maintain a clear view.

The lateral portal described above affords good visualization from the mid to inferior aspect of the cotyloid fossa to the lateral edge of the acetabulum and posterior to the mid-posterior point of the acetabular circumference, including the places to which loose foreign bodies tend to migrate. Visualization anteriorly can be carried to somewhat beyond the mid-anterior point along the acetabular margin. Greater visualization can be achieved with 60–90-degree arthroscopic optics.

Posterior

On those rare occasions necessitating a posterior portal, the surgeon may raise the table's level somewhat and take special care to avoid the course of the sciatic nerve using blunt dissection with the switching stick or blunt obturator between the skin and the hip joint's capsule, in addition to the placement of the posterior portal skin incision not more that 45 degrees below horizontal on the way to the hip joint.

Hip arthroscopy continues to gain widespread acceptance with increasing indications. Although safety in this procedure is well documented, a thorough knowledge of the optional portals is mandatory. The different portals have varying abilities to visualize different anatomic structures. Knowledge of anatomical relationships is of utmost importance in the utilization of the various portals. Patient position, lower extremity positioning, and portal placement can all affect these relationships. In the hands of knowledgeable and experienced orthopedic surgeons, hip arthroscopy will remain a safe and efficacious way to both diagnose and treat hip pathology.

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10
Specialized Equipment

Mark I. Froimson and Viktor E. Krebs

Hip arthroscopy is successful and reproducible only with the use of specialized equipment. A number of unique features of the hip make arthroscopic access more difficult than in other joints. Its deep location and thick soft tissue envelope pose challenges to conventional arthroscopic equipment. Additionally, the high degree of conformity of the ball and socket articulation makes entry to the joint itself impossible without adequate separation of the opposing surfaces. Appreciation of these factors has fueled a number of innovations which have given rise to the evolution and acceptance of this procedure. As the pathology within the hip has been identified, specialized equipment has been created to allow manipulation, excision, and ablation. In fact, because hip arthroscopy is an equipment- and instrument-dependent procedure, progress has been made only when new equipment and instruments have been introduced.

It is imperative that one have an understanding of the equipment needed to facilitate hip arthroscopy before one undertakes this technically dependent procedure. There is no doubt that the procedure is more likely to achieve its objective if the equipment can be set up favorably to assist the surgeon. A number of devices are practically mandatory, and their absence cannot be compensated for. Others simply make the job easier and may be more a matter of preference than a requirement. Nonetheless, a firm understanding of the resources available will allow the surgeon the greatest chances of accessing the sought-after pathology.

A systematic approach to hip arthroscopy and the necessary equipment will ensure that the procedure progresses smoothly. One needs to consider not only the specialized arthroscopic equipment that will be required, but also the setup of the room and the positioning of the patient. Important concerns also include a method of hip distraction, radiographic visualization, capsular distention, and joint instrumentation. This chapter will focus on the technical aspects of the tools necessary to access the human hip arthroscopically.

Room Setup

The operating room must be of sufficient size to accommodate both the arthroscopic and radiographic equipment that may be utilized. It is often necessary for the surgeon to be able to visualize both monitors simultaneously, and it is therefore essential to plan the arrangement of the OR properly with this in mind. Whether the patient is positioned supine or lateral, the monitors are typically set up on the side of the table opposite the surgeon, while the scrub nurse and assistant are generally on the same side as the surgeon. Although the principles and essentials of the equipment are the same regardless of patient positioning, some unique differences deserve special attention.

The supine position is often favored by the infrequent or inexperienced hip arthroscopist for several reasons. The setup and feel are quite familiar to the hip surgeon accustomed to treating hip fractures. A standard fracture table can be utilized, the surgeon can be positioned lateral to the patient, and the image intensifier can easily be maneuvered in as necessary. (See Chapter 8.)

The lateral position cannot be utilized without the addition of specialized patient-positioning and hip traction devices. The patient must be secured so that the direct lateral position does not change with the application of traction. The positioning apparatus must not interfere with placement of the anterior portal and must not obstruct radiographic visualization of the hip joint. Many standard hip replacement positioners will meet these requirements. In addition, because the lateral position requires the use of the image intensifier across the table (to obtain an AP image of the lateral patient), one must allow for its placement either above or below the table. Although some prefer to tilt the C-arm over the distal aspect of the table, most have found it can be better accommodated out of the operative field by passing it under the table. This requires reversing the OR table so that the pedestal is under the foot of the table, the C-arm passes under the pelvis, and the surgeon can approach the hip from distal to proximal. Most surgeons prefer to stand anterior to the patient, allowing better access to the anterior portal, but some are more comfortable approaching from posterior.

Distraction

Although the method of applying distraction varies between the two approaches, its importance cannot be overemphasized. Initial attempts by Burman in 1931 to visualize the hip joint arthroscopically without distraction made this point abundantly clear. He concluded that it was "manifestly impossible to insert a needle between the head of the femur and the acetabulum!"[1] Without distraction, Burman is essentially correct, and until its use only the periarticular structures could be visualized and manipulated. Adequate distraction of the hip is important not only to visualize the confines between the femoral head and acetabulum but also to prevent scuffing. The arthroscope and the arthroscopic instruments can easily be brushed against the chondral surfaces, resulting in scuff marks if the hip is not distracted sufficiently. (See Chapter 8.)

Instrumentation

Arthroscopic access to the hip joint requires specialized instrumentation that allows controlled, atraumatic penetration of the periarticular soft tissues, abductor musculature, and hip joint capsule. Because of the depth of the hip joint from the surface, specially designed extra-long arthroscopic instruments are generally required to enter the hip joint and perform any necessary procedures. In selected smaller individuals who have thin soft tissue envelopes, it is sometimes possible to use arthroscopy instruments designed for use in the shoulder or knee. It is best, however, not to expect this to be the case.

All arthroscopic instrumentation should be passed through sturdy metallic sheaths or cannulae long enough to traverse soft tissues surrounding the hip once a portal is made. Retained cannulae prevent loss of joint capsular distention and loss of visualization through multiple perforations in the hip capsule. They also reduce the risk of instrument breakage, further trauma to periarticular soft tissue, and neurovascular injury. In addition, retained cannulae allow for an easy interchange of instrumentation among portals to allow better visualization and instrumentation access to the hip joint.

Several commercially available hip arthroscopy sets have been designed to address the special needs of this procedure. Although some of the specifics may differ and the sets will continue to evolve, many common features define the successful instrument set. It must include cannulated spinal needles for entry into the hip joint, guidewires which can be passed through the spinal needle, and finally cannulated blunt trocars for introduction of the arthroscopic cannulae into the hip joint. (Figure 10.1.) The availability of these tools makes reliable and reproducible entry into the hip possible with minimal intra-articular trauma. Multiple portals can be established under image guidance and arthroscopic confirmation.

FIGURE 10.1. Cannulated spinal needles for entry into the hip joint, guidewires and cannulated blunt trocars for introduction of the arthroscopic cannulae into the hip joint (Arthrex Corp, Naples, FL).

FIGURE 10.2. A specially designed Nidinol guidewire may be passed through the center of the spinal needle, confirming position within the joint.

Surgical Technique

With the patient properly positioned, either supine or lateral, and with confirmation of the potential for distraction of the joint, the hip is distracted. Initially, a 6-in. long, 15-gauge spinal needle with a thick wall is inserted into the anterior paratrochanteric portal. Fluoroscopy is used to ensure that the needle has not been grossly misguided. Once the joint is confirmed to have been entered, release of the negative pressure within the joint is accomplished by injection of air or saline. The joint is then distended with approximately 40 ml of fluid, and the intracapsular position is confirmed by backflow through the needle. At this point one can see an immediate increase in the distraction, a decrease in the force reading on the tensiometer, or a combination of the two. A second spinal needle is then inserted into the proposed posterior paratrochanteric portal. Free exchange of fluid confirms that both needles are within the joint.

A specially designed Nidinol guidewire is then passed through the center of the spinal needle, its position confirmed in the joint, and the spinal needle removed. (Figure 10.2.) This Nidinol wire has "memory" and is resistant to kinking within the joint. Utilizing this wire as a directional guide, a blunt cannulated trocar with metallic sheath is inserted to the level of the hip capsule after a small stab incision is made in the skin. The blunt trocar can be exchanged with a sharp trocar for controlled penetration of the hip capsule, although some prefer to penetrate the capsule with a blunt trocar. Some surgeons prefer to simply use the spinal needle as a directional guide to cannula introduction without the use of the wire, but this requires greater experience in the "feel" of the hip.

It is important to have multiple cannulae or sheaths, which can be used interchangeably. Arthrex and Dyonics both have dedicated hip arthroscopy instrumentation, with complete families of cannulae available. The diameter of the working cannulae can vary depending on the individual systems, but generally are from 4.0 to 5.5 mm, so that they can mate with most standard shavers. (Figure 10.3.) Graduated metal cannulae (or alternatively dilation tubes, which range in diameter from 2 mm to 7 mm or 10 mm) can assist in more diffi-

FIGURE 10.3. The diameters of the working cannulae can vary depending on the individual systems, but generally vary from 4.0 mm to 5.5 mm, so that they can mate with most standard shavers.

FIGURE 10.4. Graduated metal cannulae (or alternatively dilation tubes which range in diameter from 2 mm to 10 mm) can assist in more difficult situations.

cult situations. (Figure 10.4.) The larger cannula can be placed over the working cannula with the assistance of a switching stick. Retained cannulae prevent loss of joint distention, reduce the risk of instrument breakage, and reduce the soft tissue trauma and potential neurovascular injuries associated with multiple perforations.

Distention

Once the portals have been established, the hip is distended with fluid. Normal saline is the solution of choice, as this has shown no untoward effects on articular cartilage and no harmful systemic effects due to absorption of extravasated fluid by the surrounding soft tissues. Initially, the inflow is attached to the arthroscopic cannula. Although gravitational flow can been used, this does not provide enough pressure to keep the hip joint distended. An arthroscopic pump more reliably maintains the constant pressures needed to keep the joint distended, and therefore significantly aids in visualization. A number of standard pumps are available that allow independent control of both pressure and flow rates. Although these systems have a hand-held controls that allow the surgeon to control flow and pressure manually, it is generally preferable to have an assistant monitor the pump operation. The arthroscopic sheath should generally permit high-volume inflow as well as accessory fluid outflow openings. This can aid visualization when a second outflow cannula has been temporarily lost. It is, however, standard to manage outflow through a second cannula.

Arthroscopes

It is advantageous to have both 30- and 70-degree arthroscopes available to allow complete visualization of the hip joint. There is no doubt that most of the intra-articular structures in the hip joint can be visualized with the standard 30-degree scope, by varying the angle of the arthroscope and by exchanging the scope among the various portals. There are times, however, when a 70-degree lens is needed for complete visualization, particularly when one is dealing with a tight hip joint. Surgical instruments and the arthroscope can be interchanged among any of the portals.

Modern video equipment allows for documentation with either video or still photographs, without interfering with surgical viewing. Optical technology has advanced significantly to provide clear images with a minimum of dark spots or glare.

Standard Tools

Standard mechanical shavers will pass through the long cannulae. In addition, curved-tip shavers can be utilized but need to be passed through flexible cannulae. Extra-length curved shaver blades have been designed to allow for operative arthroscopy around the convex surface of the femoral head. (Figure 10.5.) Extra-length flexible cannulae allow for passage of these curved blades. These curves are available with the working opening on either the convex or concave surface, depending on the location of the pathology and ease of access to it. Full-radius resectors, serrated shavers, and aggressive meniscal shavers, as well as others can all be used in the appropriate instances.

Long suction punches, which allow simultaneous resection and aspiration of tissue, as well as suction graspers to withdraw loose bodies, have been designed specifically for hip arthroscopy. (Figure 10.6.) As it is sometimes difficult to reach all areas visualized, it is particularly useful to have the option of suctioning the loose body or flap to the grasper for removal. Such punches and graspers usually require larger, disposable cannulae for best access. In addition, the capsule should be released with a long arthroscopic knife. The cannula is withdrawn after the knife is introduced, the capsule incised under direct vision, and the sheath is then reintroduced. This can greatly improve maneuverability and reduce the incidence of articular cartilage scuffing.

A number of probes and hooks can by used for evaluating the intra-articular structures. (Figure 10.7.) An extra-long arthroscopic nerve hook is the instrument of choice for assisting with the diagnostic portion of the procedure. It can be used to palpate the acetabular rim and labral attachment.

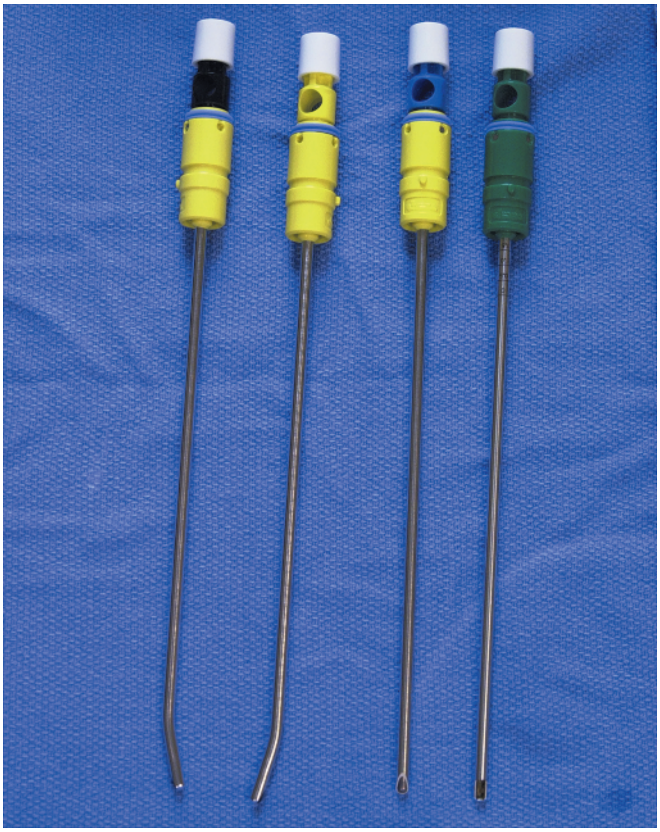

FIGURE 10.5. Extra-length curved shaver blades have been designed to allow for operative arthroscopy around the convex surface of the femoral head.

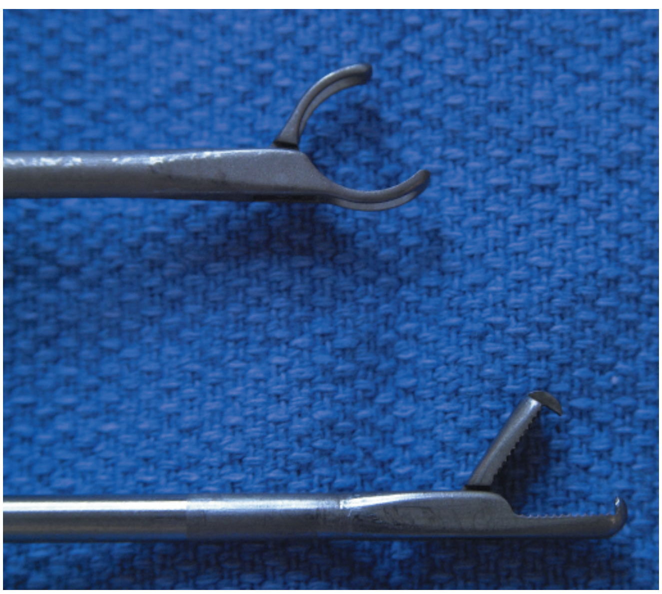

FIGURE 10.6. Alligator and extended-opening graspers to withdraw loose bodies have been designed specifically for hip arthroscopy.

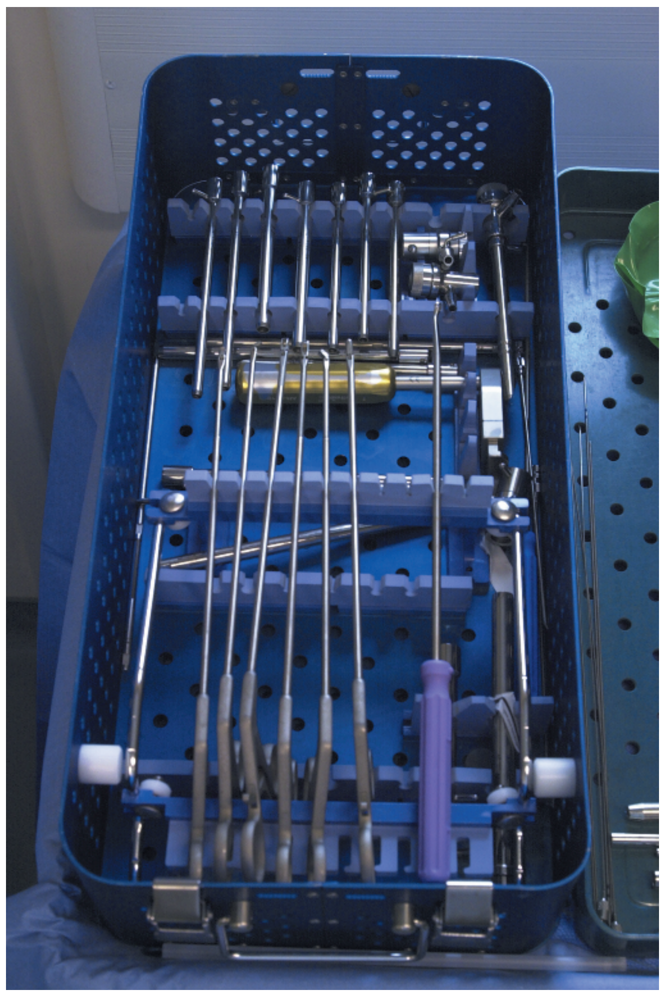

FIGURE 10.7. A number of probes, hooks, and graspers can be used for evaluating the intra-articular structures.

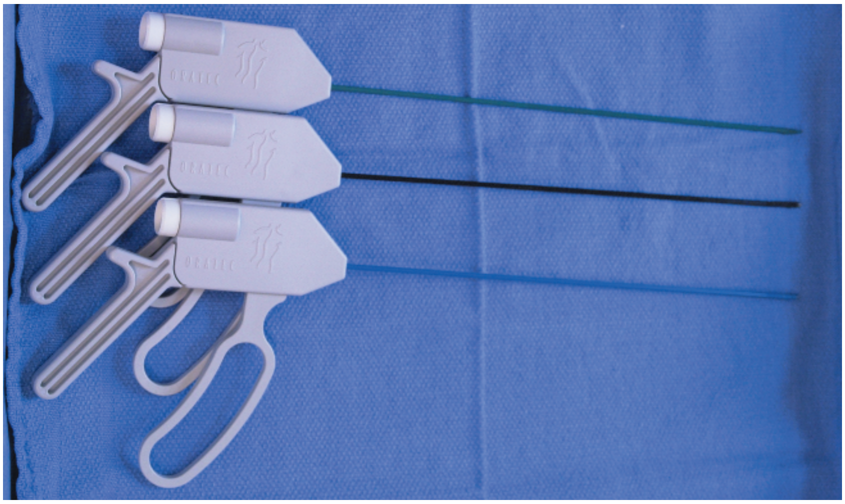

FIGURE 10.8. The Oratec probes use RF (radiofrequency) energy to create a thermal effect on tissues.

Thermal Devices

Thermal tissue ablation has become a useful adjunct in the treatment of pathology in many joints, and the hip is no different. The ability to coagulate and cauterize in a normal saline environment is essential in hip arthroscopy. The Concept meniscectomy electrode is a reliable tool. The insulation extends down to a right-angled tip. In our experience, compared with newer radiofrequency and laser devices, the insulation on the meniscectomy electrode is the most durable, with less chance of damage or of a loose piece of insulation breaking off in the hip joint. The cautery is extremely useful in debriding the torn labral rim and can also be used to debride chondral flaps. It can also coagulate the inflamed, redundant synovial tissue folds.

There has been a proliferation of devices used to deliver heat energy to tissue for the purpose of ablation or shrinkage. It is important that the surgeon using this technology be familiar with the characteristics of the particular device and its potential uses. Ablation typically occurs at higher temperatures in shorter times, whereas shrinkage of collagen requires a controlled delivery of heat at a specific temperature.

The Oratec uses RF (radiofrequency) energy to create a thermal effect on tissues. (Figure 10.8.) It delivers controlled thermal energy for cutting and coagulation with precise temperature control. Its applications in arthroscopy are expanding, and it has been used extensively in the shoulder and the knee. The Oratec probe is most commonly set at a temperature of 67°C at the probe tip. Basic science studies have shown that this temperature results in alteration of collagen proteins with resultant shortening of the fibers. At higher temperatures it also can be used to cut and coagulate. While it has not been used extensively in the hip, its potential applications include debriding labral tears, shrinking the redundant labrum, coagulating and shrinking synovial folds, and smoothing chondral irregularities. Oratec has developed specialized attachments for use in hip arthroscopy.

Bipolar cautery is another tool for controlled delivery of heat to the tissue. The Arthrocare wand is available in many shapes, diameters and sizes. (Figure 10.9.) The 30-degree tip is end-cutting and is particularly useful in ablating tissue in hard-to-reach areas. Its uses are virtually identical to those de-

FIGURE 10.9. The Arthrocare wand is available in an extended length with angled tip.

scribed earlier, and the choice often depends on familiarity and availability.

The Holmium laser has also been applied to hip arthroscopy. It appears to be falling out of favor simply due to the ease of use of these other thermal products at a significantly lower cost. In an environment where lasers are readily available, the surgeon may consider its use in the hip as an ablater of soft tissues. Specialized laser tips have been developed for use in the hip.

Instrument-Related Complications

The single most common complication, which is probably underreported, is "scope trauma." The dense soft tissue envelope about the hip limits the maneuverability of instruments, and the hip is a tightly contained joint. The convex articular surface of the femoral head is especially vulnerable to injury. (Figure 10.10.) This may occur during either portal placement or subsequent instrumentation and requires a very thoughtful approach when carrying out operative arthroscopy of the hip.

The labrum is also susceptible to damage during portal placement. Such damage is most likely to occur when trying to use a more cephalad position for penetrating the capsule, attempting to avoid the articular surface of the femoral head. The labrum is inadvertently penetrated, potentially resulting in significant damage and uncertain long-term consequences. During portal placement, it is best to try to come in low under the labrum, but then to direct upward or to lift up to stay off the articular surface of the femoral head.

The risk of instrument breakage is greater than with other joints and is not rare during arthroscopic hip procedures. The high conformity of the hip joint and the dense soft tissue envelope again limit the maneuverability of the instruments, resulting in significant torque on the relatively small devices, increasing the potential for breakage. In addition, the extra-length instruments used in hip arthroscopy create a longer lever arm and more potential for excessive torque or bending incidents. The variety of extra-length instruments available for arthroscopy is limited, and there is a tendency simply to use extra-length instruments available for other endoscopic needs, such as abdominal or gynecologic procedures. One must be very aware that these instruments are designed for more delicate soft tissue uses. Improper application in hip arthroscopy makes them especially susceptible to breakage. Portions of such instruments may break off and drop free into the joint. It is imperative under these circumstances to remain calm, turn off the irrigating solution, and always keep the fragment in view. Do not proceed with the intended surgical procedure until the instrument part is removed. The broken part may be stabilized using a small magnet (a Dyonics Golden Retriever) inserted through an appropriate portal until it can be secured by a grasping instrument and removed.[2]

One technique used to reduce the stress on the instruments is to create a capsulotomy around the portals. Through this entry point the instruments are easier to maneuver within the

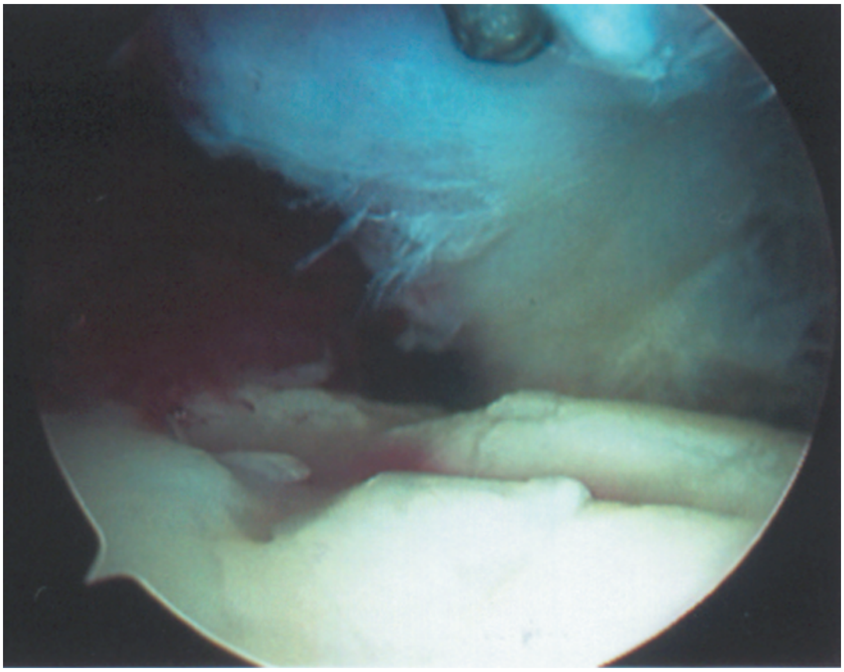

FIGURE 10.10. Arthroscopic photo of a femoral head with damage to the articular surface from an instrument at prior athroscopy.

confines of the joint. The capsulotomy can be performed with a motorized full-radius resector, an electrocautery knife, an arthroscopic banana blade, or a side-biting suction punch. Cuts made with the electrocautery knife not only release the synovium, but reduce bleeding, which enhances visualization.

Future Developments

Further advancements are necessary in optical equipment, manual and motorized instruments, and simple, reliable traction devices specific to hip procedures. The ability to develop instruments that improve access around the convex surface of the femoral head will further expand the role of hip arthroscopy. Flexible instruments and arthroscopes have the potential to reduce articular scuffing while improving visualization and access. Furthermore, such tissue-engineering principles as cartilage resurfacing and transplantation hold promise in expanding our ability to address lesions and injuries of articular cartilage. Finally, refinements in patient selection and the increased availability of specific outcome data will help to define the role of hip arthroscopy in orthopedic practice.

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11
Loose Bodies

Victor E. Krebs

Removal of intra-articular loose bodies from synovial joints has essentially become the territory for the orthopedic surgeon with experience in arthroscopic techniques. Arthroscopy has been reported for and effectively applied to the removal of loose bodies and foreign objects in the wrist, elbow, shoulder, ankle, knee, and hip. Although widespread use of the arthroscope in the hip joint has not been as prevalent as its use in other joints, the indications are becoming more clearly defined. Treatment of symptomatic loose bodies within the hip joint or in the pericapsular region is the most widely reported and accepted application for hip arthroscopy. Advancement of specialized arthroscopic and distraction equipment has made this technique a first-line consideration for patients with documented symptomatic loose bodies within or surrounding the hip capsule. Although arthrotomy remains the gold standard technique for direct visualization and removal of intra- and extra-articular objects or bodies, the morbidity associated with this procedure is significant. Exposure during hip arthrotomy is not comparable to the visualization that can be achieved through the arthroscope, unless the femoral head is dislocated and the ligamentum teres sacrificed. Arthroscopy therefore offers the least traumatic method for visualization of the hip and removing loose bodies. The procedure can be performed on an outpatient basis, has a low number of reported complications, and does not have an extended postoperative recovery period. Importantly, attempting arthroscopic removal of loose bodies does not preclude, complicate, or "burn bridges" for future procedures.

Loose bodies in the hip amenable to arthroscopic removal in most cases are a direct result of either antecedent trauma or disease. In the case of traumatic injury or dislocation of the hip joint, the diagnosis and source of the loose fragments within the joint should be apparent, or at least highly suspected. In some instances, a loose body may be a singular, isolated problem with no readily identifiable cause; a careful history may reveal a "minor injury" that was perceived as a pulled groin muscle. In this situation, low-energy occult trauma may have resulted in a chondral or bony injury and the formation of a loose body. In most situations, though, singular or multiple loose bodies represent the consequence of a more complex pathologic process. Diseases known to affect the hip and to present with symptomatic loose bodies include Legg-Calvé-Perthes disease, osteochondritis dissecans, avascular necrosis, synovial chondromatosis, and osteoarthritis. Every attempt should be made, therefore, to identify the underlying disease process and site of loose body origin prior to and during arthroscopic diagnosis and treatment.

Types of Loose Bodies

Loose bodies may be ossified and non-ossified and classified as osteocartilaginous, cartilaginous, fibrous, or foreign. By far, the most commonly identified and reported loose bodies associated with the hip are ossified, mainly because they are evident on plain radiographs. As our diagnostic acumen and understanding of early hip pathology improve, the presence and significant of cartilaginous and fibrous processes within the joint will undoubtedly expand.

Osteocartilaginous loose bodies are composed of bone and cartilage, and in some cases are detectable on plain radiographs. Byrd has demonstrated the usefulness of arthroscopy in the management of loose fragments in the hip, and has reported successful debridement in a series of three young, active adults. Each patient had a successful outcome, with complete pain relief and return to full activity after an average follow-up of 22 months.[1] These loose bodies may originate from several sources in the hip. The most common are osteochondral fractures, osteochondritis dissecans, synovial osteochondromatosis, and osteophytes (These are listed in no particular order, as the frequency of each is not extensively reported.) The classic disease process resulting in ossified bodies is synovial osteochondromatosis, which is reviewed in Chapter 14.

Osteochondral fractures are not uncommon, and result during traumatic dislocation of the hip and in association with acetabular fractures. These high-energy injuries alone place the patient at risk for aseptic necrosis of the femoral head and post-injury arthritis.[2] When these insults are combined with retained bone and/or cartilage in the weightbearing articular surface, joint longevity is invariably compromised.[3] When loose bodies are identified by computed tomography during closed treatment of acetabular fractures or hip dislocations, Keene and Villar advocate the early arthroscopic retrieval of traumatic loose bone fragments from the joint to eliminate further insult to the already damaged articular surface.[4] Although this seems like a clear indication, Bartlett et al have reported a cardiac arrest in this situation secondary to intra-abdominal extravasation of fluid through an operatively reduced, isolated double-column fracture of the acetabulum. For this reason, they do not advocate arthroscopic hip procedures for patients with acute or healing acetabular fractures.[5] Philipon advocates the combination of hip arthroscopy with open reduction of acetabular fractures through an ilioinguinal approach. Loose bone and cartilage fragments can be removed from the joint prior to and during reduction, and the adequacy of the reduction can be indirectly visualized prior to final fixation.[6]

Osteochondritis dissecans (OCD) is a common condition in children, adolescents, and young adults that can affect any diarthrodial joint. In the hip joint, few cases have been reported as isolated lesions on both the acetabular and femoral sides of the joint.[7–9] OCD is an osseous lesion with a mechanical or traumatic etiology. The process begins as avascular necrosis with secondary involvement of the overlying cartilage; the lesion forms a transitional zone that harbors the potential for complete healing or progression to an osseous defect. OCD is distinguished from osteochondral fractures and epiphyseal ossification disturbances by age distribution, localization, and the radiologic and surgical presentation. Therapy is directed by symptoms and MRI findings. Lesions with intact cartilage should be managed expectantly with conservative measures. Cartilage defects with or without incomplete separation of the fragment, fluid around an undetatched fragment, or a dislodged fragment may benefit from arthroscopy with possible intervention.[10] (Figure 11.1) Bowen has described the removal of loose bodies due to osteochondritis dissecans of the femoral head associated with Legg-Calvé-Perthes Disease.[7] Osteochondritis dissecans after skeletal maturity was reported in approximately 3% (14/465) of adults who were treated for Legg-Calvé-Perthes disease as children. In asymptomatic hips, no treatment was indicated. In symptomatic patients, arthroscopic surgery of the hip was employed to remove the loose osteocartilaginous fragments. Filipe et al have also reported the occurrence of loose bodies or OCD lesions in patients with a prior history of Legg-Calvé-Perthes disease. They concluded that an OCD fragment should be removed surgically when it is mobile, bulging into the joint space, or when there are signs of early arthrosis.[11]

Loose bodies may also present in patients with degenerative arthritis, secondarily causing increased pain and mechanical symptoms. Solitary loose bodies may be present with no identifiable source, and others can be directly traced to fracture of a periarticular osteophyte. (Figure 11.2.) A patient with a symptomatic loose body in the hip and documented degenerative changes presents a treatment dilemma. The overall prognosis is usually dependent upon the extent of underlying degeneration rather than the presence or absence of a loose body. When radiographic evidence of disease is less advanced, or a young patient with a degenerative hip presents with a relatively recent onset of mechanical symptoms, arthroscopic debridement is a potential consideration.[12] This is

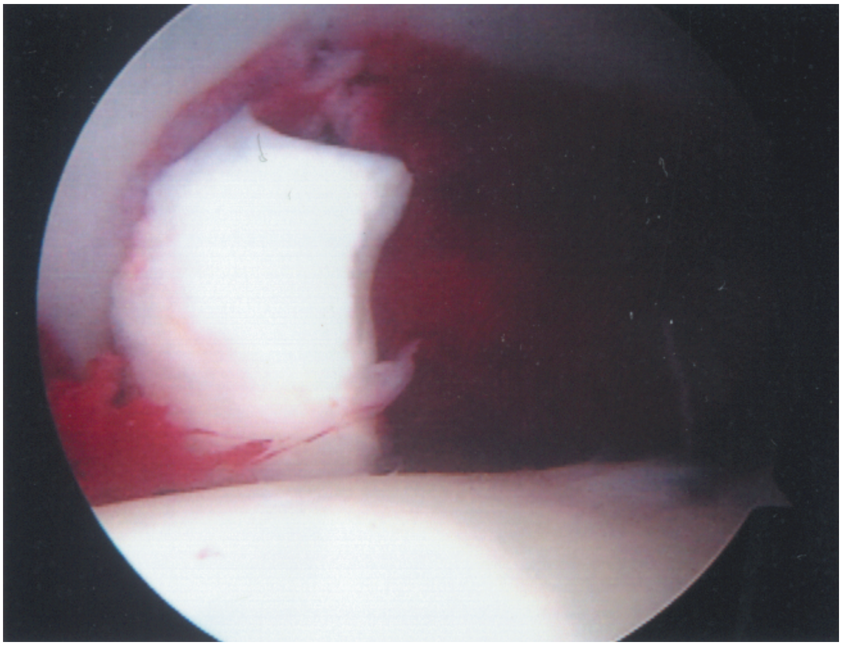

FIGURE 11.1. Dislodged chondral fragment in a patient with OCD. (The loose cartilage has migrated into the fovea.)

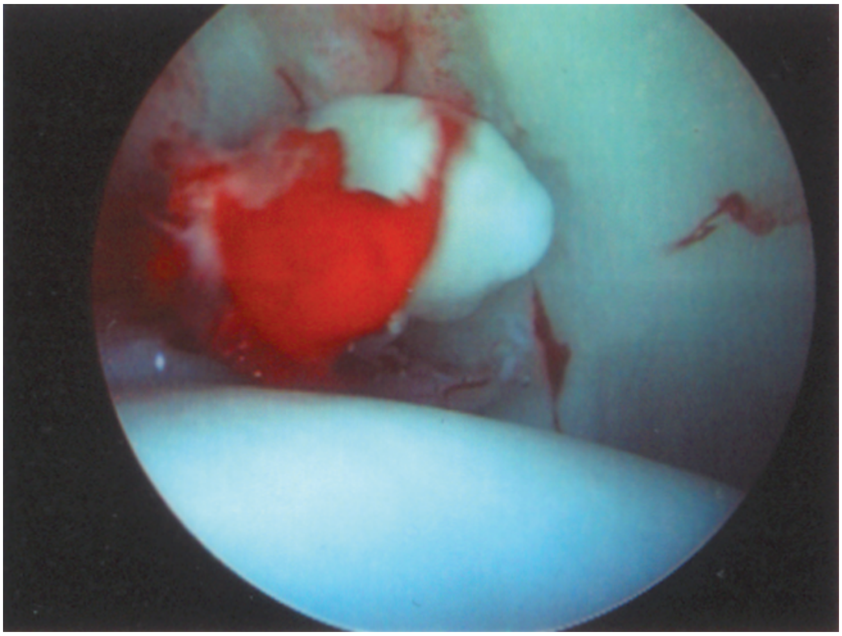

FIGURE 11.2. Solitary loose bodies may be present with or without an identifiable source.

considered a palliative procedure to delay the ultimate need for a total hip arthroplasty, and should be combined with appropriate conservative measures. Advanced radiographic disease also precludes consideration of an arthroscopic procedure, because capsular and periarticular contracture prevents adequate distraction of the joint.

Cartilaginous loose bodies are radiolucent and in most situations originate from the articular surfaces of the femoral head and acetabulum, although they can also occur de novo in association with conditions that cause chronic synovial inflammation. These bodies are difficult to diagnosis, because radiography and plain magnetic resonance imaging usually fail to identify them.[13,14] A high index of suspicion, a careful history, and a physical examination are required to direct the appropriate testing, whether CT or MR arthrography. Isolated chondral injuries are less common in the hip than in the shoulder or knee because of the constrained mechanics of the hip joint and the high energy required to cause subluxation or dislocation. The majority of reported cases describing symptomatic loose cartilaginous bodies in the hip are related to traumatic events.[1,4] Significant impact loading from a direct fall on the lateral aspect of the hip, or extreme axial compression of the lower extremity that results in a subluxation or dislocation is required to cause a chondral injury in a normal hip. (Figure 11.3) Reports of hip joint exploration, open or arthroscopic, following traumatic dislocation or acetabular fracture have identified the presence of numerous cartilage fragments within the weightbearing joint surface. Avascular

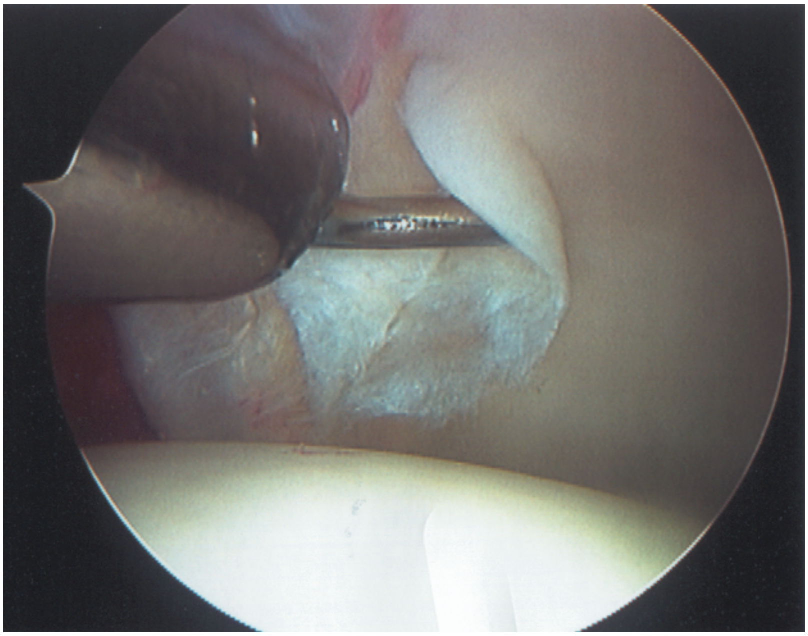

FIGURE 11.3. Subluxation or dislocation may cause a chondral injury in a normal hip.

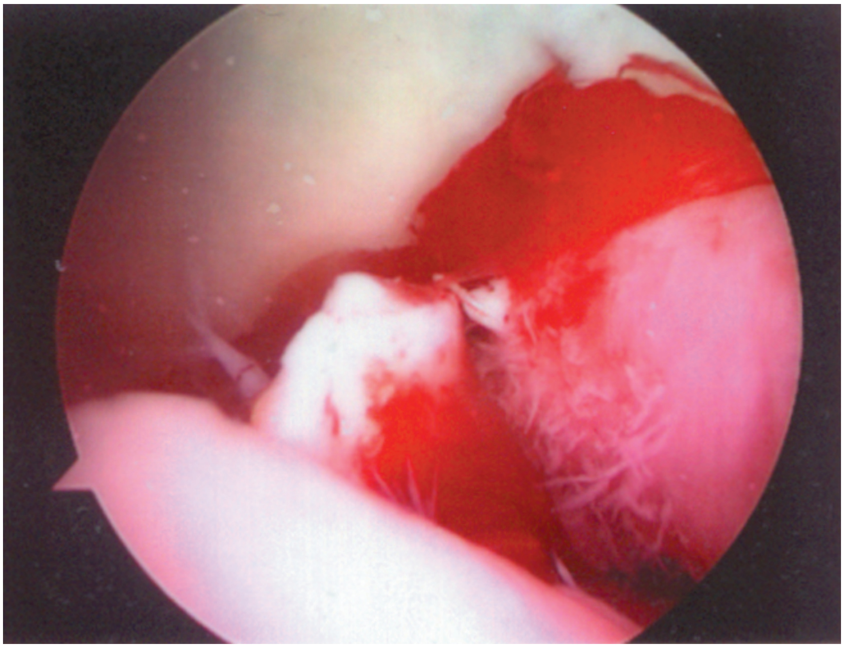

Figure 11.4. Avascular necrosis of the femoral head may also result in the shedding of cartilaginous loose bodies or fragments.

necrosis of the femoral head may also result in the shedding of cartilaginous loose bodies or fragments. (Figure 11.4) AVN results in deterioration of the chondral surface and development of flap lesions that become acutely symptomatic. Chondral shedding and formation of radiolucent loose bodies and fragments also occurs during various stages of osteoarthritis and rheumatoid arthritis.[12] (Figure 11.5.)

Fibrous loose bodies have been reported in other synovial joints, and have been identified in the hip more recently during diagnostic arthroscopy for intractable hip pain.[15] These radiolucent loose bodies result from hyalinized reactions of the synovium secondary to trauma or from chronic inflammatory conditions. Synovial thickening and impingement within the hip capsule are theorized to result in fibrosis, which with repetitive motion and impingement may become pedunculated. These pedunculated synovial folds may detach and fall into the joint as a loose body. Conditions that result in chronic synovial inflammation (detailed in Chapter 14), such

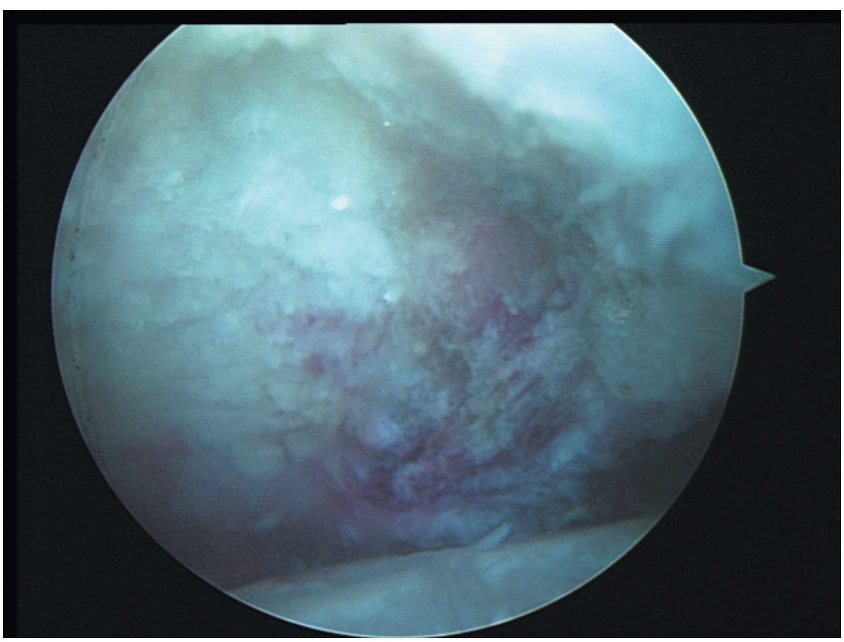

Figure 11.5. Chondral shedding and formation of radiolucent loose bodies and fragments also occurs during various stages of osteoarthritis and rheumatoid arthritis.

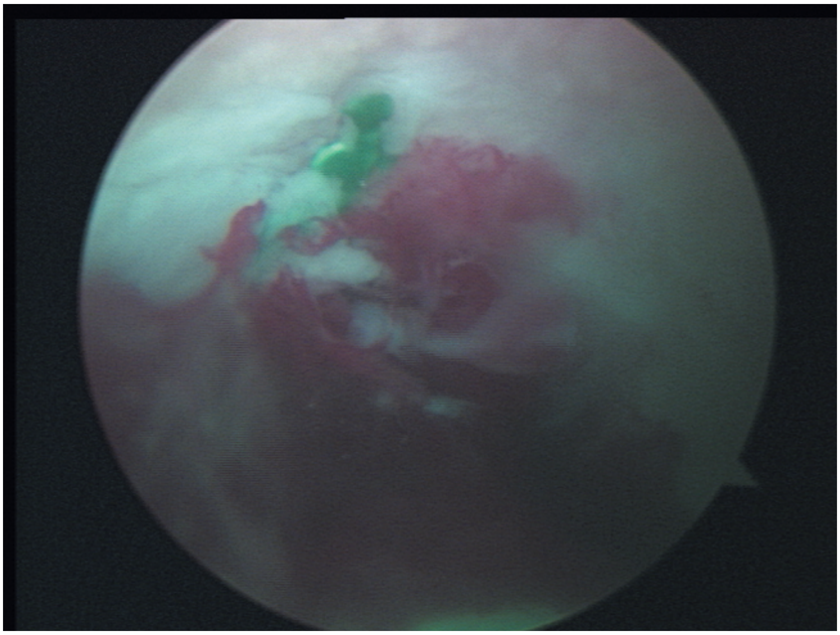

FIGURE 11.6. A fragment of a plastic cannula is retrieved arthroscopically.

as rheumatoid arthritis, PVNS, hemophilia, tuberculosis, and synovial chondromatosis may produce multiple fibrous loose bodies known as "rice bodies." Intra-articular tumors, such as lipomas, and localized nodular synovitis may also become pedunculated and drop free into the joint.[15]

Foreign bodies are classified as any material not native to the human body. In the hip joint, bullets, shrapnel, needles, portions of drain tubes, and broken arthroscopic instruments have all been reported.[16–22] (Figure 11.6.) Following total hip and hemiarthroplasty, broken wire and retained or entrapped polymethylmethacrylate cement have been reported and removed using arthroscopic techniques.[18–20] (Figure 11.7.) Dislocations of hip implants, both in the perioperative period and later, have resulted in fragmentation of cement and generation of other foreign bodies that prevent successful closed reduction.[21,22] Arthroscopy of the joint has allowed minimally invasive removal of the objects, and significantly less morbidity than an open removal and reduction procedure.

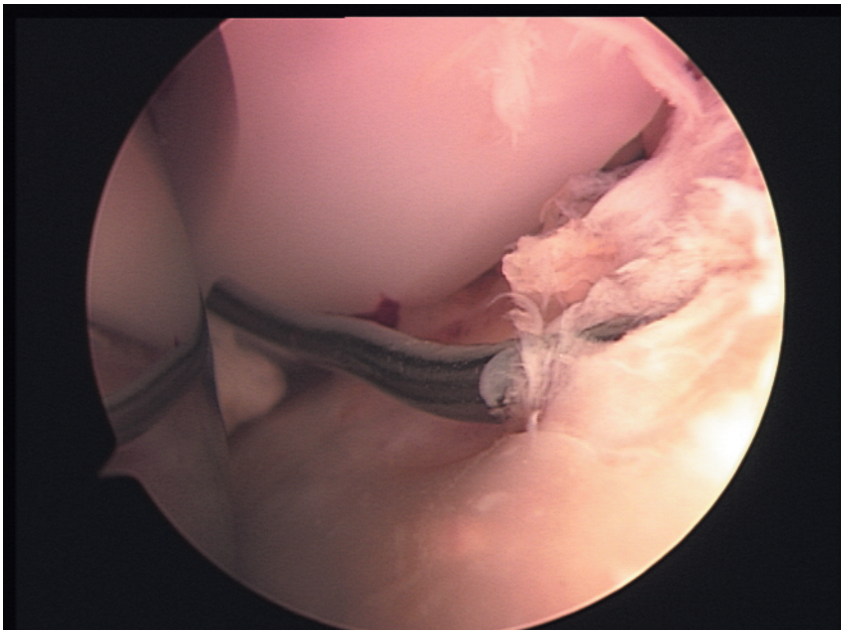

FIGURE 11.7. Following total hip arthroplasty, broken wire can be removed using arthroscopic techniques.

Evaluation

The clinical presentation of anterior groin pain, episodes of locking, painful clicking, buckling, giving way, and/or persistent pain within the hip during activity can be associated with intra-articular loose bodies.[13,23,24] The diagnosis is not difficult to overlook, given the subtle and nonspecific complaints of most patients who have had no major traumatic injury to the hip. McCarthy et al demonstrated that loose bodies within the hip joint, whether ossified or not, correlated with locking episodes with anterior inguinal pain.[13,24] When considered in the differential for vague mechanical symptoms around the hip joint, the diagnosis can be determined with appropriate radiographic studies. (see Chapter 3). Examination findings are important in directing these advanced studies, because plain radiographs may be difficult to interpret with overlying phleboliths, bowel gas, bony shadows, and the relatively small size of an ossified or non-ossified loose body. In approximately one third of cases, radiodense loose bodies are apparent on plain radiographs. When the location is in question, intra-articular versus extra-articular, it can be confirmed by computed tomography when radiodense or by CT or MR arthrography when radiolucent.

Importance of Loose Body Removal

The presence of a loose body within the articulating surfaces of any joint will theoretically result in destruction of the hyaline cartilage, and ultimately result in premature arthritic degeneration. The significance of a symptomatic loose body in the hip joint should not be understated, and the treatment, arthroscopic or open, should not be delayed.[1,4] The highly congruent and constrained hip joint functions within very low tolerances and transmits loads with magnitudes reaching up to 10 times the body weight. Under these conditions, a loose body interposed between the articulating surfaces will rapidly result in damage. Epstein demonstrated a very poor prognosis associated with retained intra-articular fragments in a long-term follow-up study of patients who suffered posterior fracture dislocations of the hip.[3] Santora et al have also reported the importance of loose body removal from the hips of adolescent children, and have shown good to excellent results even when the diagnosis was established late.[25]

Techniques for Arthroscopic Removal of Loose Bodies

Patient positioning and setup and are the most crucial aspects of hip arthroscopy to ensure patient safety, and essential to determine the success or failure of the procedure. The ability to distract the hip enough to allow the insertion and manipulation of instrumentation rests completely in preoperative planning and appropriate placement of the patient on the hip distractor or fracture table. Positioning of the patient is a matter of surgeon preference, and either the supine or lateral position will allow access to the majority of the hips' intra-articular surfaces. (see Chapter 9.) Fluoroscopy is used to confirm the 6–10 mm of articular distraction required for instrument insertion and manipulation, and also the location of radiodense loose bodies. Accurate portal placement, as detailed in Chapter 8, is essential for optimal visualization, safety, and operative access. The surgeon must always be cognizant of the cross-sectional and three-dimensional anatomic relationships, tissue planes, and neurovascular structures around the hip, especially their proximity to the portals and the loose body, or bodies, being removed.[26]

Once the patient is set up and the appropriate portals are established, systemic inspection of the entire joint should be carried out to avoid missing any loose body that may be present. Visualization of a loose body must not only be complete and unobstructed, but the arthroscope should also be positioned so that it does not interfere with the manipulation of the working instruments. The author prefers the lateral position, and working through anterior and posterior paratrochanteric portals. Selection of either a 30-degree or 70-degree arthroscope will provide visualization of the hip joint and, based on the location of the fragment, will allow manipulation and help avoid collision with the working instruments. Localization and survey of the loose bodies during the initial inspection will determine the best method for removal.

Two techniques or methods can be employed to remove loose bodies; these are based on the size and composition of the object. Small loose bodies or non-ossified fragments are removed from the joint by suction and lavage. Larger or ossified loose bodies are removed using triangulation techniques and mechanical morcellation. (Figure 11.8.) Delicate arthroscopic instruments should not be used for morselization, although it is always tempting to use them because they are more maneuverable. But this is the most common way to cause instrument damage, breakage, and formation of an iatrogenic foreign body. A sturdy, long pituitary grabber or a Kerrison rongeur used through a large-bore cannula is a better alternative than a long, flimsy basket punch. (Figure 11.9.) When the bodies are coalesced or too large for expedient morcellation, a miniarthrotomy can be used as an adjunct to the arthroscopic portion of the procedure.[27] Pedunculated "loose bodies" may be removed after the restraining pedicle is cut with scissors or electrocautery. Regardless of the size or composition of the loose body, specialized arthroscopic equipment is required to work in and retrieve objects from the hip joint. (see Chapter 10.) Especially useful and worthy of mention are graduated-diameter telescoping cannulas, long-handled alligator graspers with locking mechanisms, and long straight or curved mechanical suction shavers.

If the loose body is in the anterior or posterior synovial pouch, it may float away from the arthroscope or grasping instrument. The inflow pump should be carefully adjusted and monitored, because the slightest turbulence will cause a fragment to move away into an area that is not reachable or not easily accessible. When a loose body remains elusive, the out-

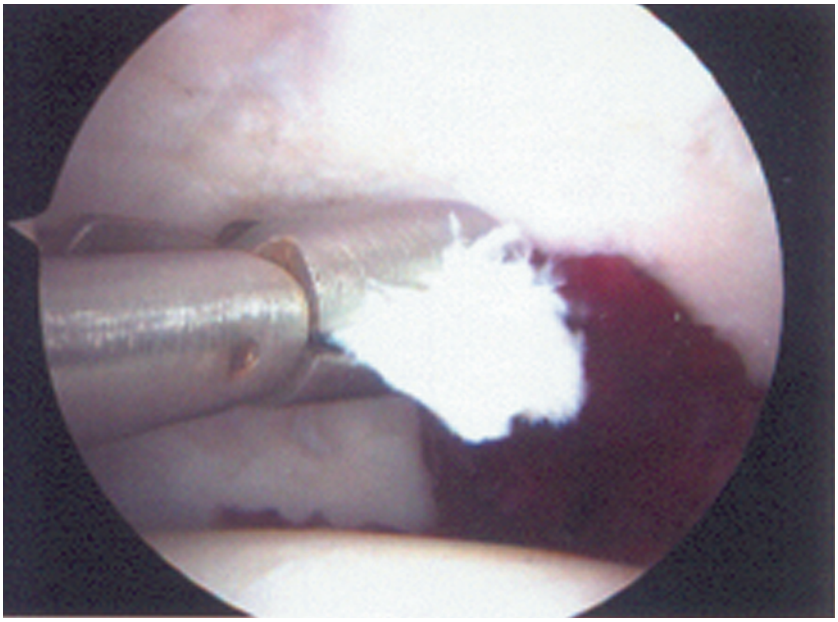

FIGURE 11.8. Larger and ossified loose bodies are removed using triangulation techniques and mechanical morcellation.

flow of irrigating solution can be reduced or turned off, and through a third portal a small suction tip can be used to capture the fragment. Frequently, the loose body will be drawn to the suction tip, where it may be held until an instrument can be brought in to grasp it. The loose body may also be trapped or stabilized by triangulating a spinal needle to it, piercing it with the needle, and holding it in place until a grasper can be triangulated to its location. Once it is within the jaws of a grasper, the loose body should be slowly withdrawn to the portal entrance. If the fragment is not small enough to pass easily through the portal incision, enlarge it so that the loose body can be extracted without getting free or lost in the periarticular soft tissues. It is better to enlarge the portal than to have the loose body slip free within, or near, the joint.

If multiple loose bodies are present, remove the smaller ones first. Removal of the larger ones first may require enlargement of the portal and may result in significant leakage of irrigation solution from the joint. Once all loose bodies that can be seen are removed, suction the joint, especially the anterior and posterior synovial recesses and the fovea and ligamentum teres. Occasionally this will pull small, previously unseen loose bodies into view. Finally, try to identify, if possible, the pathologic process producing the loose bodies and treat it appropriately, that is by biopsy, synovectomy, or chondroplasty. Loose bodies that gravitate into the posterior or in-

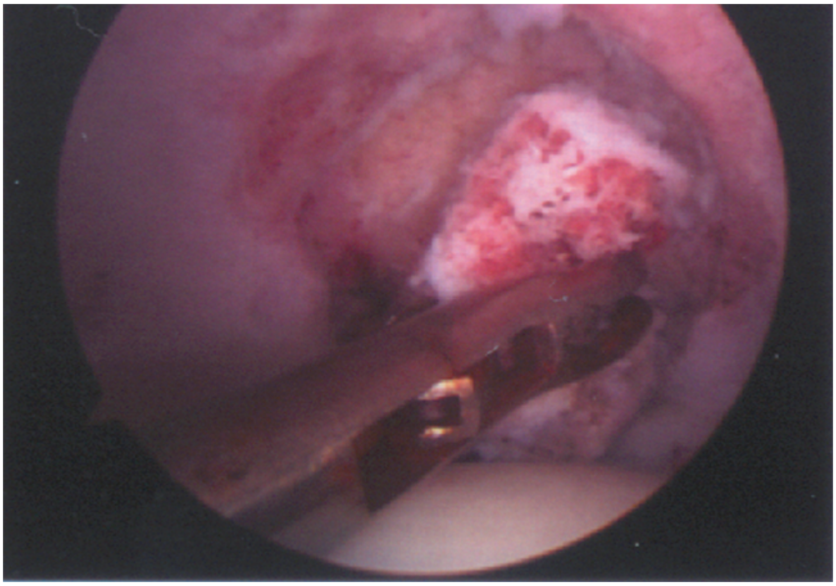

FIGURE 11.9. A sturdy, long pituitary grabber or a Kerrison rongeur used through a large-bore cannula.

ferior capsular recesses may not be accessible arthroscopically. If a fragment is visible posteriorly, but not reachable, a mini posterior arthrotomy can be performed easily and safely when using the lateral position.[27]

Conclusions

Arthroscopic removal of symptomatic loose bodies from the hip joint has become an accepted treatment option, and the clearest indication for arthroscopic intervention in the hip. Although accepted, the procedure should be used judiciously within its narrowly defined indications, because it is technically difficult, has a steep learning curve, requires specialized equipment, and is not without complication. Removal of loose bodies from an articulation has been effective in relieving mechanical symptoms, but although it makes intuitive sense that loose body removal prevents future joint degeneration, this has been shown only in the posttraumatic situation.[3] When hip disease or a pathological condition results in loose body formation, symptomatic improvement can be expected after arthroscopic removal, but the effect on the future of the joint remains dependent on the natural history of the underlying condition. Examples include osteoarthritis, synovial chondromatosis, and avascular necrosis; in each process the disease is affected, but not cured by arthroscopic intervention. Progression or recurrence of disease unfortunately cannot be predicted with our current knowledge, except in advanced cases that undoubtedly will progress to joint degeneration necessitating joint replacement. The minimally invasive nature and low morbidity associated with hip arthroscopy make the procedure ideal for establishing an early preventive strategy to treat symptomatic patients with loose bodies in the hip joint. Regardless of the underlying disease, intervention may slow disease progression that would have otherwise been managed using palliative measures. Before advocating preemptive and widespread hip arthroscopy, disease and stage-specific intervention needs to be delineated to determine when and if arthroscopy is beneficial. The current literature essentially supports the applicability of hip arthroscopy in the removal of loose bodies, alluding to its efficacy in specific situations. Long-term outcome studies supported by large numbers of patients will be required to prove or disprove the effectiveness of these interventions.

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Section III
Hip Joint Disorders

12
Acetabular and Labral Pathology

Joseph C. McCarthy, Philip Noble, Michael Schuck, Frank V. Aluisio, John Wright, and Jo-ann Lee

The diagnosis of acetabular labral tear as a cause for hip pain has received little attention in the orthopedic literature, until recently. Many reasons contributed to making this diagnosis difficult. Radiographs readily visualize the bony architecture of the hip and pelvis, but not the chondral surfaces. Bone scans can demonstrate areas of increased uptake, but not the relatively avascular labrum. Tomography again witnesses only the bony anatomy of the femoral head and acetabulum. Computerized tomography, especially with thin sections and multiplanar reconstruction, allows excellent resolution for ossified loose bodies, degenerative joint disease, and bony displacement, but not chondral pathology. Magnetic resonance imaging facilitates visualization of osteonecrosis, muscular anatomy, and joint effusions, but is not reliable for diagnosing labral injury.[1]

Clinically the etiology of hip pain can be equally perplexing. Pain felt in the hip area can be referred from the spine, the sacroiliac joint, the retroperitoneum, and the pelvic structures, as well as the pervasive muscular envelope surrounding the joint. In addition, localized entities may produce pain in the same inguinal area as hip abnormalities do. These entities include inguinal or femoral hernias, psoas bursitis, enlarged inguinal lymph nodes, femoral pseudoaneurysms, and tendon avulsions.

Moreover, hip conditions that are self-limited may be difficult to distinguish from chondral injury. These self-limited causes of inguinal hip pain include transient synovitis, which is often viral or associated with hepatitis or collagen disease. Posttraumatic hematoma may involve the joint or surrounding soft tissues. Joint pain following reduction of a dislocation may or may not be associated with a labral injury.

Prior to the advent of hip arthroscopy, surgeons were reluctant to perform an open arthrotomy of the joint for diagnostic reasons because of the many associated potential risks. These risks included osteonecrosis, heterotopic bone formation, infection, neurovascular injury, thromboembolic disease, and muscle weakness. For this reason patients with hip pain were often treated medically with rest, anti-inflammatories, and physical therapy for protracted periods of time. While these treatment techniques may be successful for muscle strains, they will not resolve an acetabular labral tear.[1–3]

Historical Context

Although Burman first reported arthroscopy of the hip in cadavers in 1921, clinical experience with this technique was not forthcoming until the 1950s. In 1957 Patterson described tearing of the acetabular labrum following posterior hip dislocation.[4] The displacement of this tissue prevented concentric hip reduction. Dameron published a similar bucket-handle tear of the labrum following posterior dislocation in 1959.[5] Altenberg, in 1977, was the first to suggest that a torn labrum may predispose to degenerative arthritis. He performed an open arthrotomy to resect the labrum in his two cases.[6]

Harris and Bourne, in 1979, implicated the infolded intra-articular labrum as an etiologic factor in hip osteoarthritis.[5] This work was corroborated three years later by Cartlidge and Scott.[7] In 1984 Ueo and Hamabuchi found that labral tears may result in cystic degeneration and subsequent osteoarthritis.[8] Four years later Ikeda found that labral tears occur not only in adults, but also in adolescents in Japan.[9] Other international authors published the association of dysplasia with acetabular labral tears. Dorrell and Catterall reported 11 cases in England.[10] Nishina et al from Japan visualized the labral lesion at the time of Chiari osteotomy.[11] Klaue, Durnin, and Ganz published the Swiss experience.[12] They showed the association of lateral acetabular rim separation with labral tearing. Legg-Calvé-Perthes disease may also be associated with labral disease. Grossbard and later Fitzgerald described this finding.[13]

The recognition that labral tears do exist and are the byproduct of diverse developmental and traumatic etiologies facilitated the development of arthroscopic techniques to access, image, and treat these chondral injuries. McCarthy et al reported on 94 patients following hip arthroscopy. Fifty-five of these had abnormalities of the labrum.[1] In a second report, he presented a classification of labral lesions. For the first time the relationship between labral tearing, associated articular chondral changes, and patient outcome was correlated.[14]

Lage also classified 37 cases from Villar's practice that had labral tears.[15] Farjo et al reported on their experience of 28 patients and corroborated the poor results of hip arthroscopy for labral tear in the presence of arthritis.[16] Finally, McCarthy, Aluisio, et al presented the association of labral tears with occult trauma.[17] The chondral lesions occurred in this group of patients without major hip trauma. Often the inciting event was a pivoting maneuver during an athletic activity, such as tennis, karate, hockey, football, or soccer.

The previous skepticism that labral tears occur has now been supplanted by the development of techniques to better diagnose and treat them. The poor sensitivity and specificity of conventional radiographic studies has now evolved to high-contrast, multiplanar, thin-section magnetic resonance imaging and more recently to gadolinium-enhanced arthro MR scanning. (see Chapter 3.) The techniques and equipment for performing hip arthroscopy have also improved. The minimally invasive nature of this operation has led to its performance, for both diagnostic and therapeutic applications, as an outpatient procedure. The risks of this procedure, when compared to an open arthrotomy, have been remarkably reduced.[18] As experience in arthroscopic hip surgery has increased, clinical, cadaveric, and basic science research has been stimulated to further understand the morphology and function of the labrum, both in health and disease. These efforts recently have focused on cadaveric anatomic features as well as classification systems associated with labral tears.

Acetabular Labral Lesions

Cadaveric Research

The labrum acts as a stabilizer of the hip joint. But in the dysplastic hip, it becomes part of the weightbearing surface of the acetabulum. It is postulated that this causes overload of the superior and/or anterior labrum in tension and shear, leading to labral injury.[19]

Some studies do not support the theory that the labrum plays a crucial role in hip stability, although it has been demonstrated that the presence of the labrum per se has no significant influence on the weightbearing function of the normal joint.[20] A possible role of this structure is to seal the joint, thereby providing stability by allowing atmospheric pressure to aid in keeping the joint reduced. The contribution of the labrum to joint stability is expected to be greatest at the extremes of motion, where impingement can cause traumatic dislocation.

It has been suggested that the acetabular labrum might play a role in the development of hip osteoarthritis, but to date few studies have been undertaken to test this theory.[6,10,12,15,21–23]

Imaging

Several studies have explored the use of MR arthrography to identify labral pathology. Hodler, et al in 1995 showed that MR arthrography is superior to plain MR in identifying labral surface lesions, but neither method could identify labral degeneration on a consistent basis.[24] Likewise, Czerny, et al in 1996 also showed MR arthrography, with 90% sensitivity and 91% accuracy, to be superior to plain MR in detecting labral lesions.[25] The work of Petersilge, et al in 1996 also supports the use of MR arthrography in detecting labral lesions.[26] Leunig, et al in 1997 found MRA to be 63% sensitive in detecting 16 tears and 92% sensitive for 12 degenerative labra.[27] McCarthy and Marchetti demonstrated a 74% sensitivity, an 83% specificity, and a 78% accuracy in diagnosing anterior labral pathology. However, the sensitivity for detecting posterior lesions (20%) and lateral tears (11%) was much poorer. Their study also emphasized the importance of off-axis tangential images to properly visualize the anterior hip quadrant.[23]

Cadaveric Data

We performed the following anatomic study to determine the prevalence, location, and morphology of acetabular labral lesions in adult hips.

Fifty-four acetabulae were harvested from adult cadavers ranging in age from 48 to 102 years (average age was 78). A generous incision was carefully made in each hip capsule, so the femoral head could be dislocated in an atraumatic manner, to avoid creating labral lesions postmortem. Each specimen was examined by gross observation and stereomicroscopy. All labral lesions were described in terms of both location and morphology, and classified as one of five types:

1. Complete labral separation from the acetabular rim. (Figure 12.1.) This sometimes was observed in combination with other lesions described below. The separation always occurred at the junction of the labrum and the articular cartilage, such that a probe could be passed from the articular surface through the separation to the capsule.
2. Fraying of the free edge of the labrum. In these specimens, the labrum remained firmly attached to the acetabular rim, but the free edge consisted of frayed and fibrillated tissue with little or no structural support.
3. A circumferential depression at the labral–cartilage junction was frequently observed. In this lesion the labrum remains attached to the acetabular rim and is similar in appearance and location to a complete separation of the labrum at the labral–cartilage junction. Based on the appearance and prevalence of these two lesions, we believe that the appearance of a discontinuity in the acetabular surface at the labral–cartilage junction is a precursor to complete labral separation.
4. Flat, degenerative labral lesions. (Figure 12.2.) These lesions are essentially thin extensions of the labral edge along

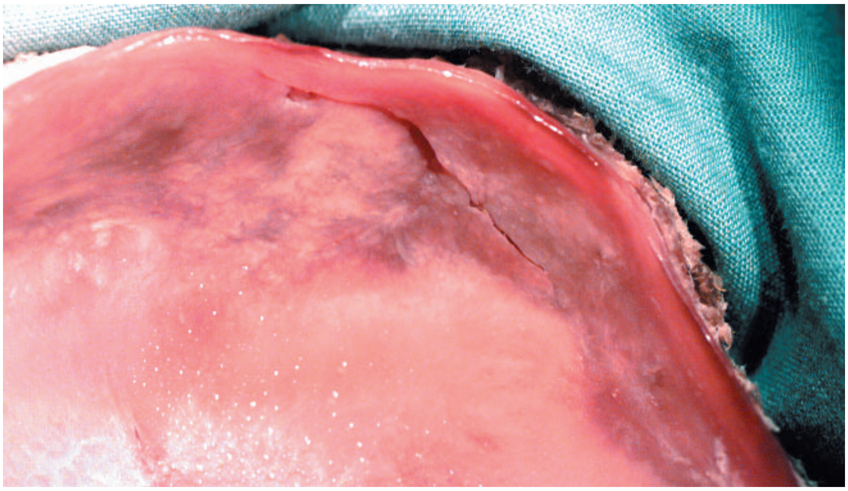


FIGURE 12.1. Cadaveric photo of a complete labral separation from the acetabular rim.

the inner aspect of the hip capsule. These lesions may extend as much as 2 to 3 times the height of the normal labrum. The labral–capsular sulcus between the abnormal labrum and the hip capsule remains intact. The labral tissue is always tough and scarlike in appearance; it clearly differs from the smooth, resilient consistency of the normal labrum.

5. Fraying at the labral–cartilage junction. The appearance is similar to the fraying of the labral edge that we more frequently observed, but involves only the junctional area. This lesion may be an intermediate lesion between partial separation (groove) and complete separation of the labrum from the acetabular rim.

Location of Lesions

The acetabulum is divided into eight equal regions to describe the location of various lesions: anteroinferior, anterior, anterosuperior, superior, posterosuperior, posterior, posteroinferior, and medial. The inferior region is occupied by the transverse ligament. The normal weightbearing regions of the acetabulum are the anterosuperior and superior regions.

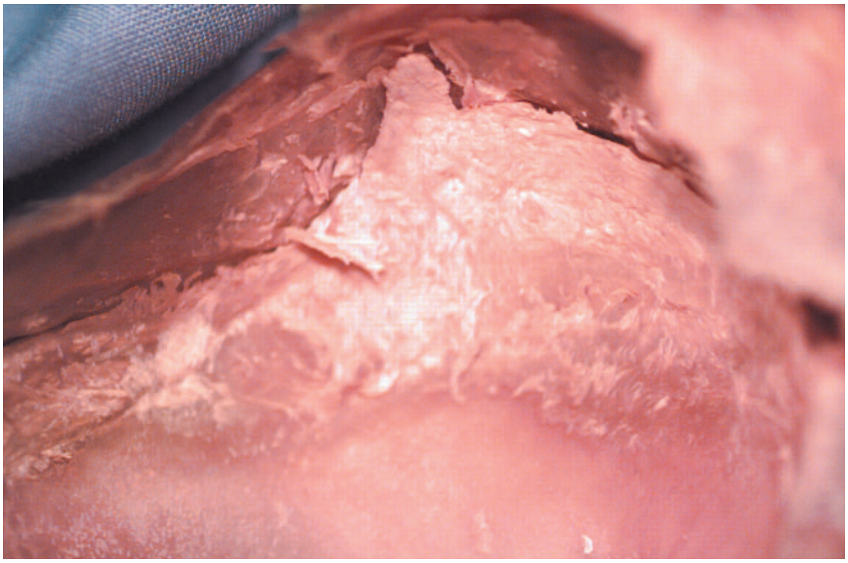


FIGURE 12.2. Cadaveric photo of a flat, degenerative labral lesion.

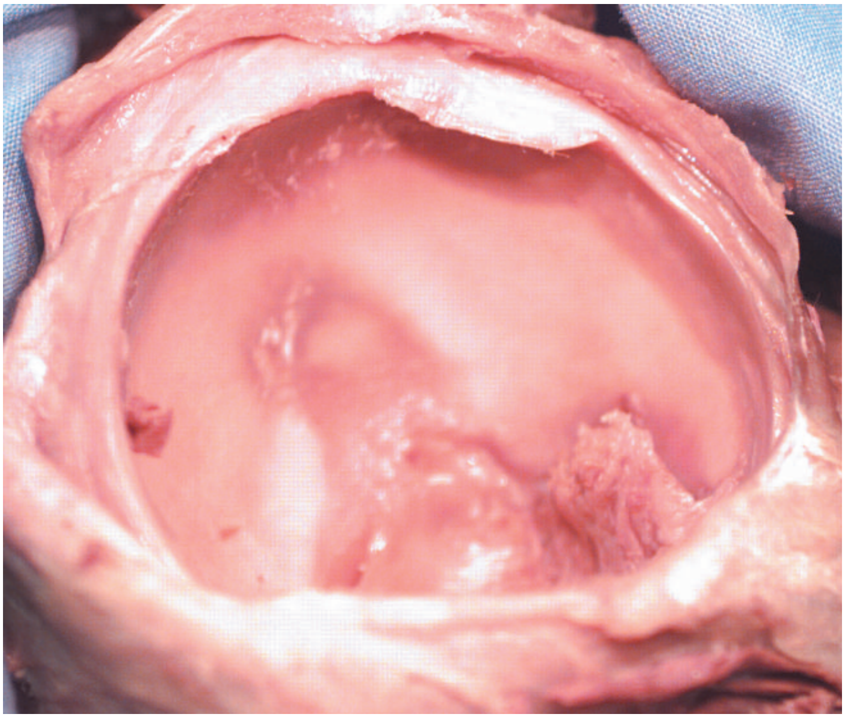


FIGURE 12.3. Cadaveric photo of the labrum as it surrounds the entire rim of the acetabulum to the transverse acetabular ligament.

Results

Normal Labrum

Our observations of the normal labrum are consistent with earlier reports. The labrum appears as a fibrocartilaginous structure, triangular in cross-section, that surrounds the entire rim of the acetabulum. (Figure 12.3.) It is smoothly joined inferiorly to the transverse acetabular ligament. Likewise, there is a smooth transition between the labrum and the articular cartilage within the acetabulum. A perilabral sulcus exists between the labrum and the capsule of the hip joint. This sulcus is deepest superiorly and very shallow inferiorly, where the capsule lies against the transverse ligament. Synovial tissue lines this sulcus as well as the inner surface of the hip capsule.

Lesions

A total of 113 labral lesions were observed in 54 acetabuli (average 2.1 per specimen). Overall, 93% of the specimens (50 of 54) had at least one labral lesion, most commonly a separation of the labrum from the acetabular rim at the labrum–cartilage junction (32%). Other commonly observed lesions were fraying of the free edge of the labrum (24%); the presence of a groove or indentation at the junction of the labrum and the articular cartilage (19%); a flattened, degenerative labrum composed of rough, scarlike tissue (13%), and fraying at the labrum–cartilage junction (11%).

Locations

Labral lesions were most commonly observed in the anterosuperior (27%) and anterior (20%) regions of the acetabulum ($p < 0.001$).

In previous anatomic studies, the normal labrum has been described as a homogeneous structure on the acetabular rim, slightly thicker in the posterosuperior region and slightly thinner in the anteroinferior region.[28] The labrum is strongly attached to the transverse acetabular ligament inferiorly.[28–30]

A groove or gap between the labrum and the articular surface, especially near the labral attachment to the transverse ligament,[28] is described as a normal variant by some authors.[21,28–29] A system for classification of labral pathology was proposed in 1996 by Czerny et al, who identified three types of lesions: labral hypertrophy (type I), labral tear (type II), and labral avulsion (type III).[25]

Separation of the labrum from the labral–cartilage junction has been described by several authors.[9,12,22,26,27] This lesion has also been described by a number of other names. It has been called a "bucket-handle" lesion[4,5,9] a "longitudinal peripheral tear"[15,32] and a "labral avulsion."[25]

Fraying of the labral edge has also been described previously as a "radial fibrillated lesion"[15]and "fibrillated edge."[32]

As mentioned above, some authors have described a groove at the labral–cartilage junction as a normal variant.[21,28,29] Several authors have briefly described "degenerative" lesions of the labrum[20,26,27,32] but it is unclear from these descriptions if they are referring to a flat lesion, such as we observed, or some other labral change.

Clinical Locations

The majority of labral studies have found a preponderance of lesions in the anterior, anterosuperior, and superior regions of the acetabulum.[1,15,21,22,25–27] Studies from Japan have consistently found more posterior lesions.[8,9,32,33]

Summary

The cadaveric data show that labral lesions are extremely common, present in 93% of specimens.

Because the labrum is thought to be a stabilizing structure in the hip, labral pathology might contribute to the development of osteoarthritis in a number of ways. Injury or degeneration of the labrum could result in instability of the femoral head in the acetabulum, resulting in cartilage damage adjacent to the damaged labrum. This instability might also be more "global," resulting in cartilage damage in the weight-bearing region of the acetabulum.

If it can be clearly shown that labral lesions contribute to cartilage degeneration, then the early recognition and treatment of these lesions will become an important part of osteoarthritis prevention.

Acetabular Labrum

Microangiographic Studies and Spalteholz Staining

The microvascular anatomy of 10 acetabula was determined using a modification of the Spalteholz tissue-clearing technique described by Crock (1967)[34] and Arnoczky (1982).[35] Six male adult cadavers with an average age of 71 (range, 62–82 years) were obtained from the Gross Anatomy Laboratory. The femoral circumflex arteries and the internal iliac arteries of each cadaver were exposed, sequentially incised, and cannulated with a Foley catheter. The catheter balloon was inflated, and all adjacent arterial branches were securely ligated or clamped. A bolus of 150–200 cc of tattoo ink was injected via the catheter into each artery with firm manual pressure. The catheter was then removed, and the circumflex and internal iliac arteries were ligated to prevent leakage. Within 24 hours of ink injection, a hip capsulotomy was performed, and the femoral head was carefully dislocated on each side. The pelvis was removed from the cadaver, stripped of muscle and other soft tissues, and placed in buffered formalin for 3–5 days. After removal from the formalin, the acetabula were resected from the pelvis with a band saw. The specimens were then rinsed in running water, followed by dehydration in a series of graded alcohol solutions (70% ETOH for one day; 95% ETOH for one day; and 100% ETOH for 7–10 days).

The specimens were rinsed again in running water, and then placed in chloroform for 3–5 days, followed by immersion in methyl salicylate (oil of wintergreen) for at least 1 week. The origin and location of vessels in and near the labrum was determined by stereomicroscopy. The anatomic location of all vessels was described by dividing each acetabulum into eight regions (anterior–inferior, anterior, anterior–superior, superior, etc.). Each vessel was also described in terms of its diameter, proximity to the labral edge and origin within the tissue layers surrounding the acetabulum.

Immunohistochemical Staining

Immunohistochemical (IHC) staining was performed on radial, wedge-shaped specimens harvested from 4 of the ink-injected acetabula and 4 embalmed acetabula prior to IHC staining. Each consisted of the labrum and the underlying acetabular margin. Two or three wedge-shaped specimens were cut from each acetabulum, representing various regions around the rim.

After decalcification in nitric acid, each specimen was embedded in paraffin wax and cut into 5 mm thick sections. These sections were stained with hematoxylin and eosin, followed by factor VIII immunostaining to identify blood vessels. Factor VIII is an immunostain that binds to endothelial markers, arteries, veins, and capillaries, all of which are positive for this marker.

Stereomicroscopy of the gross specimens revealed an anastomotic network of small vessels of 0.1–0.3 mm in diameter, arranged in a circumferential network around the acetabular rim. This network was supplied in turn by slightly larger vessels (0.3–0.5 mm in diameter) extending from the outer surface of the acetabulum onto the outer surface of the labrum. These vessels were primarily located in the connective tissue and synovium in the recess between the hip capsule and the labrum.

Gross observations performed after dissection of each specimen confirmed that the vascular supply of the acetabular labrum came via the obturator artery, the superior gluteal artery, and the inferior gluteal artery, the same vessels that supply the bony structure of the acetabulum.

Immunohistochemical staining confirmed the existence of abundant vessels in the synovial tissue in the labrum–capsular sulcus and in the outer surface of the acetabulum. This pattern was observed in wedges cut from each region of the acetabulum. The parallel fibrocartilaginous fibers of the labrum are easily differentiated on histological slides from the loose connective tissues of the periosteum and synovium. While the vessels were primarily located in the connective tissues around the acetabulum and labrum, in some specimens they penetrated the outermost layer of the labrum, on its capsular side, to a depth of less than 0.5 mm. The IHC staining also

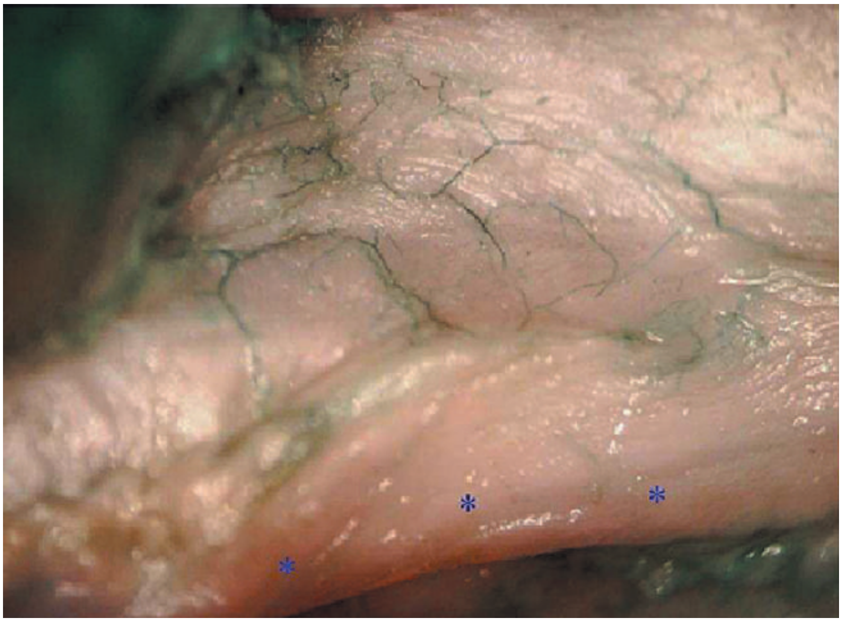


FIGURE 12.4. Cadaveric photo after staining showing no evidence of penetration of vessels from the underlying acetabular bone into the labrum.

demonstrated abundant vessels within the bony acetabulum that reach the junction with the fibrocartilaginous labrum. There was no evidence of penetration of vessels from the underlying acetabular bone into the labral substance. (Figure 12.4.) No gaps were observed in the vascular supply, and there were no regions of relative hypovascularity.

Labral Injuries: Clinical Correlations, Etiology and Classification

As noted above, the acetabular labrum is a fibrocartilaginous structure attached to the rim of the acetabulum that provides additional surface area for the articulation with the femoral head. The labrum exists at the anterior, superior (lateral), and posterior margins of the acetabulum and is absent inferiorly in the cotyloid fossa, at which point it attaches to the transverse acetabular ligament. Pathology of the labrum including tears, hypertrophy, and instability is perhaps the most common finding on arthroscopic evaluation of the hip joint.

Labral tears represent the most common cause for mechanical hip symptoms. They can be classified according to location, etiology, and morphology. With respect to location, tears can be anterior, posterior, or superior (lateral). Tears most commonly occur anteriorly in most reported series, especially in patients who have sustained occult trauma or have intractable hip pain related to athletic participation. Fitzgerald reported that 92% of labral tears were anterior in a series of patients who sustained minor trauma with associated intractable hip pain. Lage et al found 62% of their labral tears to occur anteriorly, while McCarthy noted 98% anterior tears in his series.[15,36]

Figure 12.5 demonstrates the typical appearance of an anterior labral tear (after minor trauma) with an associated anterior acetabular chondral injury. This pattern has been frequently demonstrated in the above-mentioned populations (occult trauma, sports) and represents an area in the labrum and acetabulum prone to injury. We have termed this junctional injury pattern the "watershed lesion."

Anterior labral tears are also common in patients with degenerative hip disease or acetabular dysplasia. In advanced forms of both diseases, the labral pathology can be rather diffuse and can also involve the lateral and posterior labrum.

Isolated posterior labral tears are most frequently seen after a posterior hip dislocation or with dysplasia, but are not commonly seen in other populations undergoing hip arthroscopy.

Lateral labral tears are infrequently encountered in arthroscopic evaluation, even with excellent visualization of this structure. When lateral tears occur, they are invariably associated with additional labral and acetabular pathology.

Labral tears can also be classified with respect to etiology. Tears can be degenerative, dysplastic, traumatic, or idiopathic. Degenerative tears can be seen in inflammatory arthropathies. The extent of the tear is related to the degree of degenerative changes present in the joint. Stage I degenerative tears are localized to one segment of an anatomic region (anterior or posterior), while Stage II tears can involve an entire anatomic region, and Stage III tears are diffuse and involve greater than one anatomic region. Higher-stage tears are associated with more pronounced degenerative changes in the acetabulum and femoral head.

Tears associated with dysplasia generally occur most frequently anteriorly, but can also be isolated posteriorly, or diffuse. A common finding in acetabular dysplasia is hypertrophy of the anterior labrum with associated infringement upon the anterior acetabulum. (Figure 12.6.) The hypertrophy and tearing most likely cause impingement of the labrum between

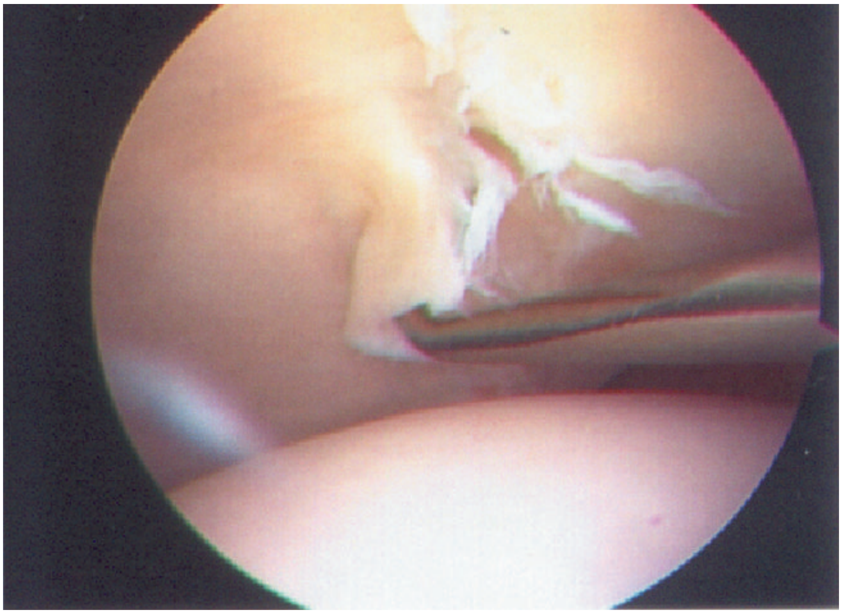


FIGURE 12.5. The typical appearance of an anterior labral tear (after minor trauma) with an associated anterior acetabular chondral injury.

the acetabulum and femoral head, accounting for the mechanical symptoms frequently present in this population.

Labral tears secondary to trauma are generally isolated to a particular region, depending on the direction and extent of trauma. Patients with known posterior subluxation or dislocation most frequently have posterior labral tears. The magnitude of force will determine whether the tear is initiated on the articular or acetabular side of the joint. If a bone fragment is avulsed as seen by x-ray or CT scan, the labral injury is most likely to occur on the capsular side and should be treated accordingly. Those with minor trauma without dislocation almost invariably have anterior tears. These tears occur in the same region as those secondary to minor dysplasia and in the athletic population with intractable pain, which led us to believe that this area is developmentally weakened and susceptible to injury, and/or that it is preferentially exposed to high shear forces leading to injury from overload.

Idiopathic labral tears do not fall into any of the above categories and were found most commonly in athletes with intractable hip pain, and in occupational-related hip pain with no evident trauma. These tears follow the pattern of the watershed lesion.

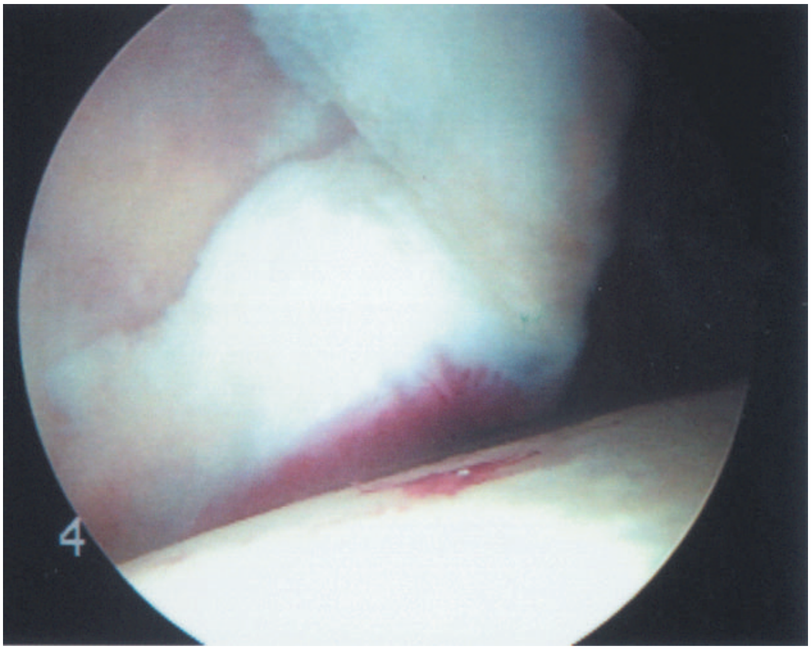


FIGURE 12.6. Hypertrophy of the anterior labrum with associated infringement upon the anterior acetabulum in a patient with dysplasia.

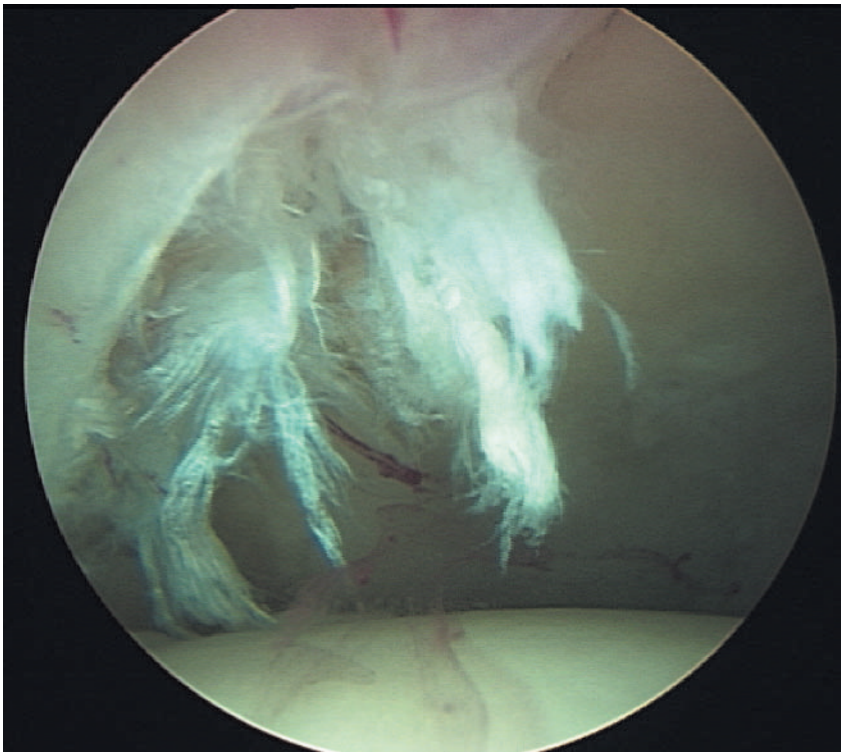


FIGURE 12.7. Labral tears are often fibrillated.

Lage et al[15] have created a classification of labral tears based on morphology, with the types being radial fibrillated, radial flap, unstable, and longitudinal peripheral. Radial flap and fibrillated tears involve the free edge of the acetabulum, while longitudinal peripheral tears involve the acetabular–labral junction. Unstable tears do not follow a specific morphologic pattern, but are termed unstable if they cause mechanical impingement. Flap and fibrillated tears tend to be unstable. Additional morphologies in our experience include interstitial tears and synovial side tears. The most commonly encountered tears in both series are radial fibrillated and radial flap tears. (Figure 12.7.)

Arthroscopic treatment of these tears involves debridement back to a stable base and to healthy-appearing tissue. This will eliminate the source of mechanical symptoms secondary to labral pathology. If there is no associated articular cartilage injury or extra-articular pathology, this debridement should alleviate the patient's discomfort. If there is associated focal

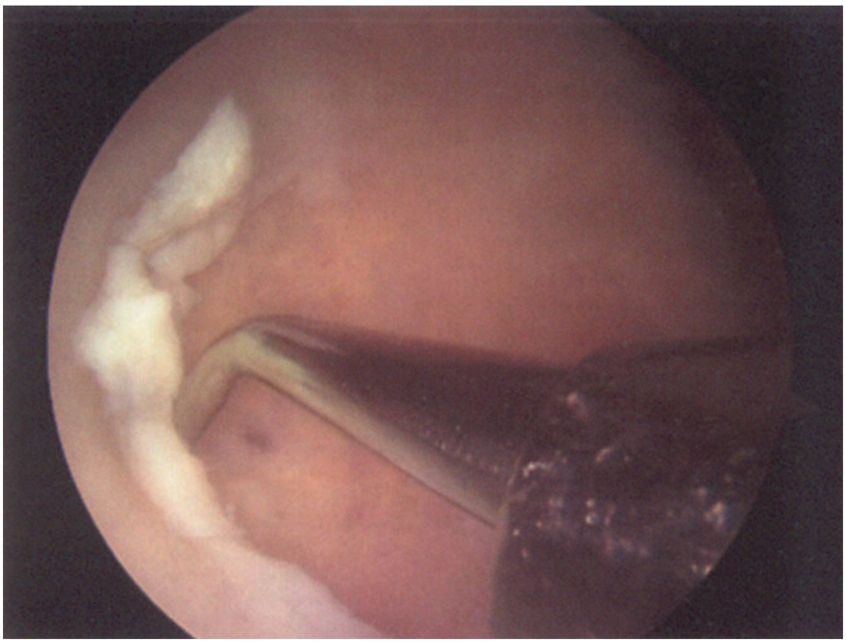


FIGURE 12.8. A subchondral acetabular cyst shown with an associated chondral flap lesion.

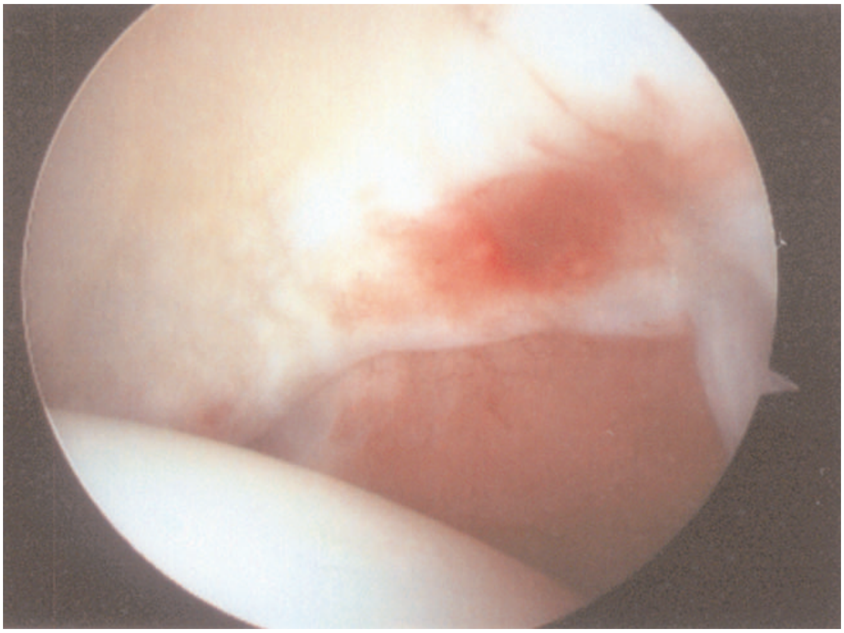


FIGURE 12.9. Stage 0: Contusion of the labrum with adjacent synovitis.

chondral defect, the subchondral bone is drilled or treated with a microfracture technique to enhance fibrocartilage formation.

Labral tears can also be associated with other intra-articular pathology. Degenerative labral tears, as already mentioned, are seen with degenerative changes in the acetabulum and/or femoral head. Anterior acetabular chondral injuries are frequently seen with anterior labral tears. These most frequently occur in an anteroinferior position and represent the "watershed lesion" demonstrated in several patient populations. Acetabular cysts have also been demonstrated in association with labral tears and chondral injuries, especially in those with advanced dysplasia and degenerative joint disease. (Figure 12.8.) In these situations the cyst is most often the result, and not the cause of the patient's mechanical symptoms. Thus, as in a Baker's cyst in the knee, treatment should be directed at the intra-articular chondral abnormality.

Most important, labral tears have now been classified with relationship to outcome. McCarthy et al reviewed 62 hip arthroscopies.[36]

Hip pathology in association with acetabular labral injuries demonstrated arthroscopically has been incrementally classified and correlated with severity and prognosis. Stage 0 (Figure 12.9), as compared to a normal acetabular labrum, constitutes a contusion of the labrum with adjacent synovitis (1 hip). Stage 1 (Figure 12.10) is a discrete labral free margin tear with intact femoral articular and acetabular articular car-

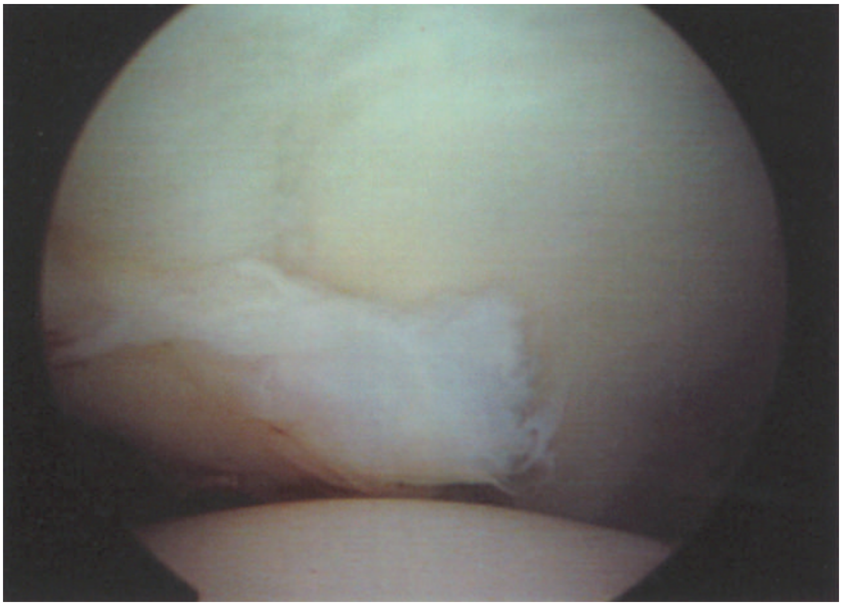


FIGURE 12.10. Stage 1: Discrete labral free margin tear with intact femoral and acetabular articular cartilage.

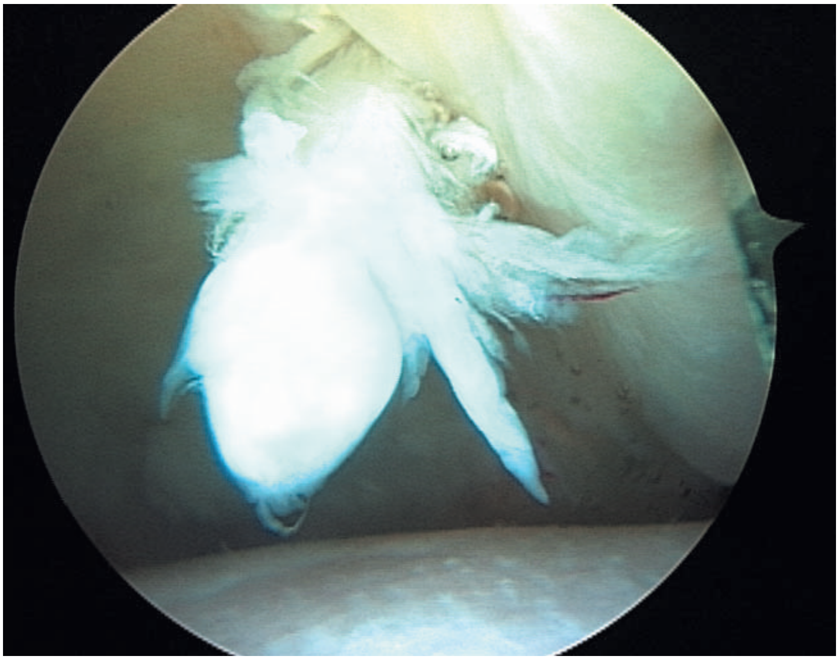


FIGURE 12.11. Stage 2: Labral tear with focal articular damage to the subjacent femoral head but with intact acetabular articular cartilage.

tilage (10 hips). Stage 2 (Figure 12.11) is a labral tear with focal articular damage to the subjacent femoral head, but with intact acetabular articular cartilage (11 hips). Stage 3 is a labral tear with adjacent focal acetabular articular cartilage lesion, with or without femoral head articular cartilage chondromalacia. Stage 3 labral tears are further subclassified depending on the acetabular cartilage defect. Stage 3A (Figure 12.12) lesions involve less than 1 cm of acetabular articular cartilage (21 hips) and Stage 3B (Figure 12.13) lesions involve greater than 1 cm of acetabular cartilage (10 hips). Stage 4 (Figure 12.14) constitutes a diffuse acetabular labral tear with associated diffuse, arthritic articular cartilage changes in the joint (9 hips). Ninety-five percent (59/62 hips) of the time the labral injury involved the anterior half of the joint. Two patients had a traumatic tear posteriorly associated with an MVA dashboard injury. All patients who had combined anterior and lateral labral injury had associated degenerative arthritis in the joint.

At a minimum of 2 years from hip arthroscopy, patient results were directly correlated with the stage of labral injury. There was one stage 0 lesion and 10 stage 1 labral lesions. All but one of these patients had a good to excellent result (91%). This single patient required an iliopsoas release with V–Y lengthening of the iliotibial band 9 months after ar-

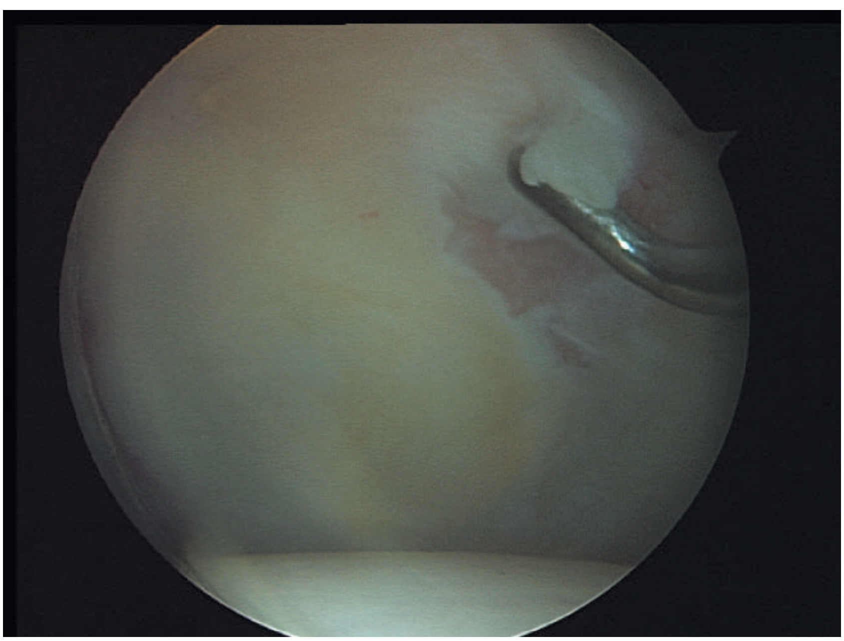
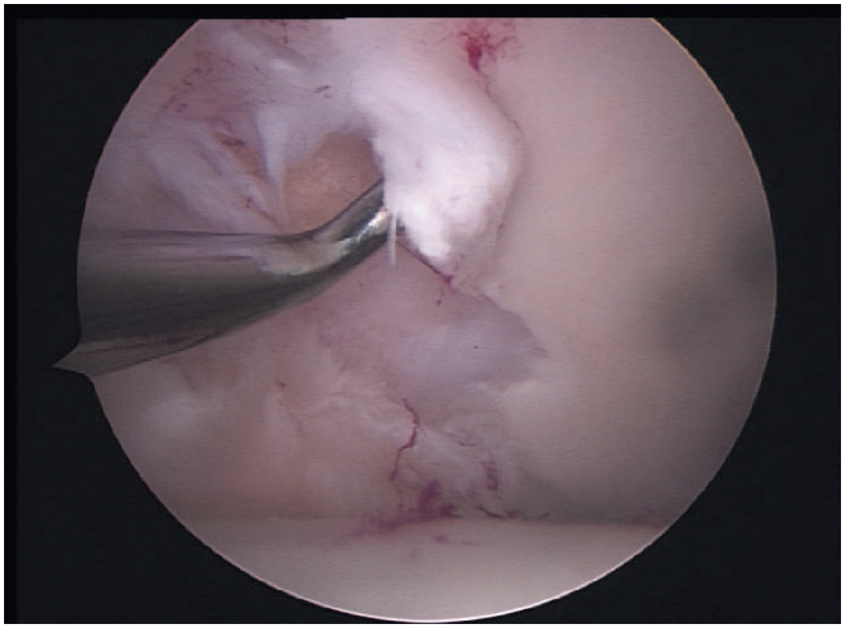


FIGURE 12.12. Stage 3A: Lesion involving less than 1 cm of acetabular articular cartilage.

FIGURE 12.13. Stage 3B: Lesion involving greater than 1 cm of acetabular cartilage.



throscopy for recurrent painful snapping hip. In addition, there were 11 patients with stage 2 labral tears. Two patients (18%) required further surgical intervention secondary to a poor result, including open synovectomy, capsulectomy, and release of the reflected rectus femoris tendon. There was an 82% good to excellent outcome (9/11 hips) when the tear was resected in stage 2 labral lesions.

Stage 3 labral tears did not fare nearly as well, and the extent of the acetabular cartilage erosion directly impacted the result. Stage 3A labral tears (21 hips) were associated with a good to excellent result in 15 cases (71%), and 2 patients underwent open synovectomy, anterior capsulectomy, and rectus femoris release. Within the Stage 3B group (10 hips) there were 40% good to excellent (4/10 hips), 30% fair (3/10 hips), and 22% poor (2/10 hips). Two patients (20%) underwent further surgical intervention.

Stage 4 labral tear (9 hips) results directly correlated with the extent of hip joint degenerative arthritis. If the articular cartilage involvement was diffuse on the femoral head and acetabulum, regardless of the plain radiographic appearance, the symptomatic improvement post arthroscopy was transient. Seven patients (78%) were associated with a poor result in

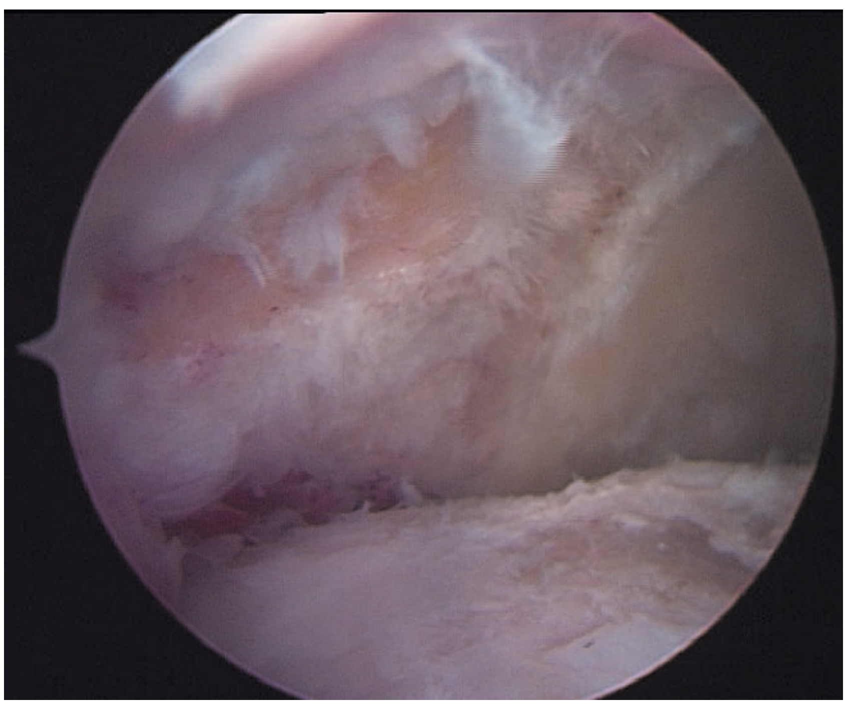


FIGURE 12.14. Stage 4: Diffuse acetabular labral tear with associated diffuse arthritic articular cartilage changes.

follow-up and 43% (3/7 hips) eventually went on to total joint arthroplasty within 2 years of arthroscopy.

Complications included a single transient lateral femoral nerve palsy, which resolved within 2 weeks of arthroscopy, and there were no cases of wound infection, deep vein thrombophlebitis, neurovascular injury, or osteonecrosis of the femoral head. Furthermore, all hips were well visualized at surgery.

Labral Injuries: Clinical Correlations

Clinical (Arthroscopic) Database

Between 1993 and 1999, 436 consecutive hip arthroscopies were performed by a single surgeon. The indications for surgery included: Painful mechanical symptoms (i.e., painful clicking, locking, buckling, or catching); localization of the patient's presenting pain to the groin; recalcitrance to 6 months of appropriate conservative management (consisting of rest, activity modification, physical therapy, and anti-inflammatory medication); reproduction of the patient's symptoms by provocative physical exam maneuvers (such as the hip extension test, the flexion–adduction–internal rotation test, or resisted straight leg raise); and corroborative positive imaging studies (MRI or MR arthrogram) indicating the presence of a loose body or labral lesion.

The vast majority of patients in the study cohort fell into three broad categories: Those with pain associated with a history of repetitive microtrauma (typically in the context of recurrent pivoting and/or twisting athletic maneuvers); those with pain following a specific precipitating traumatic event; and those with pain associated with occult mild (Crowe type I) developmental hip dysplasia.[37] A distinct minority of patients (less than 5% of the study cohort) were operated upon because of symptoms attributable to a subset of specific rare conditions that afflicted their hips (such as synovial osteochondromatosis, pigmented villonodular synovitis, or Ehler-Danlos syndrome). Cases performed in the setting of a prior total hip arthroplasty were excluded from further analysis. All of the remaining 436 cases were included in this study.

All of the arthroscopies were performed in the lateral decubitus position utilizing longitudinal traction and a well-padded ischial post. Access to the joint was established via standard anterolateral and posterolateral paratrochanteric portals.[1] During the diagnostic portion of each case, the position of the arthroscope was alternated between these two portals in order to maximize intra-articular visualization.

The senior surgeon prospectively recorded the arthroscopic findings of each case in a clinical database. It should be noted that all pathology was evaluated and described by a single individual. Thus, potential error from interobserver variability was eliminated. Specific emphasis was placed upon the morphology and location of all labral lesions, as well as the distribution and severity of associated articular cartilage defects on both the acetabulum and the femoral head.

The severity of the articular cartilage lesions was graded according to the Outerbridge classification system, wherein grade I refers to softening and/or swelling of the cartilage; grade II refers to fragmentation and fissuring involving an area that is less than 0.5 in. in diameter; Grade III consists of identical criteria as grade II but involves an area greater than 0.5 in. in diameter; and Grade IV refers to full-thickness cartilage erosion with exposed subchondral bone.[38]

The presence or absence of occult hip dysplasia was determined preoperatively by the senior surgeon based upon plain radiographic analysis.

Cumulative Findings

Of the 436 patients who underwent hip arthroscopy 250 (54.8%) were noted to have labral tears. There were 130 females and 110 males. The average age of this patient group was 37.3 years (range, 14–72). There was minimal difference (1.7 years) between the average age of the male and female patients. All labral tears were located at the articular, and not at the capsular margin of the labrum. Almost all of these lesions (234, or 93.6%) were located in the anterior quadrant of the acetabulum. Posterior labral pathology was more commonly associated with a discrete episode of hip trauma, typically involving impact loading of the extremity, causing the femoral head to be driven posteriorly within the acetabulum.

Tears at more than 1 site around the labrum were relatively uncommon, with an overall prevalence of 8.4%. However, in the majority of cases with a lateral tear (6 of 8), and half the cases (15 of 30) with a posterior tear, an anterior labral lesion was also present. This strongly suggests that in some patients the labrum tears anteriorly, then posteriorly or laterally, either in response to the same acute incident, or with increasing instability with repetitive loading of the joint at the extremes of motion, in many patients who had anterior tears. None of the labral tears involved the capsular margin of the labrum. In fact, 100% of the tears occurred along the articular margin of the labrum.

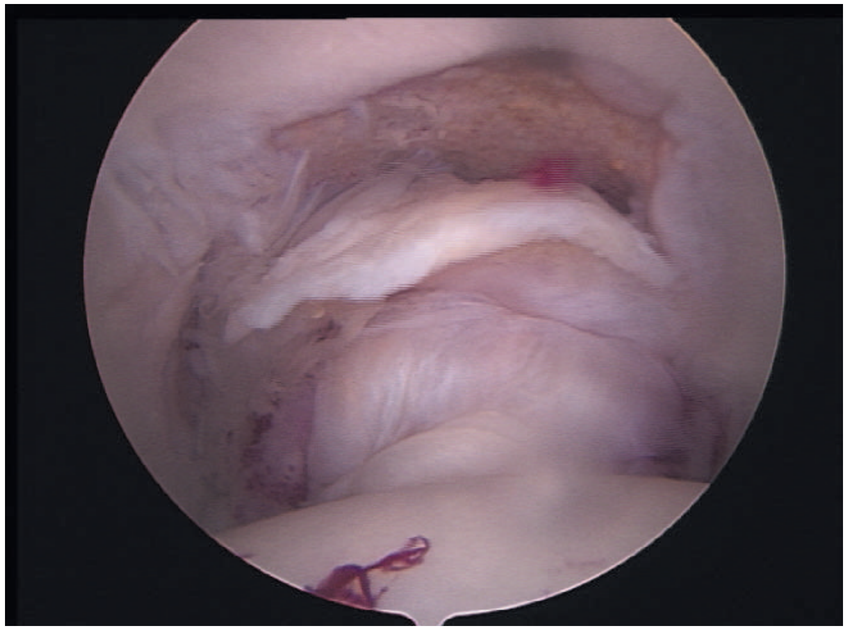
Of the 436 subjects, 223 (49%) were noted to have labral fraying in regions where there was no frank disruption (tearing) of the labrum. (*Note:* Some of these regions of labral fraying were associated with frank labral tears in other locations.) This fraying universally involved the articular margin of the labrum directly adjacent to the labral–cartilage junction. Seventy-four (33%) of patients had anterior labral fraying; 88 (40%) of patients had lateral labral fraying; and 61 (27%) of patients had anterior–posterior labral fraying.

Among the total 436 subjects, 269 (59%) had anterior acetabular articular cartilage injuries; 110 (24.1%) had lateral acetabular articular cartilage injuries; and 114 (25%) had posterior acetabular articular cartilage injuries.

Anterior Labral Tears

Among the 234 hips with anterior labral tears, 6 (2.6%) had associated lateral labral tears, and 15 (6.4%) had associated posterior labral tears.

FIGURE 12.15. A grade III anterior acetabular articular cartilage lesion.



One hundred sixty-one (68.8%) of these patients had associated anterior acetabular articular cartilage lesions (14.3% of which were grade III and 59.6% of which were grade IV). (Figure 12.15) Seventy-seven (32.9%) of these patients had associated lateral acetabular articular cartilage lesions (27.3% of which were grade III and 5.2% of which were grade IV). Eighty-two (35%) of these patients had associated posterior acetabulum articular cartilage lesions (22% of which were grade III and 15.9% of which were grade IV).

Among the 234 hips with anterior labral tears, the prevalence of associated anterior, lateral, and posterior femoral head articular cartilage injuries was 45.7%, 21.8%, and 23.9% respectively.

Anterior Labral Fraying

Among the 74 hips with anterior labral fraying in the absence of a frank anterior labral tear, none had associated lateral labral tears, and only 3 (4%) had associated posterior labral tears. (Figure 12.16.)

Thirty-nine (53%) of these patients had associated anterior acetabular articular cartilage lesions (23% of which were

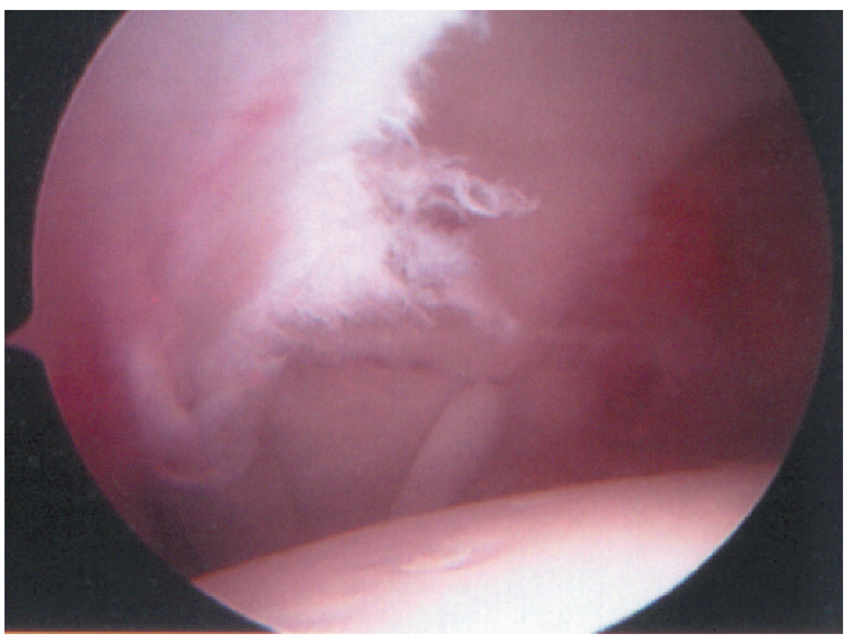


FIGURE 12.16. A posterior labral tear.

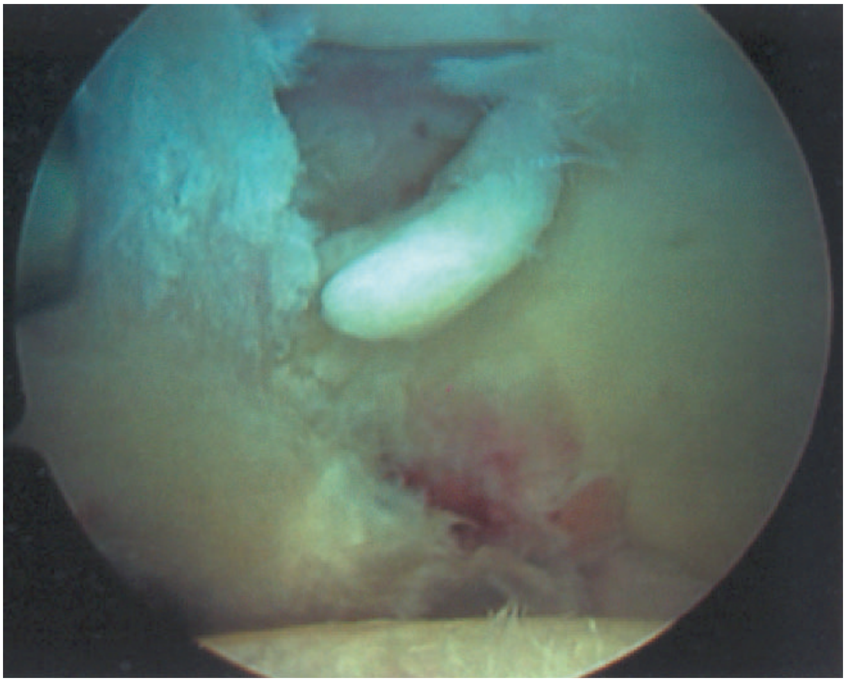


Figure 12.17. A focal full-thickness chondral flap lesion.

grade III and 10% of which were grade IV). Thirteen (18%) of these patients had associated lateral acetabular articular cartilage lesions (46% of which were grade III and 23% of which were grade IV). Eleven (15%) of these patients had associated posterior acetabulum articular cartilage lesions (27% of which were grade III and 9% of which were grade IV).

Among the 74 hips with anterior labral fraying in the absence of a frank anterior labral tear, the prevalence of associated anterior, lateral, and posterior femoral head articular cartilage injuries was 72%, 26%, and 23%, respectively.

Anterior Acetabular Articular Cartilage Lesions

Among the 269 hips with anterior acetabular articular cartilage lesions, 29 (10.8%) were grade I; 51 (19.0%) were grade II; 42 (15.6%) were grade III; and 147 (54.6%) were grade

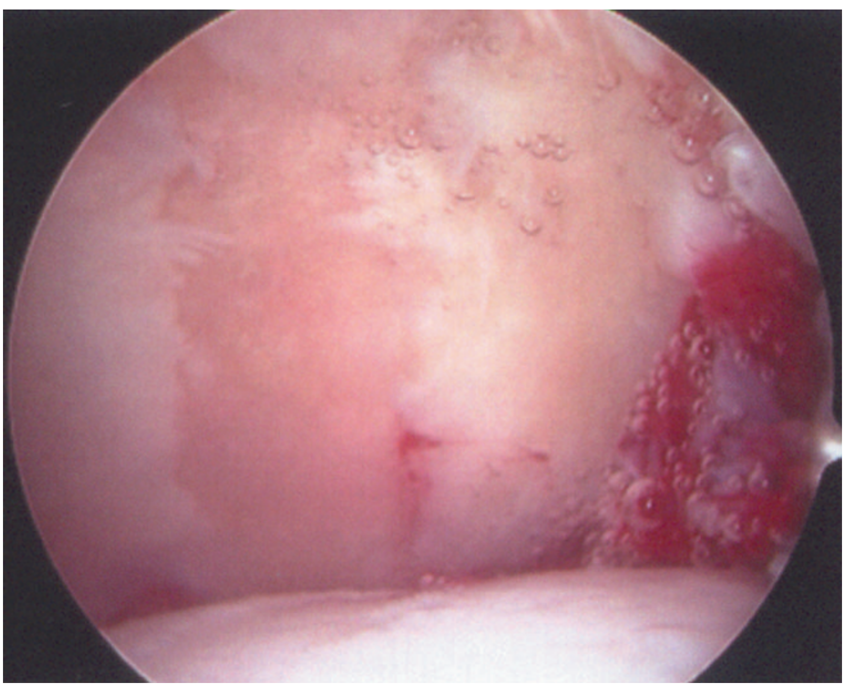


Figure 12.18. Localized full-thickness chondral wear (with no associated chondral flap).

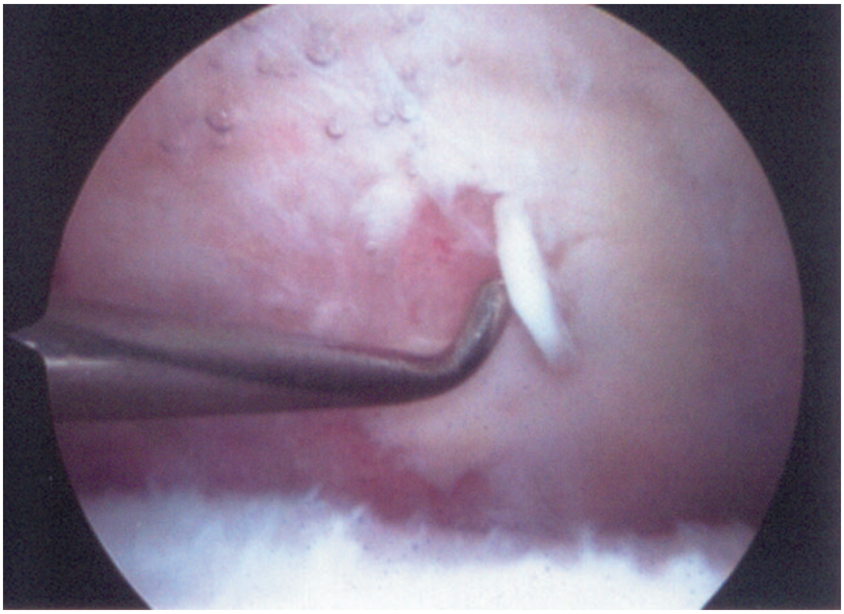


Figure 12.19. Full-thickness wear seen with global degenerative joint disease.

IV. There were three distinct patterns of grade IV lesions: Focal full-thickness chondral flaps (Figure 12.17); localized full-thickness chondral wear with no associated chondral flap (Figure 12.18); and full-thickness wear associated with global degenerative joint disease (Fig 12.19). Thirteen (8.8%) of the 147 patients with grade IV anterior acetabular articular cartilage lesions demonstrated degeneration throughout the involved hip.

The anterior acetabular grade IV lesions that consisted of chondral flaps frequently manifested the following constellation of features: They were associated with an adjacent tear of the articular margin of the anterior labrum (Figure 12.20);

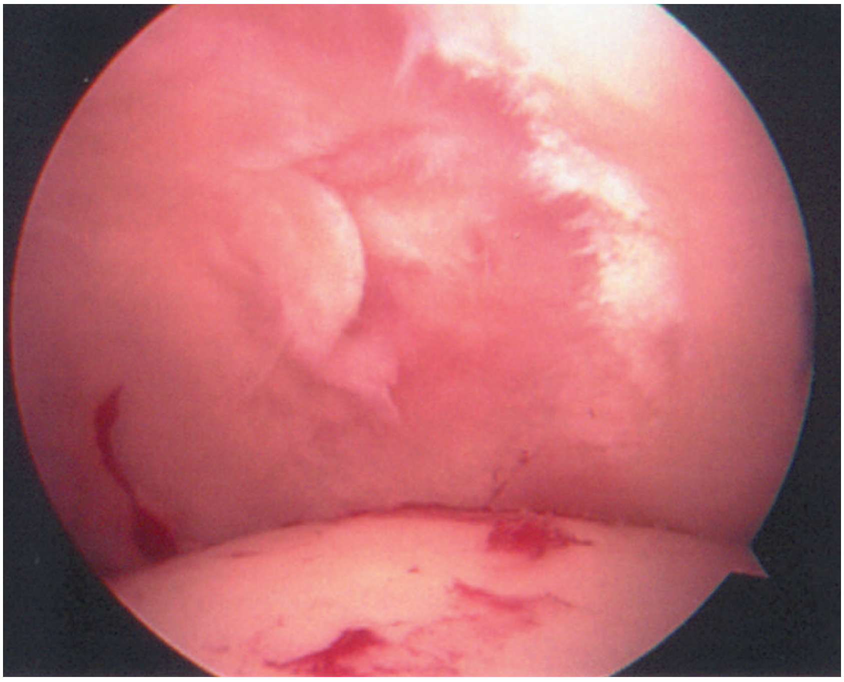


Figure 12.20. A chondral lesion associated with an adjacent tear of the articular margin of the anterior labrum.

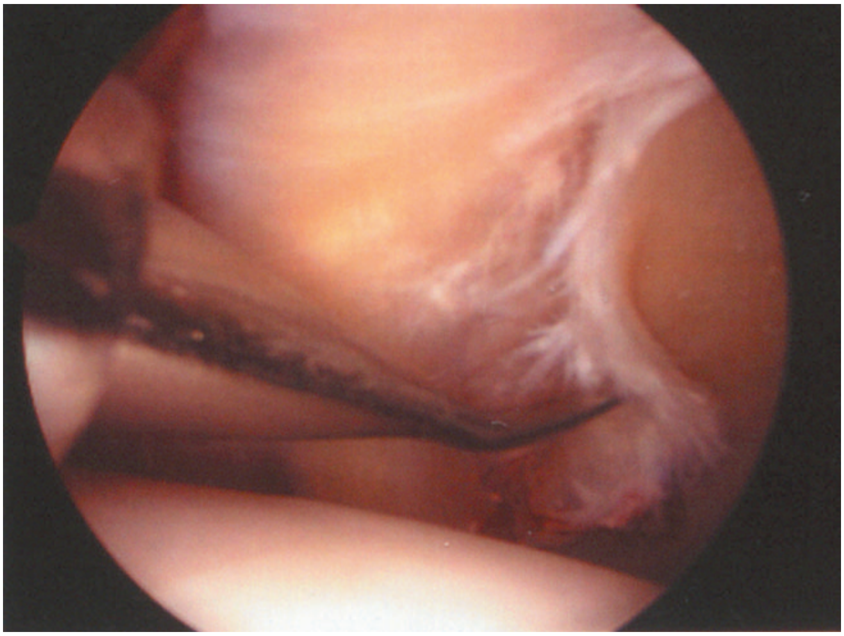


FIGURE 12.21. An articular chondral flap lesion emanating from the adjacent anterior labral tear.

the free margin of the articular chondral flap emanated from the adjacent anterior labral tear (Figure 12.21); the intact hinge of the articular flap was located medially. Chondral flaps in other regions of the acetabulum were present far less frequently, and they rarely presented with a similar constellation of features when they did occur.

Among patients with anterior acetabular articular cartilage lesions, the prevalence of associated anterior, lateral, and posterior labral tears was 59.9%, 2.6%, and 7.8%, respectively.

The prevalence of associated anterior, lateral, and posterior femoral head articular cartilage lesions in this subset of patients was 60.2%, 23%, and 23%, respectively.

Of these patients, 106 (39.4%) had associated posterior acetabular articular cartilage lesions (17.9% of which were grade III and 13.2% of which were grade IV). One hundred one (37.5%) of these patients had associated lateral acetabular articular cartilage lesions (23.8% of which were grade III and 4.9% of which were grade IV).

Lateral Labral Tears

Among the 8 hips with lateral labral tears, 6 (75%) had associated anterior labral tears. Seven (88%) of the patients with lateral labral tears had associated anterior acetabulum articular cartilage lesions (25% of which were grade III and 38% of which were grade IV). Four (50%) of these patients had associated lateral acetabular articular cartilage lesions (13% of which were grade III and none of which were grade IV). Four (50%) of these patients had associated posterior acetabular articular cartilage lesions (25% of which were grade III and none of which were grade IV).

Among the 6 hips with lateral labral tears, the prevalence of associated anterior, lateral, and posterior femoral head articular cartilage injuries was 100%, 50%, and 50%, respectively.

Lateral Labral Fraying

Among the 88 hips with lateral labral fraying in the absence of a frank lateral labral tear, 9 (10.2%) had associated posterior labral tears, and 66 (75%) had associated anterior labral tears.

Seventy-six (86%) of these patients had associated anterior acetabular articular cartilage lesions (7% of which were grade III and 70% of which were grade IV). Forty-seven (53%) of these patients had associated lateral acetabular articular cartilage lesions (28% of which were grade III and 2% of which were grade IV). Forty-eight (55%) of these patients had associated posterior acetabular articular cartilage lesions (19% of which were grade III and 17% of which were grade IV).

Among the 88 hips with lateral labral fraying, in the absence of a frank lateral labral tear, the prevalence of associated anterior, lateral, and posterior femoral head articular cartilage injuries was 73%, 48%, and 39%, respectively.

Lateral Acetabular Articular Cartilage Lesions

Among the 110 hips with lateral acetabular articular cartilage lesions, 21 (19.1%) were grade I; 59 (53.6%) were grade II; 23 (20.9%) were grade III; and 7 (6.4%) were grade IV. Two (28.6%) of the 7 patients with grade IV lateral acetabular articular cartilage lesions had diffuse hip degeneration.

The prevalence of associated anterior, lateral, and posterior labral tears in this subset of patients was 70%, 3.6%, and 13.6%, respectively. The prevalence of associated anterior, lateral, and posterior femoral head articular cartilage lesions in this subset of patients was 69.1%, 59.1%, and 47.3%, respectively.

Eighty-three (75.5%) of these patients had associated posterior acetabular articular cartilage lesions (14.5% of which were grade III and 10.8% of which were grade IV). Of these patients, 102 (92.7%) had associated anterior acetabular articular cartilage lesions (11.8% of which were grade III and 65.7% of which were grade IV).

Posterior Labral Tears

Among the 30 hips with posterior labral tears, 15 (50%) had associated anterior labral tears. Posterior labral pathology was more commonly associated with a discrete episode of hip trauma, which typically involved a mechanism whereby the femoral head was driven posteriorly within the acetabulum. Fraying of the labrum, in the absence of frank separation of the labrum from the articular surface, was observed in 162 cases (36% 0f 456). Seventy-five (46%) of these patients were female and 87 were male (54%). The average age of this patient group was 40.0 years (range 14 to 72), 3 years older than patients with labral tears. There was no significant difference between the average ages of the male and female patients.

There were no instances of fraying and frank labral separation. (*Note:* Some of these regions of labral fraying were associated with frank labral tears in other locations.) In every instance, the frayed tissue involved the articular margin of the labrum directly adjacent to the labral–cartilage junction. There was a relatively uniform distribution of the frayed regions around the circumference of the acetabulum: 74 (33%) cases were located in the anterior acetabulum, 88 (40%) were lateral, and 61 (27%) were posterior.

There were two distinct patterns of association between frayed areas of the labrum and discrete labral lesions. Almost all cases of anterior fraying occurred in acetabula without a labral tear. Conversely, 75% of cases with posterior fraying (46 of 61) or lateral fraying (66 of 88) also had a tear of the anterior labrum. This suggests that anterior labral tears lead to a disruption of stability of the joint, causing abnormal motion between the labrum and the femoral head laterally or posteriorly, leading to localized fraying of the labrum. Another possibility is that, in the face of an anterior tear, the labrum gives way slightly in extremes of external rotation, leading to sliding of the femur in contact with the labrum. With repetitive loading, this in turn could lead to fraying of the labrum.

Twenty-one (70%) of these patients had associated anterior acetabular articular cartilage lesions (24% of which were grade III and 48% of which were grade IV). Fifteen (50%) of these patients had associated lateral acetabular articular cartilage lesions (20% of which were grade III and none of which were grade IV). Thirteen (43%) of these patients had associated posterior acetabular articular cartilage lesions (15% of which were grade III and 15% of which were grade IV).

Among the 30 hips with posterior labral tears, the prevalence of associated anterior, lateral, and posterior femoral head articular cartilage injuries was 47%, 27%, and 23%, respectively.

Posterior Labral Fraying

Among the 61 hips with posterior labral fraying in the absence of a frank posterior labral tear, none had associated lateral labral tears, and 46 (75%) had associated anterior labral tears.

Fifty (82%) of these patients had associated anterior acetabular articular cartilage lesions (8% of which were grade III and 60% of which were grade IV). Thirty-seven (61%) of these patients had associated lateral acetabular articular cartilage lesions (27% of which were grade III and 54% of which were grade IV). Thirty-five (57%) of these patients had associated posterior acetabular articular cartilage lesions (20% of which were grade III and 17% of which were grade IV).

Among the 61 hips with posterior labral fraying in the absence of a frank posterior labral tear, the prevalence of associated anterior, lateral, and posterior femoral head articular cartilage injuries was 74%, 46%, and 43%, respectively.

Posterior Acetabular Articular Cartilage Lesions

Among the 114 hips with posterior acetabular articular cartilage lesions, 21 (18.4%) were grade I; 52 (45.6%) were grade II; 24 (21.1%) were grade III; and 17 (14.9%) were grade IV. Five (29.4%) of the 17 patients with grade IV posterior acetabular articular cartilage lesions had diffuse hip degeneration. Posterior acetabular articular cartilage pathology was more commonly associated with a discrete episode of hip trauma, which typically involved a mechanism whereby the femoral head was driven posteriorly within the acetabulum.

The prevalence of associated anterior, lateral, and posterior labral tears in this subset of patients was 71.9%, 3.5%, and 11.4%, respectively.

The prevalence of associated anterior, lateral, and posterior femoral head articular cartilage lesions was 75.4%, 61.4%, and 50.8%, respectively.

Eighty-three (72.8%) of these patients had associated lateral acetabular articular cartilage lesions (27.7% of which were grade III and 3.6% of which were grade IV). One hundred six (93%) of these patients had associated anterior acetabulum articular cartilage lesions (9.4% of which were grade III and 64.2% of which were grade IV).

Cartilage Lesions

On arthroscopic examination, 329 patients (72%) had some form of injury to the acetabular cartilage. Of these patients, 171 (52%) were female and 158 (48%) were male. The average age of this patient population was 37.8 years (range 14 to 82). There was minimal difference in ages between males and females (1.1 years). Discrete chondral lesions were present anteriorly in 269 cases (59%), posteriorly in 110 cases (24.1%), and laterally in 114 cases (25%). The severity of cartilage pathology also varied with anatomic location within the socket. This is reflected in the average Outerbridge score, which was 3.17 (of a possible 4) anteriorly, 2.33 posteriorly, and 2.14 laterally. Similarly, 55% of anterior lesions involved exposure of subchondral bone (Outerbridge IV), compared with 15% of posterior lesions, and only 6% of lateral lesions.

There were 3 distinct patterns of grade IV lesions: Focal full-thickness chondral flaps; localized full-thickness chondral wear with no associated chondral flap; and full-thickness wear associated with global degenerative joint disease. The anterior acetabular grade IV lesions that consisted of chondral flaps frequently manifested the following constellation of features. They were associated with an adjacent tear of the articular margin of the anterior labrum; the free margin of the articular chondral flap emanated from the adjacent anterior labral tear; the intact hinge of the articular flap was located medially. Chondral flaps in other regions of the acetabulum were present far less frequently, and they rarely presented with a similar constellation of features when they did occur. Cases of diffuse degeneration of the articular surface were relatively rare, ranging from 4.8% anteriorly, 4.5% posteriorly, and only 1.8% laterally.

The Relationship of Labral and Chondral Pathology

There were highly significant associations between the presence of labral lesions and degeneration of the articular surface. Overall, 74% of patients with fraying or a tear of the labrum had chondral damage. Moreover, in 80% of these patients, labral and articular lesions were located in the same zone of the acetabulum. The strongest association between articular damage and labral pathology was present posteriorly and laterally; in both zones, only 12% of patients with cartilage lesions did not have a labral defect. Anteriorly, this was true in 29% of cases.

The severity of cartilage pathology was also greater in patients with labral tears or fraying. Of the 202 cases with a labral tear, 136 (67%) had a serious articular lesion (Outerbridge II, III, or IV), and 40% had full-thickness erosion. In comparison, the prevalence of these lesions in acetabula without labral tears was 43% and 21%, respectively ($p < 0.0001$). Stronger correlations were observed with fraying of the labrum, the presence of a frayed area being associated with more than twice the incidence of serious chondral defects (56% vs 21%) and full-thickness lesions (48% vs 22%). The strongest associations were observed when fraying and tears were combined as indicators of labral pathology. Of 193 patients with serious articular degeneration, only 14 (7%) had an intact labrum without fraying or a tear, compared to 43% of patients with little or no articular pathology ($p < 0.0001$).

The incidence of labral lesions (tears and fraying) and serious cartilage lesions (Outerbridge II, III, IV) was calculated for patients grouped by decade of age. With the exception of the youngest patient group (14–19 years), the incidence of labral pathology rose steadily with age to 34% in the 50–59 age group ($p < 0.0001$). Labral tears and fraying were almost universal in patients older than 60 years. Similarly, the frequency and severity of cartilage degeneration also increased with age, with an incidence of 24% in patients under 30, and 81% in those over 60 ($p < 0.0001$).

Dysplasia

Seventy (15.4%) of the 436 arthroscopy cases manifested mild to moderate occult (Crowe I) developmental hip dysplasia. Among the patients with dysplasia, there was a 48.6% prevalence of anterior labral tears, a 4.3% prevalence of posterior labral tears (all of which also had anterior labral tears), a 0% prevalence of isolated posterior labral tears, and also a 0% prevalence of lateral labral tears. The anterior labrum frequently demonstrated a bulbous, hypertrophied morphology in the context of dysplasia. (Figure 12.22.)

It should be noted that the prevalence of anterior labral tears in this subset of patients (48.6%) is quite similar to the prevalence of anterior labral tears in the study cohort as a whole (51.3%). However, the prevalence of lateral and posterior labral tears was lower in the dysplastic subset in comparison to its respective prevalence in the entire study cohort.

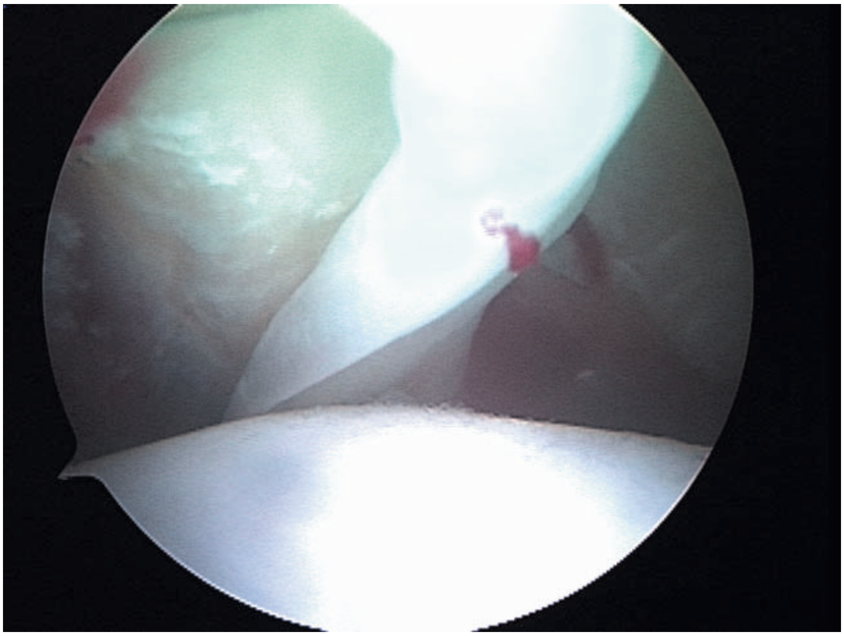


FIGURE 12.22. A bulbous, hypertrophied anterior labrum with displaced bucket-handle tear in a patient with dysplasia.

Correlations

The most striking trend observed in both the arthroscopic and cadaveric data is the overwhelming preponderance of lesions involving the anterior labral–cartilage junction. The most common location for labral tears was unequivocally the anterior articular margin. There are several hypothetical explanations for this phenomenon. These include: This region of the labrum may possess inferior intrinsic mechanical properties compared to other portions of the labrum; this region may be subjected to higher mechanical demands; or the region may be relatively hypovascular, and hence disproportionately vulnerable to wear and degeneration due to resultant compromise in remodeling and healing capacity.

The cadaveric investigation failed to detect a structural diathesis, which could support a morphologic explanation for the preponderance of anterior lesions. The normal transition between the labrum and the articular cartilage appeared smooth around the entire perimeter of the acetabulum, and there was no evidence of localized anterior structural frailty. Similarly, the analysis of labral vascularity by itself does not account for the asymmetric distribution of labral pathology. Microangiography and immunohistochemical staining both confirmed that intraosseous vessels within the bony acetabulum and the joint capsule were present on the capsular surface and reached the interface with the fibrocartilaginous labrum, but did not seem to penetrate the body of the labrum to any significant extent. The labrum itself contained no intrinsic vessels. Despite the hypovascularity of the body of the labrum, this vascular pattern was consistent around the entire acetabular rim. That is, it was not disproportionately deficient in any specific region.

The hip symptoms in a high percentage of patients were associated with athletic activities that involve strenuous, repetitive twisting and pivoting motions (such as ballet, football, soccer, basketball, and place-kicking). It is conceivable that certain recurrent torsional maneuvers preferentially subject the anterior portion of the articular–labral junction to recurrent microtrauma and eventual mechanical attrition. This scenario would be exacerbated by the diffuse suboptimal blood supply within the body of the labrum.

Two significant differences exist between the author's arthroscopic patients and the cadaveric specimens. First, the chronological age of the cadaveric acetabula was considerably greater than the age of the arthroscopy patients. Second, the patients in the arthroscopic branch of this investigation were inherently subjected to bias due to the fact that they were selected on the basis of their symptoms. The cadaveric donors, on the other hand, were not selected on the basis of symptoms. In fact, many of the donors (and perhaps the majority of them) may have had minimal hip symptoms or may not have been active enough for the pathology within their hips to cause significant difficulty. It is impressive to note that, in spite of these discrepancies, the relative frequency of junctional anterior labral tears noted in the arthroscopy group was corroborated by the cadaveric investigation.

Both the arthroscopic and cadaveric populations demonstrated that the majority of labral tears and cartilage lesions were located in the anterior quadrant of the acetabulum. Moreover, this was the most common location for lesions of the acetabular articular cartilage. Furthermore, the prevalence of severe (grade IV) articular lesions was greater anteriorly that in any other region of the acetabulum.

It should be noted that the only type of articular lesion that did *not* predominantly affect the anterior aspect of the acetabulum was labral fraying, without associated local labral tearing. The prevalence of this form of pathology was roughly equivalent in the three locations (anteriorly, posteriorly, and laterally). We attribute this finding to our belief that labral fraying is more likely to progress to frank labral disruption in this region. This contention is supported by the fact that the prevalence of frank labral tears was greatest anteriorly.

Of supreme interest is that fact that the arthroscopic data demonstrate an association between progression of labral pathology and progression of anterior acetabular articular cartilage lesions. Specifically, both the frequency and the severity of acetabular articular degeneration was dramatically higher in patients with labral pathology than in those in whom the labrum was neither frayed nor torn. While the presence of a statistically significant association between labral and chondral pathology does not prove that the two are causally related, this conclusion seems inescapable in many cases where cartilage degeneration and delamination are observed directly in continuity with preexisting labral lesions. Specifically, both the frequency and the severity of acetabular articular degeneration were augmented among patients who had true anterior labral tears versus those with anterior labral fraying alone.

Additional evidence can be found in the incidence of each type of lesion as a function of the age of the patient. However, as both chondral and labral lesions become more common with aging, it is not possible to prove unequivocally that the increase in incidence of labral lesions in one age-group decade leads to the increased frequency of joint degeneration a decade later. Nonetheless, the data do demonstrate that labral lesions leading to arthroscopic treatment are most common beyond middle age, and not in younger patients who undergo extreme activities. This speaks to the degenerative, chronic nature of labral pathology and the need for improved methods of earlier detection and diagnosis.

These observations suggest that acetabular labral pathology may indeed be a contributing factor in the evolution and progression of osteoarthritis of the hip. Anterior labral discontinuity could conceivably disrupt the stability of the hip, and hence disrupt the congruence of the hip articulation under dynamic torsional loading conditions. In this sense, the labral lesion could act as a nidus for further intra-articular degeneration. Although the weightbearing function of the intact labrum under normal loading conditions has recently been called into question by Konrath and colleagues, it remains plausible that loss of the putative stabilizing and weightbearing roles of the labrum at the extremes of motion (where the labrum would be anticipated to exert its most significant effect) could predispose the hip to further degeneration.[20]

Alternatively, lesions of the anterior labrum may represent a final common pathway of deterioration in hips with a wide variety of primary pathology. These concepts are concordant with clinical arthroscopic experience, which has yielded the impression that this process progresses in the following sequence: first, fraying of the articular margin of the anterior labrum; second, frank tearing along the articular margin of the anterior labrum; third, delamination of the articular cartilage from the articular margin adjacent to the labral pathology; and finally, more global labral and articular cartilage degeneration.

In summary, the arthroscopic and anatomic observations support the concept that labral disruption and degenerative joint disease are frequently part of a continuum of joint pathology that consists of the following sequence of events: first, excessive loading of the labrum, through traction or impingement, at the extremes of joint motion; second, fraying of the articular margin of the anterior labrum; third, frank tearing along the articular margin of the anterior labrum; fourth, delamination of the articular cartilage from the articular margin adjacent to the labral pathology; and finally, more global labral and articular cartilage destruction. Future research is needed to elucidate the processes that connect each of these events leading to failure of the articulation.

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13
Femoral Head Pathology

Mark G. Bowditch and Richard N. Villar

Pathological conditions of the femoral head constitute approximately one-third of disorders diagnosed at hip arthroscopy.[1] Because clear preoperative diagnoses are uncommon, many of the those with undiagnosed hip pain undergoing arthroscopy are subsequently found to have femoral head pathology. A recent study[1] reports that 45% of those with "idiopathic hip pain" have femoral head pathology. The purpose of this chapter is to describe in detail the arthroscopic appearance, management, and outcome of pathological conditions affecting the femoral head. The senior author's (RNV) experience of hip arthroscopy extends to nearly one thousand cases. Thirty-four percent of these had a defined lesion of the femoral head.

In order to help orientation and understanding of the subsequent descriptions, with particular reference to arthroscopic surgery of the femoral head, the senior author's technique for hip arthroscopy is briefly outlined. A more detailed description of the author's technique is available in the literature.[2]

Technique and Instrumentation

Positioning

Following general anesthesia, the patient is placed in the lateral position, with the affected leg uppermost. A C-arm image intensifier is positioned horizontally, slightly oblique to the hip so as to maximize operating space. This produces a somewhat angled anteroposterior image of the hip joint. The surgeon stands posterior to the patient, cephalad of the image intensifier arm.

Distraction

The peripheral femoral head may be visualized without traction,[3] but a full inspection and operative surgery require distraction with a specialized distractor. Vertical and longitudinal distraction is applied by a padded perineal bar and booted foot. Approximately 25 kg of distraction force is usually sufficient to distract the joint by 1.5–3 cm; however, the space achieved is sometimes considerably less than this. The surgeon should not be disappointed if this happens. It is simply a reflection of the natural suction on which a hip depends for its stability. A "trial of traction" is performed under intensification, looking for a radiolucent crescent to appear above the femoral head, which indicates the joint space is opening and the hip distractible. Once this is established, the traction is released until after draping.

Instrumentation

A standard length, 70 degree, 4.5 mm arthroscope is used in almost all cases. Occasionally, a 22.5 cm long arthroscope is used in the very obese patient. The widest field of view is achieved through manual rotation of the 70-degree arthroscope, as leverage of the instrument is almost impossible in such a deep-seated joint.

Manual and electrically powered instruments are used. Elongated and curved concave- or convex-tipped instruments improve assess and reduce scuffing to the femoral head. These instruments are usually inserted through protective, disposable Smith & Nephew endoscopy cannulae which are 5.7 mm in diameter. The cannulae are occasionally cut short to lie flush with the skin, or are not used at all to allow a greater arc of movement of instruments within the joint, particularly when operating on the femoral head. The senior author has used laser instrumentation, but has not found any additional advantages with this for arthroscopic surgery of the femoral head. Occasionally, extreme angulation of the laser fiber has been required, with a consequent risk of fiber breakage.

Irrigation System

High fluid flow and controlled joint pressures, at least 90 cm of water, are vital for arthroscopic femoral head surgery, as a tourniquet cannot be used. This is best delivered by a specialized fluid management system (eg, Forth Medical Surgery, Newbury, UK).

Portals

The senior author uses lateral supratrochanteric portals for both diagnostic and operative procedures. The initial lateral portal for the arthroscope is created 2 cm above the greater trochanter. Secondary portals for instrumentation are usually just anterior or posterior to the initial portal. The anterior portal is situated at the junction of a vertical line from the anterior superior iliac spine and another line extended forward from the tip of the greater trochanter.

Dvorak et al[3] reported that 80% of the femoral head could be visualized using the combination of the lateral and anterior portals with fluid distention alone. In the authors' practice, the lateral portal is usually satisfactory for access to the femoral head, providing distraction is good. The only true blind spot is that area of the femoral head below the fovea, immediately adjacent to the entry point of the arthroscope, if the instrument is applied closely to the head. Occasionally, the fovea and inferior part of the head are better inspected from the anterior portal.

In establishing a portal, it is essential to minimize scuffing to the femoral head. This may be achieved by passing a blunt-ended, extended, floppy guidewire into the cotyloid fossa, over which the larger cannulated instruments are inserted. Sharp obturators must be exchanged for blunt after piercing the capsule, before advancing the sheath towards the cotyloid fossa.

Instrument portals can be established at a site appropriate to the pathology. Frequently, the anterior inflow portal can be used as an instrument portal, as so much pathology in the hip is situated anteriorly.

Access to the femoral head may be facilitated intraoperatively by rotating the leg, provided the distractor permits this. Unfortunately, the increase in access is frequently disappointing. A large degree of rotation at the foot will give only a small displacement at the hip.

Arthroscopic Anatomy and Assessment of the Normal Femoral Head

The gross and arthroscopic anatomy pertaining to hip arthroscopy is described in detail in the literature[4,5] and earlier in this book. (See Chapter 5.) Because a full understanding of the normal is a prerequisite to recognizing the abnormal, this section illustrates the important intra-articular anatomy relevant to a systematic examination of the femoral head. For orientation purposes, the senior author rotates the arthroscope until the femoral head is positioned at the top of the screen and the cotyloid fossa at the bottom.

The normal femoral head is covered by hyaline articular cartilage, except for the fovea centralis, where the ligamentum teres inserts.

Articular cartilage is thickest centrally (3 mm) and thins peripherally to 1 mm. Hyaline cartilage has a smooth, glistening surface appearance. In young people, it is translucent and bluish-white, whereas with increasing age it becomes opaque and slightly yellowish. Cartilage deforms under pressure but recovers its original shape on removal of pressure. It has a firm and rubbery texture with a characteristic appearance on arthroscopic probing (Figure 13.1).

The superior part of the head, leading down towards the fovea, is normally seen directly on entering the hip joint. Slight leverage of the arthroscope is required in order to view the posterior and anterior aspects of the femoral head. Liberal use of arthroscope rotation is made in order to gain as full an assessment of the head as possible.

The ligamentum teres arises from the posteroinferior portion of the cotyloid fossa and crosses the inferior section of the joint, to insert into the anteromedial portion of the femoral head (Figure 13.2). It is a smooth, pyramidal structure with a banded appearance. It is synovium-covered, with several capillaries visible on the surface (Figure 13.3). It tightens in flexion, adduction, and external rotation, and relaxes with the converse. Its insertion is often difficult to see and is frequently covered in dense synovium. The capsular attachments to the femoral neck are not seen, but the anterior and posterior synovial gutters lie adjacent to the head. A capsular condensation, named the zona orbicularis, may be seen embracing the femoral head and is occasionally mistaken for an acetabular labrum (Figure 13.4).

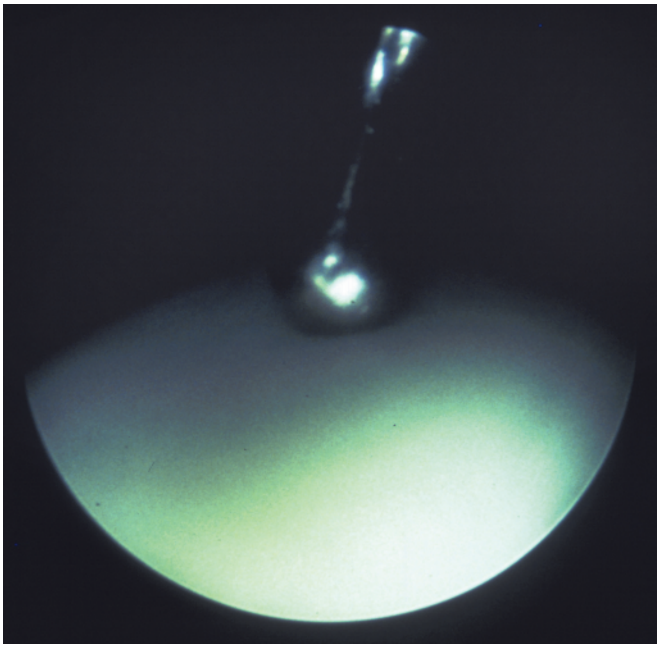


FIGURE 13.1. Normal femoral head articular cartilage with characteristic firm and rubbery texture deforming under the probe.

FIGURE 13.2. Ligamentum teres: Smooth ligamentum inserting into femoral head.

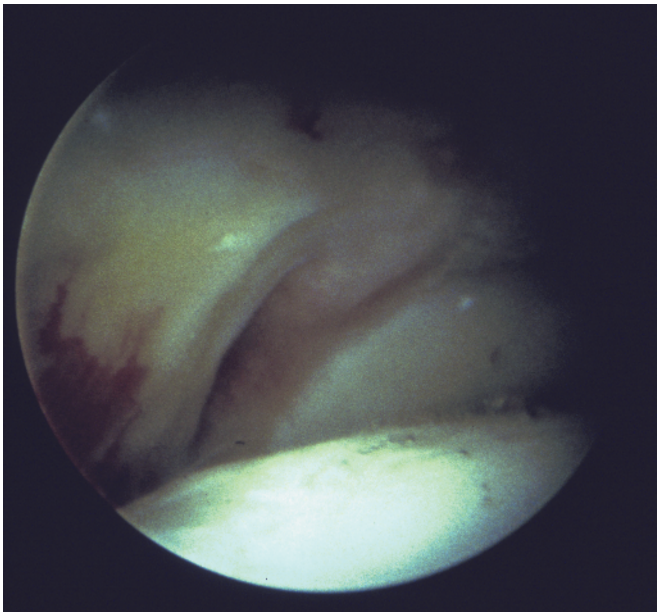


FIGURE 13.3. Ligamentum teres: Capillaries on the surface of the ligamentum teres.

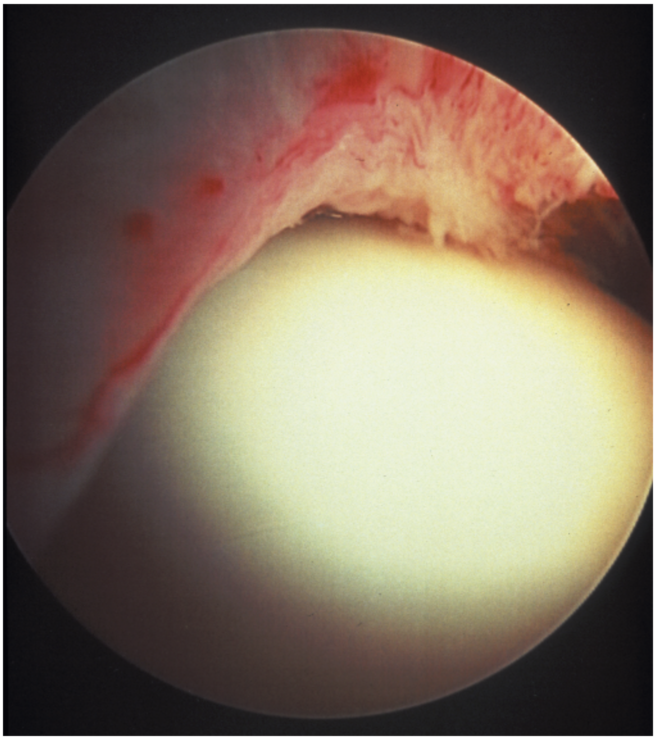
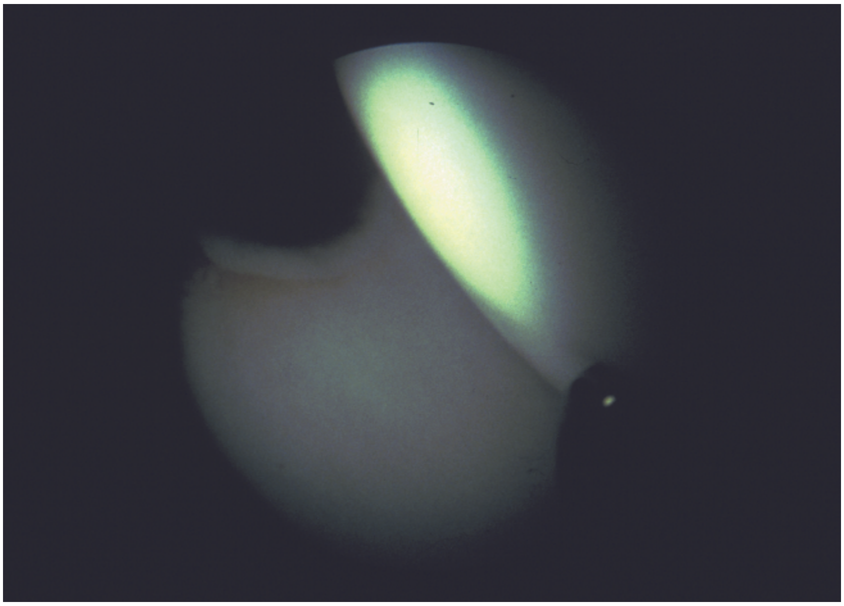


FIGURE 13.4. Zona orbicularis: A normal capsular condensation embracing the femoral head.



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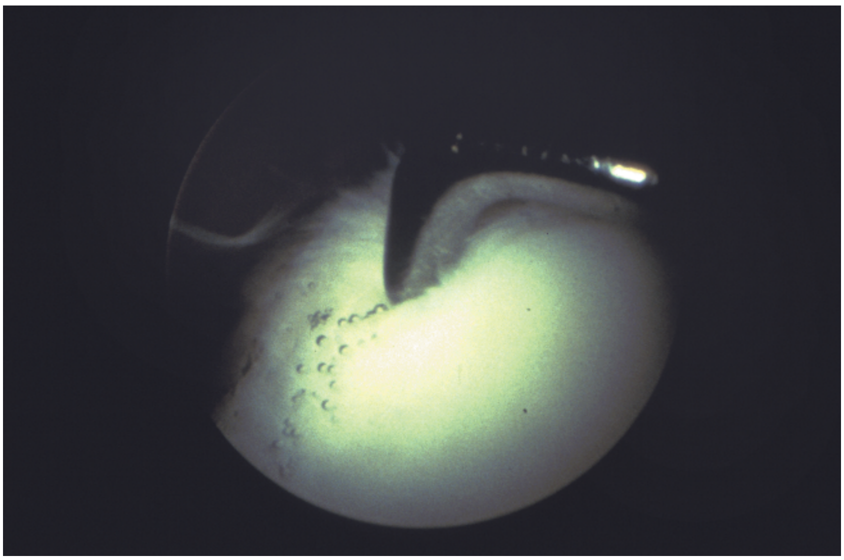


B

Figure 13.5. (A) Chondromalacia: Early chondromalacia showing cartilage softening on probing. (B) Chondromalacia: Advanced chondromalacia with severe softening and articular cartilage fibrillation.

Pathology and Management

The pathologies affecting the femoral head are:

Chondromalacia	Avascular necrosis
Chondrolysis	Ligamentum teres lesions
Chondral defects	Inflammatory disease
Osteochondral defects	Deformity
Osteochondritis dissecans	Arthrofibrosis
Degenerative joint disease	Fractures
Tumors	

Chondromalacia

Global softening of the articular cartilage, chondromalacia coxae, similar to that in the knee, has been reported.[6] It does appear to be a definite clinical entity and is sometimes the cause of hip pain. The characteristic arthroscopic appearance of chondromalacia is the loss of the normal resistance or softness to probing (Figure 13.5A). It may affect large areas of the weightbearing surface of the femoral head and lead to fibrillation and fissuring (Figure 13.5B). No specific treatment is required for most early examples; however, symptomatic improvement can be seen after hip arthroscopy.

Chondrolysis

Chondrolysis is the global loss of healthy articular cartilage. It may be seen in the hip following sepsis, trauma, or slipped capital femoral epiphysis, and is occasionally idiopathic. Reduced joint space may be seen on a plain radiograph. It ap-

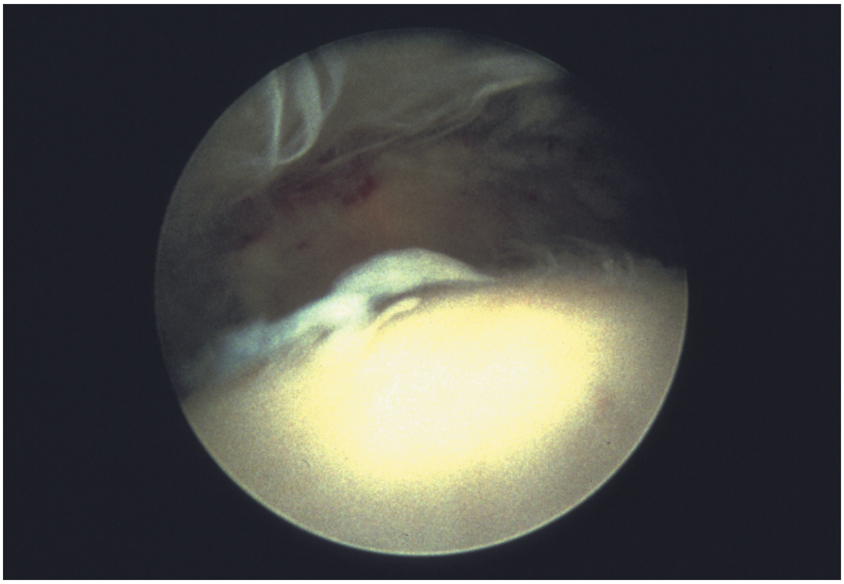


FIGURE 13.6. Chondrolysis: Irregular fluffy, thin cartilage.

pears as irregular, fluffy, opaque cartilage that is soft and thin to probing (Figure 13.6). Treatment options are few, although removal of any adhesions may improve the range of hip movements.

Chondral Defects

Localized chondral defects may be truly pathological or iatrogenic. Iatrogenic surface defects are caused by instrument or needle scuffing. Such injuries are best avoided by attention to surgical detail throughout the procedure, as well as judicious use of the guidewire during instrument and arthroscope insertion. Scuff injuries usually appear as a smooth, linear trenchlike gouge with fluffy edges (Figure 13.7). Truly pathological defects are usually rounder, with vertical sides. Scuff lesions are usually no deeper than the superficial and middle layers of cartilage. No treatment is necessary for these lesions. Although they probably do not heal fully, it is felt that such superficial lesions are unlikely to lead subsequently to degenerative change. Deeper defects are clearly a risk to later degenerative change, and treatment of these using debridement or drilling should be considered. Chondral defects may be a result of trauma, such as hip dislocation or sports injury, but may also be an early stage of degenerative disease. The usual presentation is with nonspecific pain, but mechanical symptoms may be present secondary to unstable flaps, labral tears, or loose bodies. Outerbridge's grading[7] of chondral disease, as used in other joints, may be applied to the hip. Grade I: Softening; 2: Fissuring; 3: Chondral flaps; 4: Eburnated bone. Treatment depends on the extent of the disease. Superficial lesions (grades I and II) should probably be left, whereas unstable flaps should be debrided, and consideration given to drilling exposed bony areas.

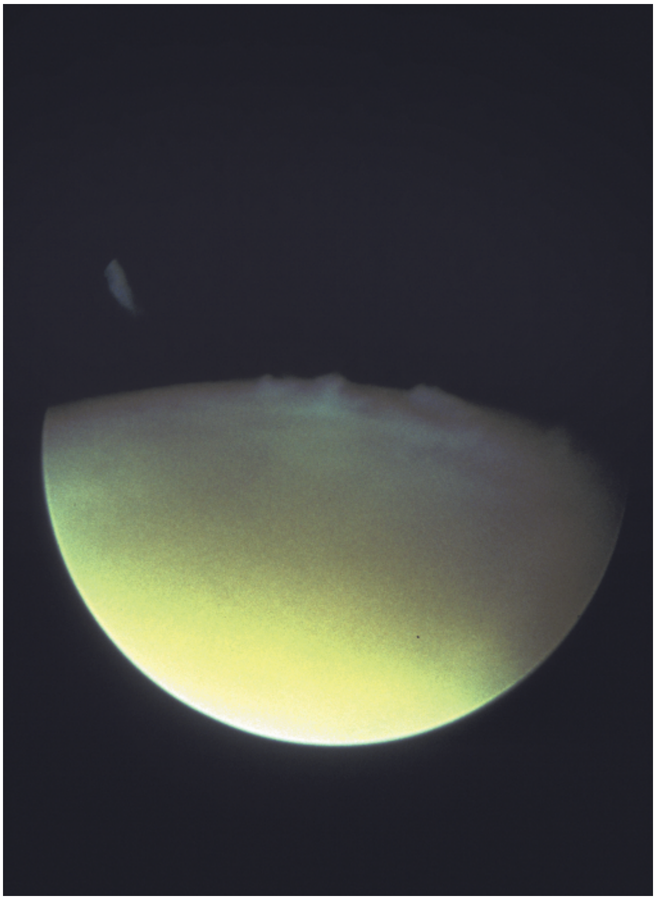
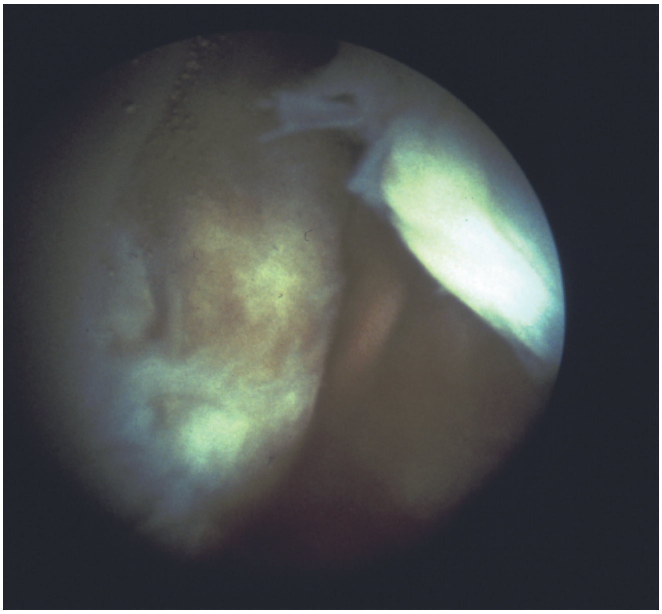


FIGURE 13.7. Scuff damage of the femoral head showing superficial fluffy disruption.



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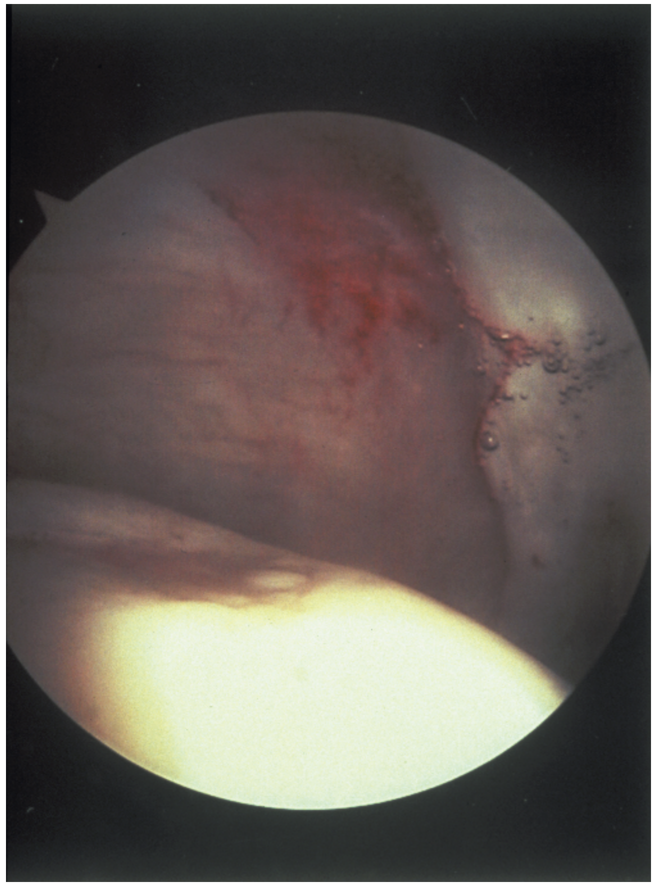


B

FIGURE 13.8. (A) Osteochondritis dissecans: A young lesion with a punched-out deficit on the femoral head and loose body. (B) Osteochondritis dissecans: A chronic lesion in which the sharp, punched-out edges have become smooth.

Osteochondral Defects

Osteochondral lesions may be localized (osteochondritis dissecans and posttraumatic) or part of a generalized joint disease such as osteoarthritis.

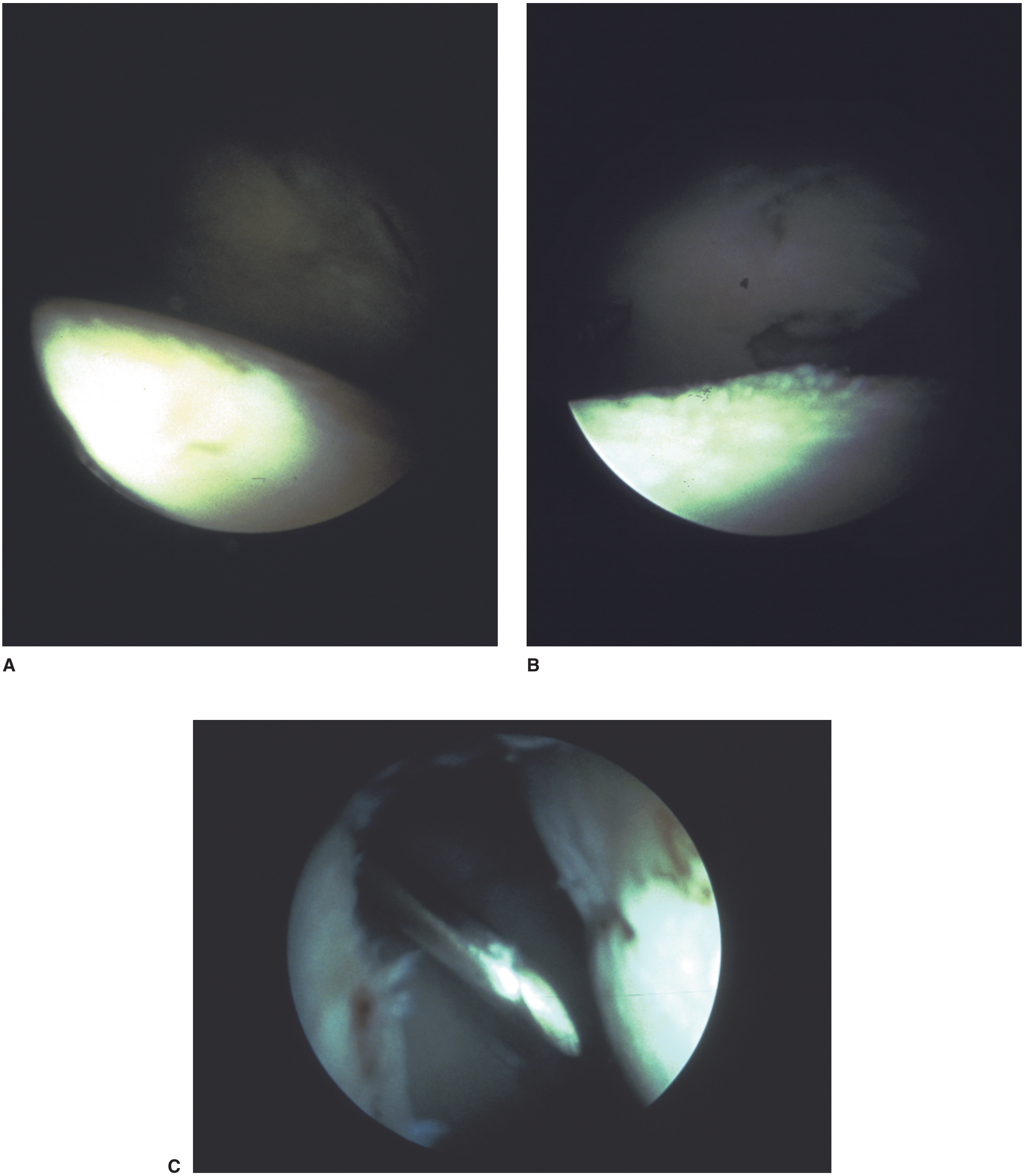
Osteochondritis dissecans of the hip tends to affect the femoral head. Symptoms are extremely variable, and radiographs are often normal or reveal only slight irregularity. In the classic case, as in other joints, there is a well-demarcated fragment of bone and overlying cartilage, which may be separated from the underlying surface. Although often on the weightbearing area, the site is variable. It frequently has a "punched-out" appearance (Figure 13.8A). Associated loose bodies are common, either lying in the defect or free. In more chronic lesions, the edges of the lesion are smoothed off (Figure 13.8B).

Arthroscopy is extremely useful for diagnosis, assessment, and treatment. Loose bodies should be removed if possible. To do so requires tightly gripping forceps with sufficient bite to grasp each pole of a loose body effectively. Unstable flaps are debrided with rongeurs or a shaver. Drilling of the defect's base is sometimes undertaken to stimulate fibrocartilage formation. If access allows, it is sometimes possible to drill a defect in a retrograde manner, passing a long drill up the femoral neck under image intensifier control until the tip emerges from the base of the defect. Osteochondral grafting or chondrocyte implantation are options to consider for the future. To date, in the author's practice, such procedures have been undertaken as open operations.

Degenerative Joint Disease

Degenerative disease is the most common finding at hip arthroscopy. Symptoms and radiographic appearances often bear no relation to arthroscopic findings. The earliest site on the femoral head is usually anterior, matching the common site of degenerative change seen in the acetabulum. Initially, the cartilage loses its glisten and assumes a yellowish matte appearance (Figure 13.9A) before fissuring, fragmentation, and eburnation occurs. (Figure 13.9B.)

At an early stage, cartilage degeneration is localized but later become more widespread and severe, involving both sides of the joint. (Figure 13.9C.) Osteophytes may form at the peripheral margins of the head, particularly posteriorly. These may cause impingement and impede instrument access. If localized and associated with otherwise reasonably healthy articular cartilage, it is worthwhile removing osteophytes. Range of motion can sometimes be improved dramatically.



A B C

Figure 13.9. (A) Degenerative joint disease, early stages: The cartilage loses its glisten and has a yellowish appearance. (B) Degenerative joint disease, intermediate stage: Cartilage fibrillation. (C) Degenerative joint disease, late stage: Bony eburnation of the femoral head and adjacent acetabulum.

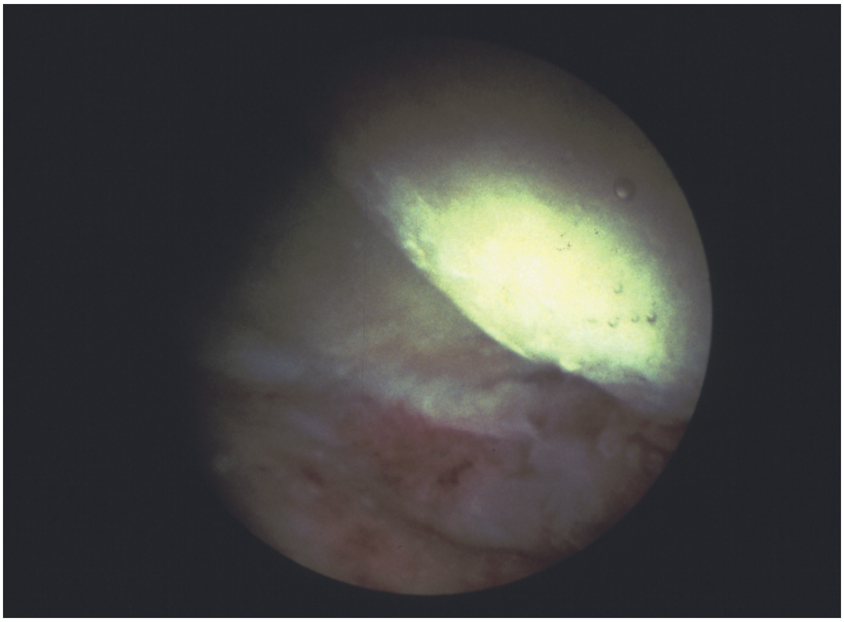


Figure 13.10. Chondrocalcinosis: Fluorescent sparkling deposits in the femoral head articular cartilage.

Arthroscopic surgery for generalized degenerative disease is unpredictable. In general, manual or powered debridement of unstable osteochondral flaps may be useful. As in the knee, an extensive washout is important. Consideration should also be given to a corticosteroid injection. It should be remembered, however, that it is possible to make a patient worse after hip arthroscopy for degenerative changes.

Inflammatory Arthropathy

Hip arthroscopy may be undertaken for inflammatory conditions such as rheumatoid arthritis, gout, psoriasis, and calcium phosphate arthropathy. The main findings are synovial hypertrophy and induration. Femoral head cartilage appearance is extremely variable, depending on the stage of the disease. In early stages, there is thinning, softening, and loss of the glisten, but surface continuity remains. Later, there is cartilage disruption and bony eburnation as in degenerative disease. Chondrocalcinosis has a characteristically striking appearance similar to that seen in the knee: sparkling fluorescent deposits are seen in the articular cartilage (Figure 3.10). Operative surgery is tailored to the extent of the disease, ranging from synovial biopsy to debridement and lavage.

Tumors

Tumors within the femoral head are very uncommon. Osteoid osteoma and chondroblastoma are known to be characteristically associated with this site, though are most unlikely to be seen at arthroscopy. Arthroscopy may be helpful in diagnosis, however, if for no other reason than exclusion.

Avascular Necrosis

The etiology and pathogenesis of avascular necrosis (AVN) are still largely unknown. The common final pathway is thought to be vascular insufficiency of the subchondral bone by extra- or intravascular obstruction, resulting in necrosis, collapse, and subsequent deformity. The overlying articular cartilage loses support and becomes damaged and degenerates. (Figure 13.11.)

The arthroscopic appearance of avascular necrosis is variable. The spectrum is from complete normality, to cartilage softening with loss of support, to fragmentation and osteochondral flaps or loose bodies (similar to Figure 13.1).

Figure 13.11. Avascular necrosis of the femoral head: Overlying thinning and loss of articular cartilage.

The role of arthroscopy in the management of AVN is controversial.[8,9] There are several reports of femoral head collapse shortly after hip arthroscopy, including several in our series.[2,8] It is unclear if it is the natural history of the condition, the fluid pressure, or the distraction that is responsible.

The authors use arthroscopy primarily to establish whether or not any articular cartilage collapse is evident. Articular collapse in its early stages is not always seen by magnetic resonance scan. If present, it is believed that the chances of revascularization being effective are reduced. Unstable chondral or osteochondral flaps and loose bodies may be amenable to arthroscopic surgery, as described for degenerative joint disease. Transient osteoporosis of the femoral head is uncommon and possibly related to avascular necrosis. We have no experience of arthroscopy in such a case.

Fractures

Femoral head fractures are uncommon, though frequently associated with high-energy trauma and dislocation of the hip. The Pipkin classification[10] may be used:

Type I: Small head fragment not attached to ligamentum teres.
Type II: Large head fragment attached to ligamentum teres.
Type III: Type I and II with femoral neck fracture.
Type IV: Type I, II, or III associated with an acetabular fracture.

Following hip reduction, an assessment of fracture reduction may be made arthroscopically, and occasionally loose bodies that may be present can be removed. (Figure 13.12.) Arthroscopy of the freshly fractured or dislocated hip, however, is not always as easy as the operator might like. Bleeding and serous exudate, combined with bony fragmentation, can make disorientation a real problem. Such fractures or dislocations often lead to early femoral head degeneration and resultant symptoms, particularly in young people. In such cases arthroscopy is helpful in diagnosis, assessment, and management as described earlier.

Ligamentum Teres

The full function of the ligamentum teres is unknown, though several theories do exist. It is generally agreed that its contribution to the blood supply of the femoral head in the adult is small. It is perhaps related to hip stability. Three types of ligamentum teres lesions have been described:[11]

Type 1: A complete rupture after trauma of surgical distraction (Figure 13.13A).
Type 2: Partial rupture (Figure 13.13B).
Type 3: Degenerated and frayed (Figure 13.13C).

Type 1 lesions are unusual and often associated with high-energy trauma to the joint. There is often a clear symptom start date, with groin pain and stiffness. Loose bodies arising from the acetabular wall, or fossa fractures, are common. Type 2 lesions tend to present with a longer history of symptoms and are often diagnosed only at arthroscopy.

The degenerative Type 3 lesion is the most common and is often associated with clearly degenerative changes on the perifoveal and anterior regions of the head. Sixty percent have a clear history of previous significant joint pathology such as Legg-Calvé-Perthes disease.[11] It is possible that a dysfunctional ligamentum teres plays an important early etiological role in the onset of degenerative joint disease. A lack of stability, similar to anterior cruciate ligament deficiency in the knee, may result in articular cartilage injury and accelerated degeneration.

Management at present is directed at removing loose flaps or frayed parts, which may cause impingement, using a power cutter.

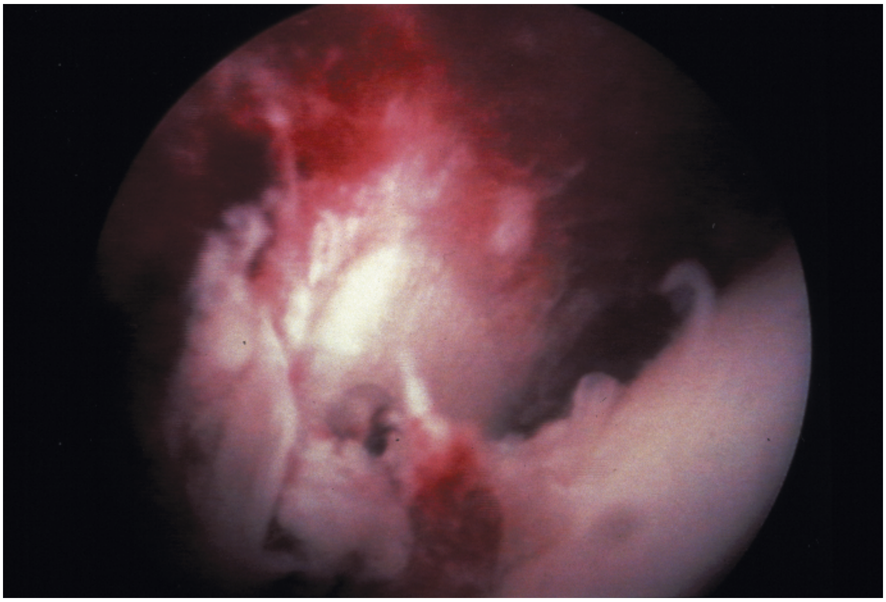


FIGURE 13.12. Fracture: Acute fracture showing hemorrhage, fibrinous adhesions, and loose debris. The difficulties of arthroscopy are clearly obvious.

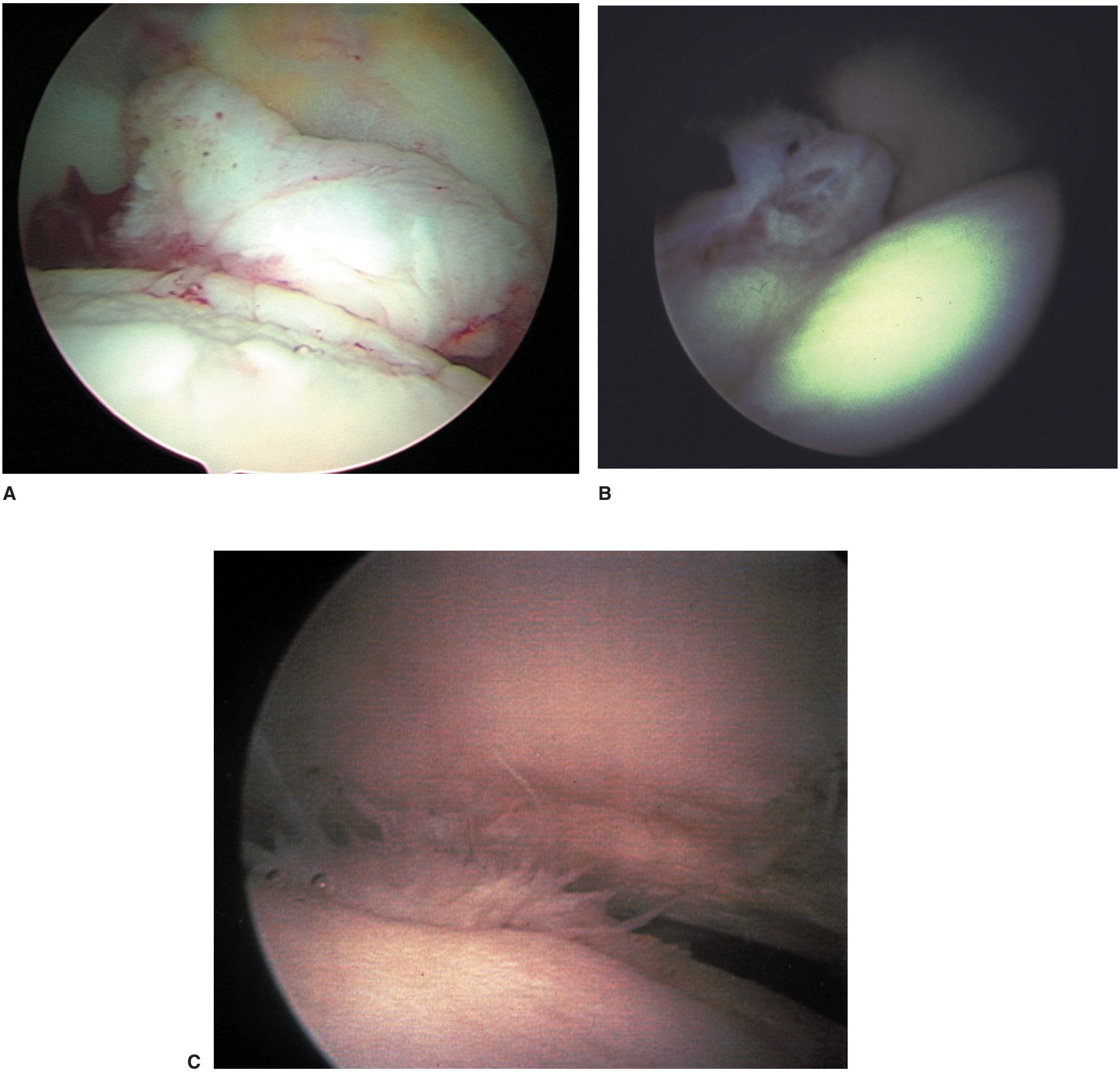


FIGURE 13.13. (A) Ligamentum teres, Type 1: A complete, acute rupture. (B) Ligamentum teres, Type 2: Partial rupture. (C) Ligamentum teres, Type 3: Degenerated and frayed appearance.

Arthrofibrosis

Arthrofibrosis is an uncommon finding characterized by numerous adhesions within the joint. It may occur spontaneously or following sepsis or trauma. The hip is usually stiff and difficult to access arthroscopically. Adhesions extend throughout the joint from head to acetabulum and capsule, obliterating the joint space. Chondromalacia or chondrolysis of the femoral head cartilage may be found. Treatment consists of removal of adhesions with both manual and power instruments.

Assessment of Femoral Head Deformity

Legg-Calvé-Perthes disease, developmental dysplasia, and degenerative disease may be suitable for femoral realignment osteotomies. In such cases, hip arthroscopy is useful for assessing intra-articular surfaces and congruence. Operative surgery may also be undertaken if degenerative changes are identified. In particular, loose bodies are frequently seen in association with Legg-Calvé-Perthes disease.

Results of Arthroscopic Management of Femoral Head Pathology

Chondromalacia

There is no specific treatment following the arthroscopic diagnosis of chondromalacia. However, a substantial number of patients improve following arthroscopy.

Chondral/Osteochondral Defects

Many localized lesions that are amenable to debridement or drilling may have an extremely good outcome and resolution of mechanical symptoms. In others, however, the progression toward generalized osteoarthritis continues.

Degenerative Joint Disease

The outcome of arthroscopic debridement is very variable. As in the knee, patients who are less advanced radiograpically have a better outcome. Sixty percent of unselected patients have symptom relief for at least 6 months. In selected patients (i.e. patients less than 50 years old with a good range of movement), however, more than 70% may gain significant benefit for up to 2 years.[2] Patients should be warned, however, that slightly less than 5% of individuals can be made worse following hip arthroscopy. In the advanced cases, temporary relief may be obtained by corticosteroid injection.

Ligamentum Teres

Impingement secondary to a torn ligamentum teres may be resolved by resection and often does well. In our series, results of surgery to the ligamentum teres alone have been promising, particularly for type 2 lesions. Associated disease is common and often requires operative attention. In such cases the outcome depends on the extent of the associated pathology.

Inflammatory conditions such as chondrocalcinosis may feel worse shortly after the procedure, but recover to benefit in the longer term. Arthroscopy for avascular necrosis, fractures, chondrolysis, arthrofibrosis, and deformity is largely diagnostic or for assessment. Results following any additional treatment are extremely variable.

Future

Future developments in the arthroscopic management of femoral head pathology are likely to involve resurfacing, revascularization, and perhaps ligament reconstruction. Resurfacing by chondrocyte grafting or osteochondral autograft transfer are exciting new developments being applied to other joints. It is probable that with instrument improvements similar procedures will be indicated and tried in the hip. One technique for treating avascular necrosis is to autograft the necrotic area, following open hip dislocation to gain access. Hip arthroscopy may have a role in minimizing the trauma of the procedure by endoscopic debridement and graft delivery.

The precise role of the ligamentum teres is unknown. In due course, it may become apparent that it has an important function in hip stability. If so, reconstruction in a similar manner to the anterior cruciate ligament in the knee may be deemed useful and may be attempted. Hip arthroscopy would be helpful in such a scenario.

Conclusions

Although hip arthroscopy is technically demanding, it is increasingly being practiced. As surgeons successfully master the ability to navigate the hip joint arthroscopically, conditions will be diagnosed at an earlier stage, and attempts at arthroscopic management will be made. This chapter has highlighted how numerous conditions affect the femoral head, but also how many are not diagnosed until arthroscopy. Since many of these conditions are found in young people, minimally invasive, joint-preserving techniques are essential for treatment. Although at present operative interventions are limited and results are extremely variable, as surgical skills and instrumentation improve, combined with earlier referral of suitable patients, results will also undoubtedly improve. Controlled studies, if practical, are desirable to counter the occasional criticism (usually by those without experience of the technique) that hip arthroscopy is a procedure looking for an indication. Nothing could be further from the truth.

The future for arthroscopic femoral head surgery, as for the joint as a whole, is exciting.

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14
Synovial and Intra-Articular Pathology

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The hip joint, a diarthrodial or synovial joint, under normal conditions can function under very high loads and stresses for seven to eight decades. The thick, fibrous joint capsule encloses the metabolically active synovial connective tissue in an environment that nourishes and protects the articular cartilage. A highly permeable vascular capillary system invests the synovium and functions to produce synovial fluid, a plasma ultrafiltrate that sustains and lubricates the avascular cartilage. The synovium is also immunologically active and harbors cells capable of phagocytosis for removal of cell degradation products from the joint and joint fluid. The synovium plays a critical role in maintaining the balance between physiological processes and pathological changes, and its proper function is essential for long-term joint durability. When aging or a pathological condition alters the function of the synovial lining, biochemical or biomechanical breakdown of the articular cartilage may occur and result in eventual progressive degeneration. Unfortunately, our knowledge of the early pathologic changes in the hip joint that preclude degeneration and arthritis have not been historically well defined or studied. In comparison to other, more accessible joints, a diagnosis of hip joint synovitis or early degeneration is more difficult because the clinical signs and symptoms are protean and nonspecific, and there are no pathognomonic radiological signs. The majority of patients with synovitis or early degeneration of the hip are not evaluated or diagnosed until the process affecting the joint is well established. Once bony changes within the hip joint have occurred, the process of joint degeneration becomes progressive and, unfortunately, in most cases irreversible.

Although trauma and repetitive impact loading account for a significant percentage of patients with early degenerative hip disease, synovial and intra-articular pathology may prove more contributory as our understanding of these processes evolves. The hallmark of early joint degeneration secondary to synovial pathology is juvenile rheumatoid arthritis. Synovitis in the immature articulation not only causes joint destruction, but also results in hypertrophy of the growth plates, bone hypertrophy, leg length discrepancy, and angular deformities. Identification and treatment of synovial disorders affecting the hip joint, systemic or local, with or without underlying bony architectural abnormalities, may in the future help curtail early hip joint degeneration. Hip arthroscopy provides us with the minimally invasive technique needed to diagnose, investigate, and treat synovial disorders of the hip at an early stage.

In the hip joint, synovial involvement in the degenerative process has been geographically described as focal or diffuse. Focal synovitis emanates from the covering of the ligamentum teres, and results in the inflammatory pulvinar located in the acetabular fossa. The diffuse pattern involves the entire synovial lining of the capsule in addition to the pulvinar. Studies have shown that changes in the synovium are a very early and integral part of osteoarthritis. Light and electron microscopic studies have revealed two distinct types of osteoarthritic synovitis: an early, proliferative form and a late fibrous form.[1] The essential feature of the proliferative synovitis is venous stasis with increased capillary permeability. A progression from proliferative to fibrous synovitis is the result of longstanding chronic venous insufficiency that results in synovial scarring and thickening.[2] Rheumatoid synovium shows similar vascular changes, but is also characterized by a severe inflammatory reaction that is moderate or absent in osteoarthritis.[2] In both situations the synovial scarring and thickening result in decreased range of motion and altered joint mechanics that may combine with the intra-articular inflammation to create an environment that destroys the articular surface.

Until the advent of reproducible and safe techniques for hip arthroscopy, access to the hip joint required an arthrotomy and its associated morbidity. Hip arthroscopy has provided minimally invasive access to the hip joint, the ability to inspect, biopsy, diagnose and, within the limits of our technology and knowledge, to treat early hip disease. When a patient presents with monoarticular inflammatory arthritis of the hip, synovial tissue biopsies provide tissue for histopathologic diagnosis, which may help guide specific therapy. Arthroscopically directed biopsy not only provides tissue, but also simultaneously provides additional information about the extent of synovitis and the state of the articular surfaces. Synovectomy may also complement the medical treatment of selected patients with rheumatoid arthritis and hemophilia.[5] Hip joint synovectomy in these systemically based disorders has been effective for pain relief and symptomatic control, but has only curtailed the relentless progression of the degenerative process. In localized conditions, such as pigmented villonodular synovitis and synovial chondromatosis, early synovectomy is the treatment of choice.[3–5] Although complete synovectomy cannot be performed with arthroscopic techniques, the perilabral tissue, inferior capsular tissue, and synovium overlying the ligamentum teres can be visualized and removed. Partial synovectomy or debulking often results in remarkable symptomatic improvement in patients with inflammatory conditions.[6–10] When a complete synovectomy is advocated, a semiarthroscopic technique has been described that may be advantageous over open synovectomy, which requires dislocation of the femoral head and increases the inherent risk of avascular necrosis in patients who are also frequently dependent on high-dose steroid medications.[4]

Intra-articular and synovial conditions have been a focus for those who advocate application of the arthroscope to the hip joint. Intervention has been reported in synovial chondromatosis/osteochondromatosis, pigmented villonodular synovitis (PVNS), inflammatory arthropathies including rheumatoid arthritis, and acute septic arthritis. Other conditions that result in acute and chronic synovitis within the hip, such as hemosiderotic synovitis secondary to hemophilia and chondrocalcinosis,[11] although not reported in the literature specifically for the hip joint, may in certain situations also benefit from arthroscopic intervention. The remainder of the chapter reviews the intra-articular and synovial conditions that have been diagnosed and treated with hip arthroscopy, provides visual documentation of the conditions, and reviews the current and future directions in the treatment of these disorders of the hip joint.

Synovial Chondromatosis / Osteochondromatosis

Synovial chondromatosis/osteochondromatosis is considered a benign disease that results in a monoarticular arthropathy. The hip is the third most common site of involvement, surpassed by the elbow and the knee.[12–15] Synovial chondromatosis was first described by Jaffe as intrasynovial cartilaginous metaplasia, a histologic diagnosis, which can result in formation of multiple intra- and extracapsular loose bodies.[15] Surgical findings reveal thickened synovium and loose bodies of varying size and composition adherent to the synovium or floating free within the joint. (Figure 14.1.) Two forms of the disease have been characterized, primary and secondary. The primary form is characterized by innumerable small, cartilaginous, loose "rice bodies," in contrast to the secondary form, which is characterized by larger coalesced masses of osteocartilaginous tissue. (Figure 14.2.) Laus and Capanna, in slight contrast, classify the process as simple synovial chondromatosis and progressive synovial chondromatosis, the former describing multiple intra-articular bodies and the later a locally aggressive, cartilaginous neoproliferation in and around the hip.[16] Milgram further subdivided synovial chondromatosis into 3 recognizable Stages. Stage I shows active intrasynovial disease with no intra-articular loose bodies; stage II reveals additional lesions with active intrasynovial metaplasia, proliferation, and free intra-articular loose bodies, and stage III exhibits multiple osteochondromal loose bodies

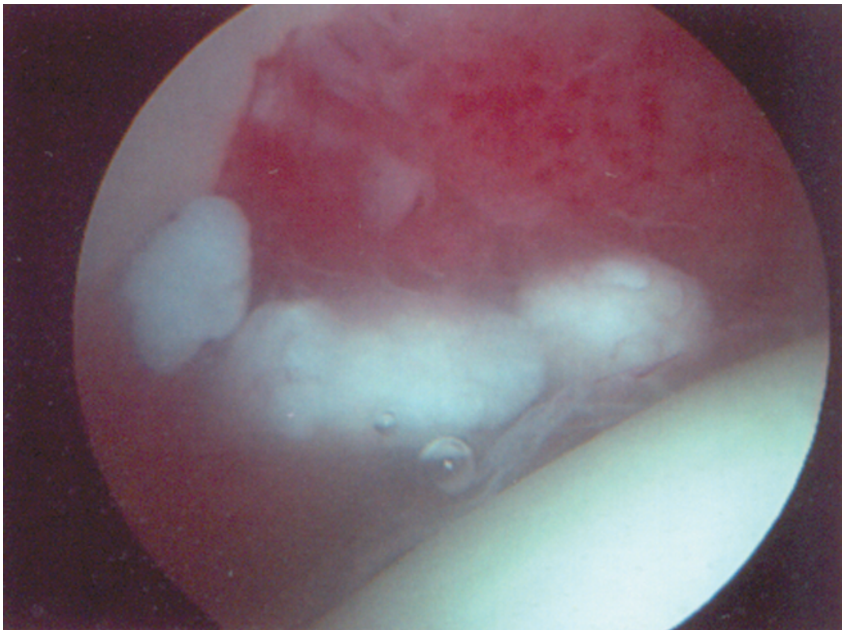
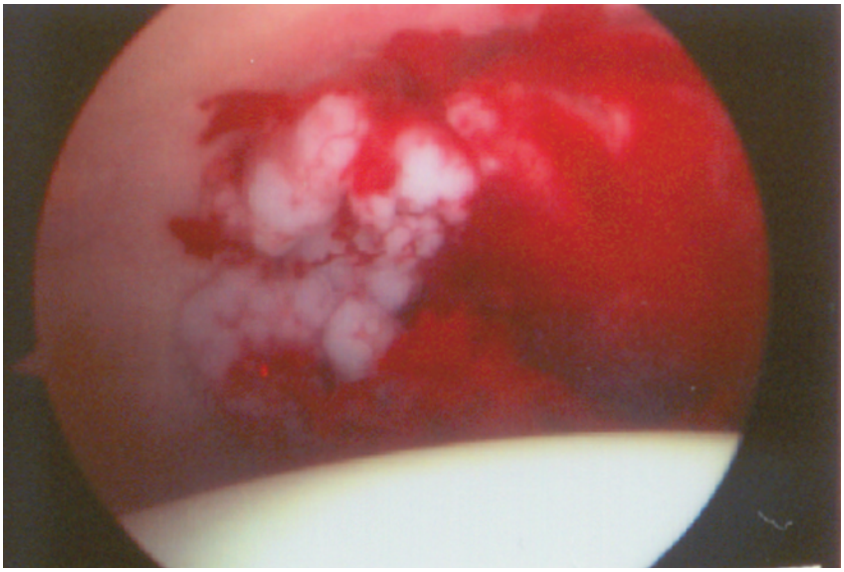


FIGURE 14.1. Loose bodies of varying size and composition adherent to the synovium.

FIGURE 14.2. Large coalesced bodies of osteocartilaginous tissue.



in the absence of intrasynovial disease.[17] The majority of reported cases involve intra-articular manifestations of the condition, although symptomatic extra-articular foci also have been described and treated surgically.[15–17]

When this condition involves the hip joint there are usually long delays in accurate diagnosis and initiation of treatment because of its insidious clinical presentation. Symptoms include the onset of dull aching pain, catching or locking sensations, and mild restriction of motion. Compounding the delay in diagnosis, plain roentgenograms demonstrate the presence of periarticular loose bodies in only 50% of the cases, because calcification within the loose bodies is not consistent.[13,18] Zwas et al described a case of hip joint synovial chondromatosis that initially presented with normal radiographs and a bone scan suggestive of a destructive, reactive articular process or late manifestation of femoral head avascular necrosis. Six-month follow-up radiographs showed radiolucencies and erosive bone changes in the joint.[19] McCarthy has reported an 80% false-negative rate for radiological investigations including plain radiography, bone scintigraphy, CT, plain MRI, and arthrography in evaluating intractable hip pain.[20] When diagnoses evident on plain films (eg loose bodies and advanced degenerative joint disease) were excluded, the accurate diagnosis of unremitting hip pain by radiographic modalities fell precipitously to 4%.

Noninvasive diagnostic yield may be increased with gadolinium-enhanced MRI.[20] (See Chapter 3.) Computed tomography (CT) or magnetic resonance (MR) arthrograms, when performed, will usually demonstrate multiple intra-articular filling defects, and are recommended in the evaluation of patients whose relatively normal initial studies fail to adequately explain the disabling hip symptoms. (Figure 14.3.)

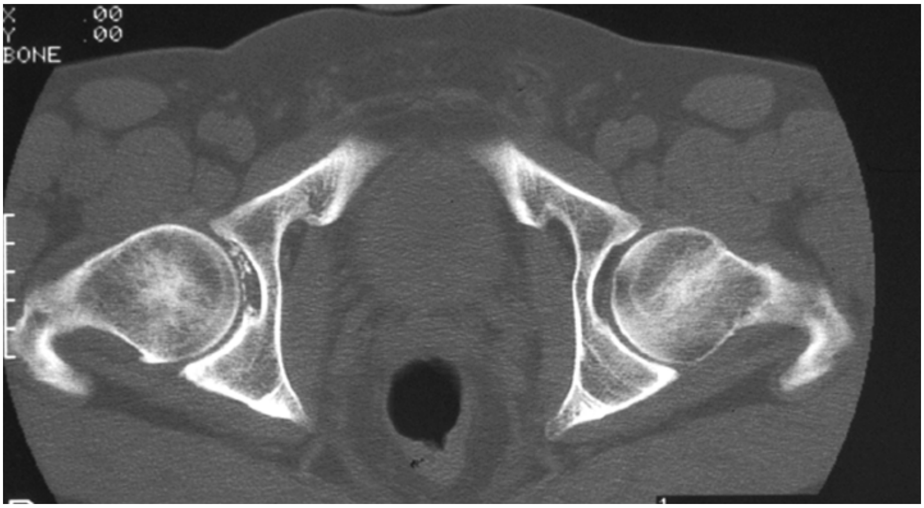


FIGURE 14.3. Loose bodies demonstrated on CT scan.

FIGURE 14.4. Loose bodies in advanced synovial chondromatosis demonstrated on plain radiographs.

Clinical history and examination therefore remain invaluable in directing the appropriate management of patients with synovial chondromatosis. Those who present with late disease can be diagnosed by plain radiographs, with findings that include lucencies and erosive, secondary juxta-articular bone erosions. (Figure 14.4.)

The loose bodies associated with synovial chondromatosis/osteochondromatosis, when small and cartilaginous, can be found in a joint with little articular destruction, while large ossified bodies may result in destructive pressure erosions of the femoral head and neck.[19] Although considered benign, synovial chondromatosis as described can be locally aggressive, and reports of sarcomatous change have been published.[16,21–24] Treatment of the condition is based on the premise that the loose and sessile bodies within the tight confines of the hip joint damage the articular cartilage and intra-articular structures. (Figure 14.5.) When proliferative, the disease may present with extensive bony pressure erosions, subluxation of the hip joint, secondary joint degeneration, intrapelvic mass formation, and pathologic fracture.[16,19,25–28]

Treatment modalities have traditionally focused on removal of loose bodies, lavage, and synovectomy. Laus and Capanna, based on their classification, concluded that simple synovial chondromatosis should be treated by partial or total synovectomy, while progressive synovial chondromatosis should be treated by total synovectomy with or without arthroplasty.[16] Radiation treatment has been attempted to halt the metaplastic process, but has proven ineffective and may also result in post-irradiation sarcomatous change.[21] Most orthopedic surgeons agree that operative treatment is indicated at an early stage in the disease when it is symptomatic and before irreversible degenerative changes have occurred. Surgical removal of loose bodies and synovectomy may relieve symptoms and prevent hip joint degeneration, the sequelae of which can be especially devastating in the younger patient population commonly affected by the condition.

Arthroscopic management of synovial chondromatosis in the knee and shoulder is well documented in the literature, and has essentially been extrapolated into similar treatment options for the hip.[14,29–36] Conflicting results in these reports have created controversies in management. Some advocate simple removal of loose bodies within the joint,[14,30,37] although others support complete or partial synovectomy to prevent recurrence.[13,15,38,39] Maurice et al reported effective treatment with removal of all loose bodies and partial synovectomy in areas of obvious synovial involvement. Their treatment is based on the theory that synovial metaplasia may be confined in focal regions; partial synovectomy in regions with abnormal appearance is therefore curative, and total synovectomy is unnecessary.[15] The classification proposed by Milgram would support management of patients with multiple intra-articular loose bodies and quiescent synovium (stage III) with simple removal of loose bodies; this, however, has not correlated well with prognosis or recurrence.[15,17] Recurrence rates for synovial chondromatosis following surgical management are reported to range between 7 and 23%.[15,30,31] Ogilvie-Harris, in patients with synovial chondromatosis of the knee, demonstrated a statistically lower recurrence rate in patients treated with arthroscopic synovectomy versus simple loose body removal.[31] Other authors have demonstrated essentially equivalent recurrence rates with removal of loose bodies alone.[30,15]

Open hip arthrotomy and synovectomy after dislocation of the femoral head remains the gold standard for definitive treatment of synovial chondromatosis at an advanced stage. Postel et al have reported on 23 cases of synovial chondromatosis treated with open arthrotomy. Eleven hips were left in situ, and 12 were dislocated. The results were better when the hip was dislocated, and the inflammatory pulvinar in the acetabular fossa was debrided; the recurrence rate and prevention of secondary arthrosis were also more favorable.[44] Gilbert et al have reported favorable results with arthrotomy in two patients with 5- to 7-year follow-up, and feel that synovectomy

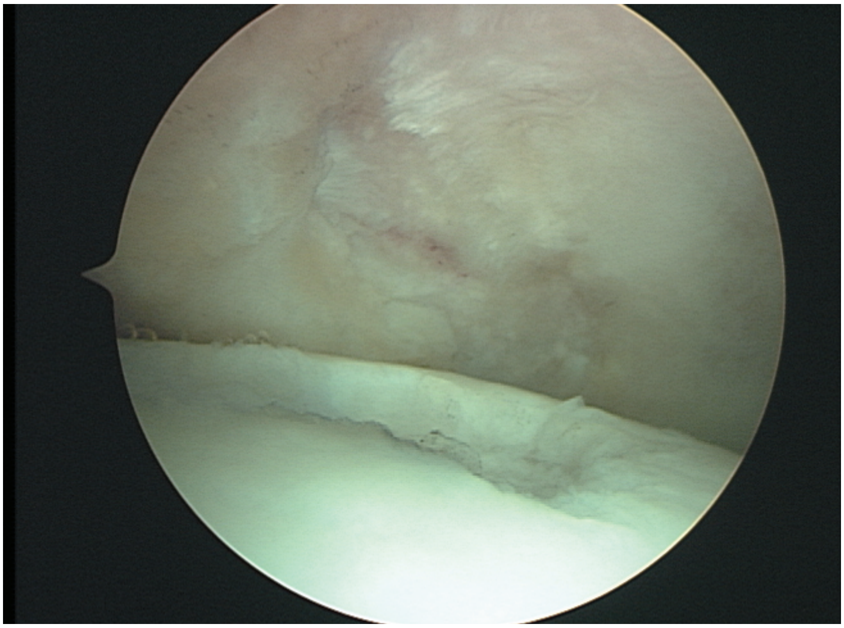


FIGURE 14.5. Late disease with erosive secondary juxta-articular bone erosions.

relieves pain and may prevent or delay the progression of degenerative changes.[41]

As mentioned, the role of hip arthroscopy in the treatment of synovial chondromatosis has been based on treatment of the process in the knee. Only sporatic reports of arthroscopic loose body removal from the hip have appeared in the literature in association with the diagnosis of synovial chondromatosis, and no single large series has been reported.[42–45] Witwity reported a case of arthroscopic removal of multiple loose bodies consistent with synovial chondromatosis.[45] Okada reported a similar case in which multiple intra-articular loose bodies were identified and removed with suction lavage during hip arthroscopy.[44] Mason et al have presented a series of 10 patients with histologically confirmed synovial chondromatosis of the hip managed initially by arthroscopy. One patient required open debridment for extracapsular disease, after arthroscopy revealed only one intra-articular loose body and numerous sessile intracapsular coalitions that could not be adequately resected. In the other 9 cases, partial synovectomy was performed. The majority of the loose bodies were non-ossified and adherent to the synovium or within the acetabular fovea and ligamenum teres. (Figure 14.6.) Chon-

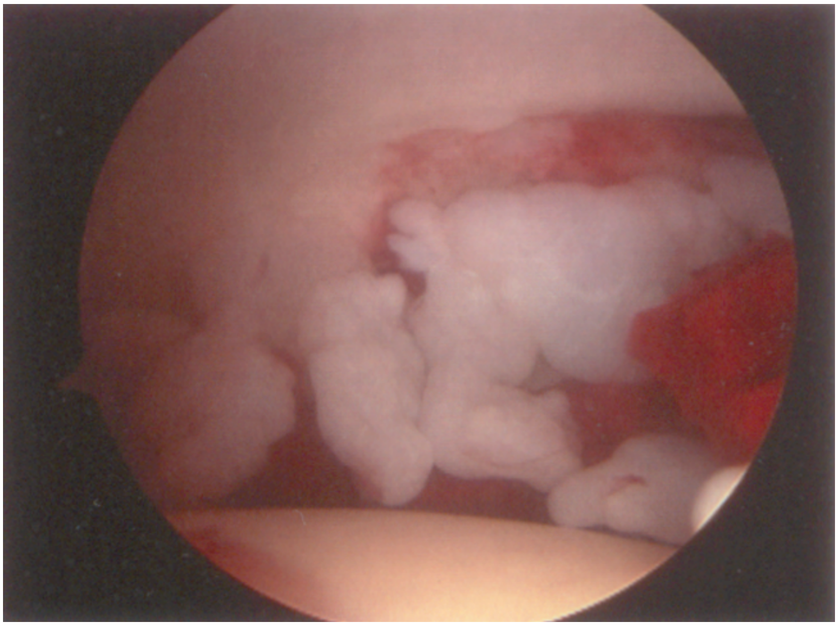


FIGURE 14.6. Loose bodies adherent to the synovium within the acetabular fovea.

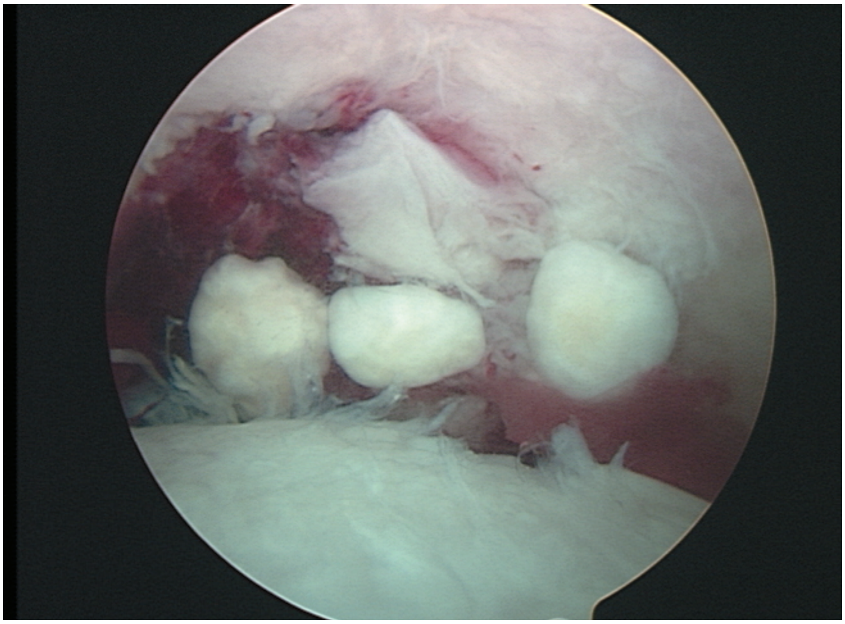


FIGURE 14.7. Chondromalacia of the femoral head secondary to loose bodies.

dromalacia of the femoral head or corresponding acetabulum was present in the majority of patients. (Figure 14.7.) Grade I changes were seen in two patients (20%), and grade II changes were seen in six patients (60%). No patient demonstrated grade III chondromalacia. Mild anterior labral fraying was seen in two patients. The patients have been followed for an average of 34 months, at which time interval seven were asymtomatic, two had occasional mild pain, and one patient had symptomatic and radiographic recurrence of the disease at 2 years.

Although there are no long-term studies comparing the results of open synovectomy versus arthroscopic removal of loose bodies and partial synovectomy for synovial chondromatosis of the hip, the experience of Mason et al favorably supports initial arthroscopic management of this condition.[46] Arthroscopy of the hip avoids the considerable surgical exposure and prolonged rehabilitation associated with open hip arthrotomy and synovectomy. The arthroscopic procedure also does not obscure or preclude future surgical procedures, including repeat arthroscopic intervention. Because the arthroscopic synovectomy is not complete, close clinical and radiologic follow-up is recommended for patients who undergo treatment by this method. If symptoms of recurrent disease occur and are secondary to intra-articular chondral or osteochondral loose bodies, repeat arthroscopy or formal open synovectomy can be selected for management. The surgical procedure chosen to treat recurrence should be individualized, taking into consideration information documented during the initial arthroscopy, the amount of visualization, percentage of synovium involved, arthritic changes, and also the time to recurrence.

Inflammatory Synovitis

Rheumatoid Arthritis

Rheumatoid arthritis is the most common inflammatory arthritis, affecting 1–2% of the population. Onset of the disease is typically in the fourth and fifth decades of life. With current medical management, overall prognosis has improved, but unfortunately after 10–12 years with the disease, more than 80% of patients have evidence of some joint deformity. Juvenile rheumatoid arthritis (JRA), although not as common, involves the hip in approximately one third of children and adolescents, leading to pain, deformity, and lifetime disability.[47] The hallmark of the disease in juvenile and adult patients is persistent immune system-mediated inflammatory synovitis of varying degrees. The resulting synovitis, when uncontrolled, can result in articular cartilage destruction, bony erosions, and subsequent deformities. In JRA, the growing proximal femur may become malformed secondary to the increased synovial blood flow associated with inflammation and synovitis, changing the mechanics of the joint and further increasing the likelihood of its early degeneration.[46]

The current mainstay of long-term treatment in rheumatoid arthritis is the use of anti-inflammatory medications, disease-modifying agents, and immunosuppresive medications. When acute symptomatic flares of synovitis occur, intra-articular corticosteroids may be used, and have shown some benefit.[46,47] If medical management is unable to curtail synovitis in the hip, progression to advanced degeneration is likely secondary to weightbearing during ambulation. Historically, orthopedic surgeons have become involved with management of rheumatoid hip problems after the degenerative process and joint deterioration have begun, rather than early in the course of synovitis and symptomatic management of the disease. Arthrotomy and synovectomy have been reported in select patient populations, but the procedure definitely has not become a routine part of the accepted treatment strategy. The painful, end-stage degenerative rheumatic hip has been effectively treated with arthroplasty, but in young patients this treatment has not been without the long-term consequences of loosening and the need for multiple revision procedures.[46–51]

Although somewhat controversial in the treatment of rheumatoid arthritis, synovectomy has been used to treat intra-articular inflammation since the early 1900s. The inferences supporting synovectomy stem from the theory that removal of the diseased synovial tissue removes the source of inflammation responsible for the degenerative process, and that healthy tissue regeneration will occur. Although clinical symptomatic improvement has been documented following the procedure, the "new" synovium has been shown to share pathologic characteristics with the original tissue.[52,53,54] The clinical improvement seen may in fact be related to the volume of synovial tissue regeneration, and the hiatus from active synovial inflammation and that which occurs during healing and reformation. Pain relief and symptomatic improvement following synovectomy in a variety of joints have been demonstrated by large, controlled multicenter studies, but unfortunately improved functional range of motion or decreased progression of joint deterioration has not been seen.[46,48–49,55] These large studies do not address the hip specifically, and include all synovial joints. When the results are separated to isolate the major weightbearing joints, the results of synovectomy have been better. This has been noted by Granberry and Brewer, who highlight the points that synovectomy is most effective early in the disease process before periostitis and erosions are evident, in monoarticular or pauciarticular forms, and when the sedimentation rate is not elevated.[50]

Another factor confounding the results of synovectomy in rheumatoid arthritis is the timing of the procedure in relationship to the amount of radiographic joint degeneration that has occurred. Most authors have refuted the utility of "late" synovectomy after radiographic evidence of joint degeneration is present,[54,56] and Heimkes et al have reported accelerated progression of the degenerative process in this situation.[56] In the case of "early" synovectomy, or treatment before radiographic change has occurred, the results in specific situations have been favorable.[9,47,54,57,58] It is in this early phase of the disease, when medical management has been ineffective, that synovectomy may contribute to the overall symptomatic treatment strategy, in concordance with medical management, rather than being perceived as interference.[58] Synovectomy may offer short-term symptomatic relief and delay the need for a more extensive total joint arthroplasty, a delay that may be very important in a young patient with the disease. The systemic nature of rheumatoid arthritis must always be kept in mind, and any surgical procedure short of arthroplasty is symptomatic treatment aimed at safely providing pain relief and maintaining mobility, not at curing the disease. There is no evidence to suggest that synovectomy retards the bony destruction or the disease process.[52,55,59,60]

The majority of published work concerning arthroscopic synovectomy in rheumatoid arthritis involves the more peripheral and superficial joints. In the lower extremity, the knee has been the focus of most studies.[5,61,62] In the knee, arthroscopic synovectomy has been shown to be comparable to synovectomy by arthrotomy in short-term reduction of pain and swelling with reduced morbidity, hospital stay, and postoperative rehabilitation. In the absence of advanced grade 3 to 4 chondral damage, improved joint function during daily activities was demonstrated.[61] Cleland et al, in a small prospective study, demonstrated symptomatic improvement in pain with ambulation and reduced knee swelling maintained at 24 months, and patients universally regarded the procedure as worthwhile.[62]

The hip joint, because of its anatomic location and in accessibility, has not commonly been treated with synovectomy, and very little published information exists to support or refute the arthroscopic procedure in this location. The few reports that exist include only small numbers of patients, and focus on the JRA population. Open synovectomy of the hip in rheumatoid arthritis has been reported, usually as part of a larger series including multiple joints, and the results have been difficult to interpret. Albright et al, in a series of nine hips (five patients with JRA) treated with subtotal and complete synovectomy, showed symptomatic improvement and preserved joint motion in four of five patients. They concluded that synovectomy of the hip may be useful for progressive hip involvement in younger patients whose skeletal immaturity contraindicates major reconstructive procedures.[63] Holgersson et al, also in a pediatric population with JRA, showed that arthroscopic intervention may be of benefit early in the disease process when evidence of joint destruction is minimal. In this series, arthroscopy provided better information about the cartilage than did roentgenograms, allowed debulking of the synovial membrane, and provided useful information that assisted in guiding future treatment.[9]

Arthroscopic synovectomy of the hip joint is definitely not being promoted as curative in the rheumatoid patient with active or chronic synovitis, but more as an adjunct in the management of selected patients with early affliction in the hip.

Synovectomy may be useful in the minimally erosive stages of the disease when the active synovitis is not suppressed by conservative modalities.[47] The diagnostic and theraputic role of hip arthroscopy, if utilized, should come early in the disease process, prior to radiographic change. In the acutely symptomatic hip, the disparity between arthroscopic and radiographic degeneration has been shown in the rheumatic by

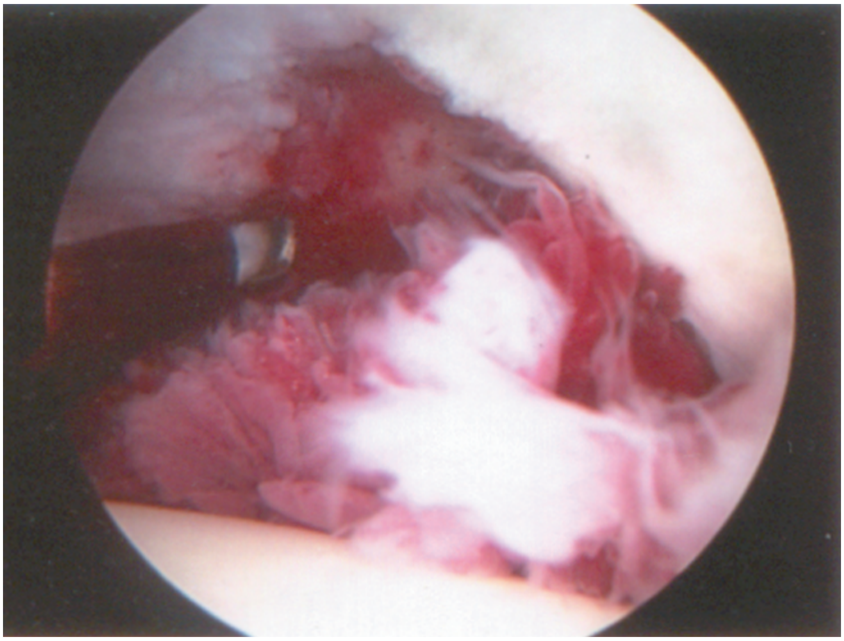


FIGURE 14.8. Thick and redundant synovium impinging at the articular–synovial junction.

Holgersson, and in the early osteoarthritic by Santori and Villar.[9,64] Symptoms in the hip out of proportion to radiographic findings can be due to varying degrees of florid synovitis and advanced articular surface damage, despite evidence of joint space preservation.[64] In this disease process, the extent of articular destruction forecasts the success for intervention, as manifested by the poor results with "late" synovectomy. In an acutely symptomatic patient with minimal radiographic degeneration of the hip joint, advanced chondral change and degeneration may still be encountered arthrocopically during the "early" synovectomy. In this situation the arthroscopic debridment and synovectomy may provide symptomatic relief, but more importantly it provides visual assessment of the articular surfaces and an accurate diagnosis. Not only can the intractable symptoms be explained, but future treatment may properly be influenced and planned. Hip arthroscopy has few reported complications, does not complicate future reconstructive efforts, and may effect, in a timely manner, the decision to provide definitive treatment via total joint arthroplasty. In the rheumatoid patient, appropriate timing for a reconstructive hip procedure may decrease the stress and prolong the function of other lower extremity joints that are secondarily affected by a proximal contracture and compensatory gait.

Rheumatoid Synovial Impingement

Chronic synovial thickening can also occur in the hips of patients with rheumatoid arthritis and other conditions that cause chronic synovial inflammation. In a "burned out" stage of any inflammatory disease, the synovium can become thick and redundant. This excess scar tissue can impinge at the articular–synovial junction in the hip joint, resulting in mechanical symptoms and severe groin pain with weightbearing and/or rotation. (Figure 14.8.) When clinically reproducible symptoms persist despite conservative measures, arthroscopic resection of the involved synovium may relieve the mechanical irritation as well as provide direct visualization of the joint surface.

Calcium Pyrophosphate Deposition Disease (CPPD) / Chondrocalcinosis

Calcium pyrophosphate deposition disease is the crystalline arthropathy most likely to affect the hip joint.[65] The cause of the disease is unknown, but pathologically it results from increased calcium or inorganic phosphate concentrations in hyaline or fibrocartilage that precipitate to form crystals. Chondrocalcinosis is the descriptive term used to denote the presence of calcium pyrophosphate crystals in cartilage, and although it occurs in the hip it is radiographically difficult to distinguish. (Figure 14.9.) The deposition and shedding of crystals lead to the clinical syndrome of calcium pyrophosphate deposition disease (CPPD), which can result in acute and chronic synovitis. It has been postulated that chronic synovitis secondary to CPPD plays a role in the initiation of hip joint degeneration and osteoarthritis.[66] Menkes et al studied the frequency and significance of articular chondrocalcinosis in hip osteoarthritis. Its presence at the time of arthroplasty was found to be significantly higher in patients with rapidly destructive hip degeneration versus patients with common osteoarthritis.[11] This rapidly destructive process has also been termed a pseudorheumatoid form of CPPD,[67] and reportedly affects about 5% of patients with CPPD. This form of the disease can progress from acute to chronic synovitis, with resulting rapid and diffuse hip joint destruction. This process

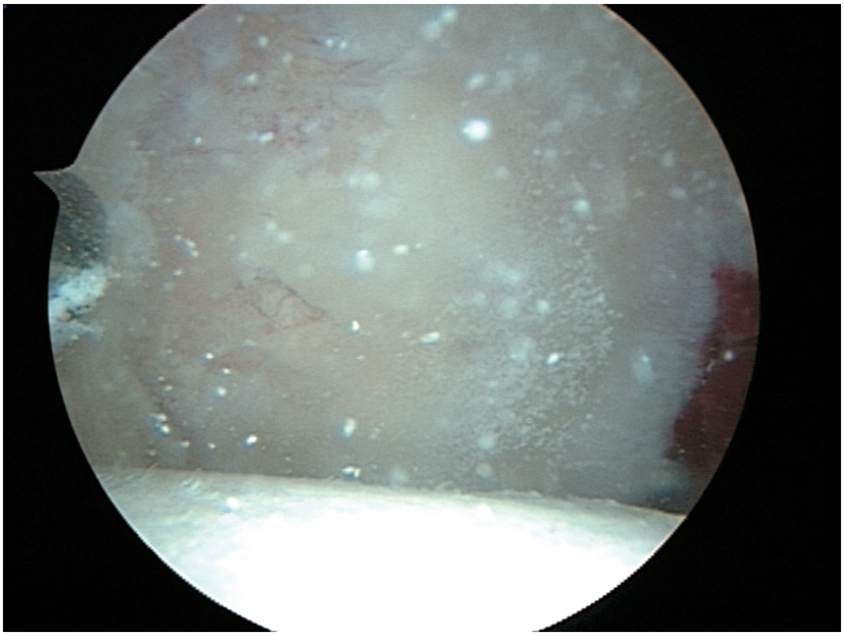


FIGURE 14.9. Joint crystals seen in a patient with chondrocalcinosis.

can be identified on serial plain radiographs by rapid axial narrowing and development of acetabular protrusio.

The role of hip arthroscopy in this condition is currently diagnostic, as CPPD has been encountered when patients present with acute, severe hip pain and aspiration results suggestive of infection. It has also been found in patients with long-standing, unremitting hip pain that has eluded diagnosis. It is unknown whether lavage, synovectomy, and debulking of the crystal-laden tissue will prevent or curtail articular cartilage degeneration. In patients with the pseudorheumatoid or rapidly destructive form of the disease, minimally invasive synovial debulking and lavage at an early stage may prove beneficial in slowing the rapid decimation of the hip joint.

Pigmented Villonodular Synovitis

Pigmented villonodular synovitis (PVNS) is a nonneoplastic proliferative disorder that can affect any synovial-lined structure, including bursae, tendons, and joints. PVNS is most commonly reported in the knee, but also occurs in the hip joint. The process occurs most frequently in the third or fourth decades of life, with no sex predilection,[68] and should be considered in the differential diagnosis for all young patients presenting with uncharacteristic clinical and/or radiographic features suggestive of early hip degeneration.[69] In the hip, PVNS most commonly presents in a monoarticular distribution, but bilateral hip involvement has been reported.[70] The etiology and pathogenesis remain obscure and undefined; the most widely accepted theories attribute this disorder to a chronic inflammatory response or a benign but locally aggressive condition of fibrohistiocytic origin.[68,71] At the cellular level, PVNS is characterized by hypervascular proliferative synovium, which is hemosiderin-laden and contains multinucleate giant cells and macrophages. These cellular immune mediators express local inflammatory cytokines, which play an important role in the stimulation of osteoclastic bone resorption, resulting in the destruction of articular cartilage and erosion of periarticular bone which characterizes PVNS.[72] These alterations in the basic synovial tissue function ultimately result in symptomatic joint dysfunction and degeneration if not diagnosed and treated.

PVNS has been described in a number of forms, which include localized (focal), diffuse, and extra-articular. The process typically begins in and usually remains confined to the joint capsule.[70] The localized or focal form involves a distinct section of the synovium, which is often described as nodular.[73] The diffuse form involves the entire synovium,[74] and the extra-articular form has been reported in isolation and in conjunction with diffuse intra-articular involvement.[70,75] These different forms may explain the variable presentation of the disease, and may also carry different prognoses, recurrence rates, and treatment options. The localized or focal form of PVNS seems to carry a better prognosis and have a lower recurrence.[70] This favorable outcome may be related to early diagnosis and treatment. The diffuse form, in contrast, has a poor prognosis, with high recurrence rates and locally aggressive progression.[76,71] The diffuse form unfortunately may be more common,[74] and may present with or progress to extra-articular extension and end-stage joint destruction. The extra-articular form may be an extension from a defect in the hip capsule, presenting as groin swelling or a soft tissue mass. Cotten et al have reported the extra-articular form in 6 of 58 patients treated with an open technique.[70] Extra-articular extension of hip joint PVNS has also been reported as a cause of secondary symptomatic compression neuropathy of the femoral and sciatic nerves.[75] There is no published histopathologic differentiation to suggest a difference between the localized and diffuse forms of the process, and the contrast may simply relate to the timing of the initial investigation and diagnosis. Focal or localized PVNS may be the early stages of the process, and diffuse and extra-articular forms may be the result of longstanding, progressive joint involvement that has been undiagnosed.

Patients with PVNS in the hip joint may present initially with a broad spectrum of slowly progressive symptoms including mild discomfort, stiffness, and limitation of motion. The physical examination may be only slightly altered or completely normal in these early stages. When the early stages have been treated expectantly for a long period of time as a muscle strain or early osteoarthritis, extensive hip joint and periarticular bone destruction may be seen upon initial presentation to the orthopedic surgeon. Progression of the disease to a more advanced state results in symptoms of persistent discomfort and mechanical impingement at the extremes of motion. The inconsistent nature of the presentation in the hip often leads to significant delays in diagnosis, and in one survey the mean delay to diagnosis was 4 years.[77] A high clinical suspicion is therefore required in the evaluation of this condition, and can be aided by specific findings on plain radiographs, as outlined in Chapter 3. Bony erosions and loss of the joint space on plain radiographs tend to be gradual and occur late in the disease process.[68,78] Therefore, MRI should be considered early in young patients with unexplained unremitting hip pain that does not respond to or improve with conservative treatment.[68,70,78,79] Magnetic resonance imaging usually demonstrates key diagnostic features, which include joint effusion, elevation of the joint capsule, hyperplastic synovium, and low signal intensity resulting from hemosiderin deposition in the synovium.[80] Although very supportive, these MRI findings are not diagnostic. The final diagnosis of PVNS is pathologic and requires a tissue biopsy for histopathologic evaluation and confirmation. MRI findings can be very beneficial in mapping the extent and form of the process, and for directing biopsy and early conservative and surgical intervention.

The role of hip arthroscopy can be both diagnostic and therapeutic, and its minimally invasive nature has made its use more appealing than arthrotomy. As in other uncommon synovial disorders, arthroscopic evaluation and treatment of hip PVNS has been extrapolated from the more common treatment of the disease in the knee joint. In the knee joint, numerous orthopedic surgeons have reported favorable short- to mid-term results following synovectomy by open, arthroscopic, and/or synoviothresis, alone or in combination therapy.[73,74,76,81] Most authors agree that treatment is most successful, measured by favorable joint function and lack of recurrence, when PVNS is treated before joint degeneration is visible on radiographs. In some reports, even late or recurrent disease responded favorably to arthroscopic synovectomy and resulted in a short-term funtional improvement.[77] Another consensus is that, when faced with recurrence, arthroscopy, combined with or converted to an open procedure, could curtail rapid progression. In advanced knee disease, or after multiple recurrences, complete synovectomy and total joint arthroplasty have been indicated, and have not been adversely affected by the previous procedures. Arthroscopic synovectomy is the procedure of choice for the initial treatment of PVNS in the knee joint, and although the results of large series are not reported for the hip joint, the procedure should also positively affect the progression of the process in this location.

In the hip, arthroscopy should be considered early in young adults with hip pain of unknown origin and with radiographic findings to suggest PVNS. The treatment options for hip joint PVNS depend completely on the timing of the diagnosis and the nature of synovial involvement. Early diagnosis is critical so steps can be taken to prevent progression to advanced hip joint degeneration.[69] The delay between the onset of symptoms and the histopathologic confirmation of this condition generally accounts for the massive local bone invasion.[78] Only early diagnosis permits conservative surgical treatment (i.e. total synovectomy). Although the reported results of synovectomy are not stellar, 65% success in a multicenter series after 3-year mean follow-up,[77] the alternative treatments in this population are also a potential long-term problem. If the the disease is diagnosed late, destructive lesions may be too extensive, and arthrodesis or total hip arthroplasty may be indicated for pain management and mobility.[82]

Hip arthroscopy can provide tissue for pathologic identification and also visualization of the focal or diffuse nature of the process, the status of the articular cartilage, and offers the ability to perform a partial synovectomy.[3] (Figure 14.10). In the young patient population affected, this minimally invasive technique is more acceptable than formal arthrotomy, and is also more likely to be done at an early stage when the most benefit can be achieved. Earlier diagnosis through arthroscopy and subsequent chemical synoviothesis might reduce the need for more aggressive surgery and improve the prognosis.[78] The information collected during hip arthroscopy can direct an appropriate treatment plan based on visualization of the joint.[3] PVNS of the hip has been treated with open and arthroscopic synovectomy, chemical or radionuclear synoviothesis, and/or total hip arthroplasty.[83] Synovectomy is effective only when articular cartilage is preserved. Localized or focal disease in the hip has been successfully treated with both open and arthroscopic synovectomy. The diffuse form is more difficult to treat with any means, and has a high likelihood of recurrence when a complete synovectomy is not performed.[71] Complete hip joint synovectomy is difficult if not impossible to do using arthroscopic techniques, but at the time of initial biopsy can be attempted and then followed by chemical or radionuclear synoviothesis. If the diffuse form recurs, a combined arthroscopic and open technique can be used to perform the synovectomy without dislocation of the femoral head.[84] Diffuse PVNS, when recurrent, eventually results

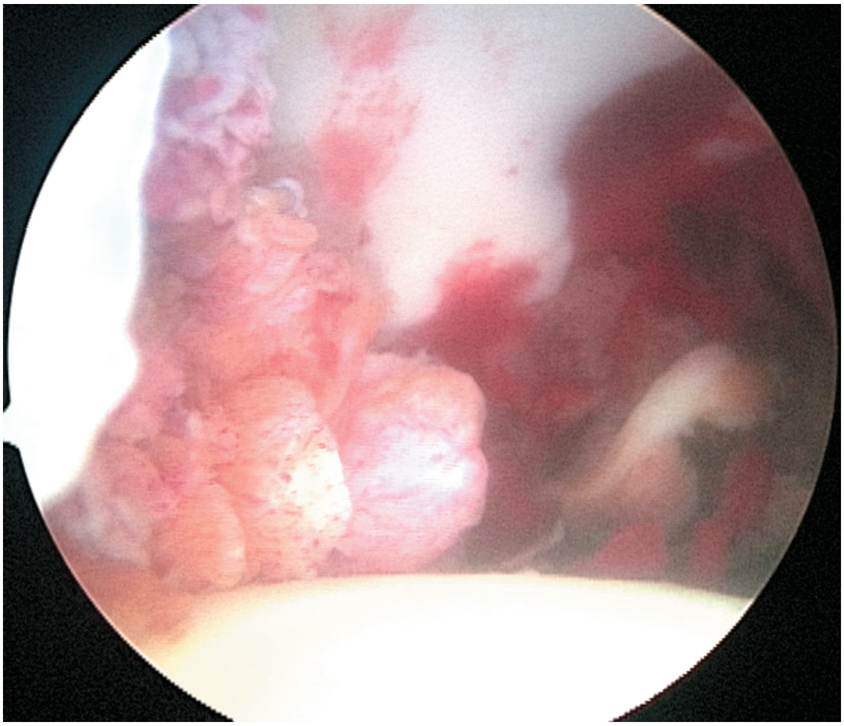


FIGURE 14.10. Synovium in a patient with PVNS.

in advanced joint degeneration, which is most predictably treated with total hip arthroplasty. Total hip arthroplasty, although of concern in such a young population, appears to be the procedure of choice for either advanced cases of PVNS or those that have failed joint-sparing procedures.[83]

Hemophilia and Hemosiderotic Synovitis

Hemosiderotic synovitis is a condition that results from chronic, repetitive intra-articular hemorrhage. Hemophilia is the bleeding disorder most commonly associated with intra-articular bleeding, but recurrent hemorrhage can also occur secondary to pigmented villonodular synovitis, synovial hemangioma, and repetitive trauma. The consequences of chronic hemarthrosis are direct damage to the articular cartilage and persistent hemosiderotic synovitis that leads to synovial hypertrophy and capsular thickening.[85] The changed hemosiderotic synovial tissue also produces catabolic cytokines and enzymes that further damage the articular cartilage.[86,87] As the synovium becomes increasingly scarred, there is gradual conversion from friable hyperemic tissue to fibrotic scar tissue.[88] The extensive fibrotic scarring in the periarticular tissues is responsible for the joint contractures so characteristically seen in hemophilia patients. In the limited confines of the hip, hypertrophic synovium may impinge during motion and weightbearing; this may not only cause painful mechanical symptoms and articular cartilage wear, but may induce recurrent bleeding. It is felt that direct damage to the chondral surface and chronic synovitis occur in parallel and set up a vicious cycle ultimately culminating in articular surface destruction and joint contracture similar to the process that occurs in osteoarthritis.[85]

Acute hemarthrosis is probably the most common type of bleeding in hemophilia patients, with 80% of the cases reported in the knees, elbows, and ankles.[88,89] Hemarthrosis affecting the hip joint occurs, but by report not as commonly as it does in the other, more peripheral joints. This can be explained by the hip joint's deep location, and the protection from mild to moderate trauma provided by the thick overlying muscular envelope. This protective anatomy may also make realization of bleeding into the hip joint less likely and more difficult to diagnose. Swelling around the hip and pelvic girdle are clinically difficult to detect, and if mild intracapsular bleeding has occurred or is occurring, it may be contained and clinically impossible to identify. It has been stated that the chronic synovitis reported in other joints is rarely a problem in the hip for patients with hemophilia.[90] In this patient population, which endures and functions with chronic pain, the symptoms in the hip region may be just better tolerated than the same process in a peripheral joint. Mild and intermittent hip symptoms therefore may be more significant in the hemophilia patient, and detailed examination and treatment in these situations may justified earlier. Delayed and/or inadequate treatment of unrecognized hemarthrosis and synovitis can trigger the pathologic changes within the joint that will eventually lead to a painful and disabling arthropathy.[89,91]

The mainstay for treatment of hemosiderotic synovitis, hemarthrosis, and arthropathy in the patient with hemophilia is conservative management with clotting factor replacement. Physical therapy,[92] intermittent steroid injections, immobilization, and activity restriction are also useful adjuvants to factor replacement after an acute bleed. Chemical and radioactive synovectomy have been shown to reduce bleeding in patients who have not responded to conservative therapy, but the procedure does not provide pain relief when mechanical symptoms or arthritic changes are present within a joint.[93] Radioactive synovectomy is indicated in patients with inhibitors to the clotting factor, patients with advanced human immunodeficiency virus or advanced hepatitis, and in those patients with multiple joint involvement.[94]

Orthopedic treatment regimes are dependent on the classification of the synovitis and the stage of the arthropathy. Synovitis can be classified into acute and chronic forms. When the synovitis has already become chronic, early arthroscopic synovectomy is recommended in the knee joint as an attempt to slow the otherwise inexorable progress of the arthropathy. Failure to treat in the early phase of the pathology causes problems in the correction of further stages.[95]

Orthopedic surgical management of the hip joint in patients with hemophilia has essentially been limited to total hip arthroplasty when painful and debilitating end-stage arthropathy is present. In reports with medium-term follow-up, the loosening rate for cemented prostheses has been high, and the complication and infection rate significant.[96,97] Some patients, however, become so disabled and confined by the severe hip joint destruction and pain, combined with increasingly frequent need for clotting factor replacement, that reconstructive surgery becomes the optimal treatment modality, despite the risk.

Synovectomy has been effectively used for the treatment of recurrent bleeds and early degenerative changes in other joints, but this has only been mentioned in the literature for the hip.[98] The reluctance regarding surgical intervention in the hip may be due to the presence of fibrosis or the potential morbidity of an open hip synovectomy in this population. Arthroscopy may offer a less invasive approach to the hip, but to date this procedure and its potential utility have not been investigated. Joint and periarticular contracture are relative contraindications to hip arthroscopy, and the procedure at this stage of the disease process would likely be of much benefit. Arthroscopic synovectomy of the hip in the hemophilia patient may be worthwhile in the early stages of recurrent hemarthrosis when synovial irritation, thickening, and fibrosis are acute. At this stage articular degeneration is minimal, and may be curtailed by debulking the synovium, reducing the volume of bleeding surface area, and decreasing the amount of scar forming within the hip joint capsule.

Synovectomy for hemophilic arthropathy is safe and efficacious in reducing recurrent haemarthroses and joint pain. Synovectomy should not be performed to improve joint mobility. The progression of the arthropathy is not arrested, and subsequently many patients will be candidates for arthroplasty or arthrodesis.

Arthroscopic synovectomy is the preferred procedure for the knee and ankle joints, although open synovectomy offers an excellent alternative. The greatest risk of these procedures is decreased range of motion, and this is most problematic in the young child who cannot cooperate with a program of physical therapy.[94]

Arthroscopic surgery, as a relatively low-risk technique, combined with early functional rehabilitation, can be used to achieve satisfactory results in patients with hemophilic arthropathy.[99]

In a study, nine knees in eight patients with severe hemophilia A, and 1 patient with hemophilia B who underwent arthroscopic synovectomy during the period of 1980–1985 were observed prospectively for 10–15-year follow-up. One complication occurred immediately postoperatively in an 8-year-old boy, in whom a severe hemarthrosis developed that required arthroscopic evacuation. His postoperative recovery was compromised, leading to significant loss of motion. Recurrent hemarthroses developed in only one patient after an injury to the knee. A second arthroscopic synovectomy was performed 45 months after the initial procedure. Other than the patient who lost motion after the postoperative complication, all patients initially regained or improved their range of motion. The latest follow-up, however, showed several patients losing motion, which correlated with clinical and radiographic evidence of progressive changes of the hemophilic arthropathy. The one patient with Factor IX deficiency required a total knee replacement 8 years after synovectomy. Arthroscopic synovectomy was effective in reducing recurrent hemarthrosis and maintaining range of motion; however, joint deterioration continued to occur, though probably at a slower rate.[100,101]

Both techniques reduce hemarthrosis. Synovectomy may be a useful adjunct to treatment in carefully selected patients with rheumatoid arthritis and hemophilia.[102] There is usually a net loss of range of motion with the open versus a net gain with the arthroscopic procedure, and roentgenographic progression of hemophilic arthropathy is slowed but not halted after synovectomy.[103]

Infection / Septic Arthritis

Hip joint infection and septic arthritis, although most common in growing children, is becoming more prevalent in the adult population due to the growing number of elderly, disabled, and immunosuppressed patients, and those with chronic systemic illnesses. The ramifications of sepsis in this major weightbearing joint can result in lifelong disability for a child, and can be responsible for the loss of independence and/or demise of an adult if not recognized and treated early. Evrard has reported a 13% incidence of mortality from hip joint infection in the adult.[104] This seemingly high mortality rate in adults may be secondary to concurrent medical issues or underlying hip disease that make diagnosis difficult and often impede appropriate, early aggressive surgical treatment. Although the rate of pediatric hip infections is not likely to increase, society's growing elderly, debilitated, and immunosuppressed population will likely necessitate an increased awareness of hip joint sepsis and may change our "classical" accepted treatment methods.

The underlying cause of "virgin" hip joint sepsis is not straightforward, and cannot simply be attributed to the common daily occurrence of transient bacteremia. A multifactorial etiology combining a susceptible joint, a vulnerable patient, transient bacteremia, systemic infection, and/or local inoculation is most likely. Understanding joint sepsis requires defining the attributes of the "susceptible" joint and the mechanisms of joint infection. The common occurrence of hip sepsis in the pediatric population can be attributed to the susceptibility conferred by the vascularity in the developing proximal femur, the intracapsular location of the femoral metaphysis, and the propensity for injury or trauma in this age group. In adults, any acute or chronic disease process that locally or systemically affects the synovial tissue may increase the vulnerability to infection. Osteoathritis, inflammatory arthropathies, avascular necrosis, trauma, crystalline arthropathy, and neuropathic arthropathy have all been shown to affect the occurrence of infection. Immune system function also plays a major role in preventing joint sepsis. Any disease or chronic illness that results in or requires immunosuppression clinically carries with it an increased incidence of hip infections.[105–110]

The mechanisms of joint infection include hematogenous spread, direct inoculation, previous surgery, and local extension. Understanding these mechanisms is of the utmost importance in determining the appropriate method of diagnosis and treatment. Hematogenous bacterial spread is one of the most prevalent mechanisms responsible for hip joint sepsis in both the pediatric and adult populations. Prior to physeal closure in children, blind-end arterial loops in the proximal femoral metaphyseal bone act as reservoirs that capture bacteria. Metaphyseal involvement results in seeding of the hip joint because of its intracapsular location. In adults, bacteremia deposits organisms in the synovium that may then enter the joint directly or indirectly.[111] Direct seeding occurs through synovial capillaries damaged by preexisting disease or degeneration. Indirect seeding is a result of synovial inflammation caused by the presence of pyogenic bacteria that release proteolytic enzymes, causing synovial breakdown and seeding of the joint fluid. Surgery or direct inoculation is the most common mechanism for infection of the adult hip. Local infection also commonly spreads to the hip joint, and should always be ruled out or completely evaluated prior to surgical treatment so the appropriate technique, approach, and debridment can be performed.

Evaluation and Diagnosis

The diagnosis of a hip joint infection can in most cases be gleaned from the history, physical examination, laboratory tests, and plain radiographs. The suspected diagnosis is then best confirmed by aspiration and culture of the joint. In situations where the clinical presentation is consistent with a hip joint infection despite nondiagnostic radiographic studies and negative cultures, a synovial biopsy is indicated. This situation may arise when acute pain occurs in the face of a preexisting degenerative condition. Exacerbation of pain in hips with osteoarthritis, avascular necrosis, and inflamatory arthritides can all present with these symptoms, and it is of the utmost importance to rule out infection so that expedient treatment can be provided. Biopsy of the synovial tissue can be performed either via CT guidance or using arthroscopic techniques. In this situation, hip arthroscopy not only provides synovial tissue for culture and pathologic analysis, but also allows visualization of the intra-articular joint structure and the ability to debride and irrigate.

In situations where the diagnosis is obvious based on a positive hip joint aspiration, consideration for arthroscopic treatment requires further evaluation to determine the feasibility of this approach. When considering arthroscopic management of an infected hip, the mechanism and duration of the infectious process should be thoroughly investigated. The virulence of the organism, if identified, should also be taken into account. From a mechanistic standpoint, the only situation amenable to arthroscopic synovectomy and debridment is acute hematogenous seeding of the joint. Chronic infection, osteomyelitis, extremely virulent organisms, and local extension of a periarticular abcess are definite contraindications to arthroscopic treatment. For this reason, addition of a CT or MRI scan is absolutely necessary to evaluate the extent of the infection and to determine the appropriateness of arthroscopic versus open treatment.

Treatment

Treatment for septic arthritis in any joint consists of drainage, irrigation, and debridement of affected synovium and necrotic debris. The elimination of infection, restoration of mobility, and maintenance of joint function define the success of the treatment. The extent of the procedure required to attain these goals in the hip joint can be variable, and depends on myriad factors related to the organism, host, and duration of the process. The appropriate surgical intervention for the treatment of hip joint sepsis should be determined on a case-by-case basis. In combination with intravenous antibiotics, successful treatment has been reported with methods as simple as repeated arthrocentesis,[112] and as extensive as Girdlestone hip resection followed by delayed hip arthroplasty. Arthrotomy is and will remain the "gold standard" definitive procedure for septic hip arthritis, but hip arthroscopy has a definite role that undoubtedly will expand as the procedure and technology evolve.

Arthroscopic management of pyarthrosis is well established in all joints accessible to the instrumentation, and has been reported in the hip for both pediatric and adult patients. Early diagnosis of a hip joint infection and then identification of the organism by aspiration are of paramount importance in determining the appropriateness of arthroscopic intervention and treatment. The timing of the diagnosis, early or late, will usually predict the success of the intervention. Identification and treatment within the first week of symptom onset increases the potential for a successful outcome. Relatively healthy patients infected with low-virulence organisms have an increased chance for a cure if treated early. Chung et al have described successful, uncomplicated arthroscopic lavage for acute bacterial sepsis in the hips of nine children. The arthroscopic treatment combined with intravenous antibiotics was effective in ablating septic disease in all nine patients.[113] Debilitated patients with concomitant disease, and infection with more virulent organisms like *Staphylococcus aureus,* gram-negatives, or anaerobes carry a much less favorable prognosis. Formal arthrotomy in these situations is the preferred treatment if the procedure can be tolerated medically. If not, hip arthroscopy may provide a viable initial alternative in the prevention of sepsis, buying time to allow optimization of the patient medically before arthrotomy is attempted. Bould et al presented a case report demonstrating the diagnostic and treatment capabilities of hip arthroscopy in the adult population.[114] Blitzer reported on four patients with septic arthritis of the hip and one with suspected septic arthritis who were treated with arthroscopic irrigation, debridement, and drainage. The patients were free of infection an average of 20.4 months post arthroscopy.[115]

In all joints, especially the hip, arthroscopic treatment of infection is indicated for the treatment of acute sepsis. Arthroscopy is not indicated and is not a substitute for open debridement in the face of bony involvement, sequestrum, abscess formation, extracapsular extension, and recurrent or chronic infection, or when local infection has spread to the hip joint. The success or failure of arthroscopic treatment for hip joint sepsis rest completely with the surgeon's selection of appropriate patients and technical ability to perform the procedure. The technique involves lavage and synovial debridement, followed by postoperative closed-tube drainage and irrigation. If extensive infection with capsular destruction or bone involvement is encountered at the time of arthroscopy, conversion to limited or formal arthrotomy should be performed so that wide debridement can be achieved. In the right situation, arthroscopy results in much lower perioperative morbidity than open arthrotomy and allows for a more expedient, successful result by shortening rehabilitation and restoring early mobility.

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15 Pediatrics

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Hip arthroscopy has obvious advantages over arthrotomy in the pediatric population. Whether hip arthroscopy is performed as a diagnostic or therapeutic intervention, it is significantly less invasive than arthrotomy and therefore allows for early recovery and return to activities. Furthermore, arthroscopy does not place the child at risk for avascular necrosis by dislocating the femoral head. Hip arthroscopy is still a technically demanding procedure in the pediatric population, but is easier to perform than in adults due to a relatively shallow joint with compliant soft tissues.[1]

Indications for hip arthroscopy in pediatric patients were first introduced into the orthopedic literature in 1977 by Richard Gross.[2] A few years later, Holgerrson et al performed 15 hip arthroscopies in pediatric patients with juvenile rheumatoid arthritis. The arthroscopies allowed inspection of joint surfaces and more information about synovitis than plain radiographs provided, as well as an opportunity for synovectomy.[3] Current indications for pediatric hip arthroscopy include septic arthritis, labral pathology, slipped capital femoral epiphysis, and Legg-Calvé-Perthes disease. The role of hip arthroscopy in the pediatric population has not been thoroughly defined in the orthopedic literature. Due to the attractiveness of a less invasive option for pediatric patients, the indications for hip arthroscopy will no doubt expand.

Anatomy

The postnatal development of the hip joint is complex. A working knowledge of skeletal maturation, vascular ingrowth, and specific biomechanical properties of the skeleton is necessary when considering arthroscopy as a treatment modality.

The pelvis is formed from the fusion of three separate centers of ossification: the pubis, ischium, and ilium. All fuse into a single bone by early adolescence. The site of convergence and fusion of the three centers of ossification is the triradiate cartilage, which eventually fuses and forms the mature acetabulum. These primary centers of ossification must be recognized on radiographs for a correct diagnosis of hip pathology.

Proximal femoral development occurs as a result of the fusion of three separate centers of ossification: the femoral head, the greater tuberosity, and the lesser tuberosity. Staheli et al have documented the changes of the proximal femur from the neonate to the adult.[4] The neck shaft angle begins at 155 degrees in the neonate, decreases to 130 degrees, and the anteversion of the femoral neck, begins at 40 degrees in the neonate and decreases to 10 degrees in the adult. These developmental changes can affect the biomechanics of the proximal femur, increasing vulnerability to injury from either trauma or repetitive stresses.

The acetabulum has a fibrocartilaginous labrum attached to its margin that increases the depth of the joint. The labrum does not form a complete circle and is continued inferolaterally as the transverse ligament across the acetabular notch. The acetabular fossa lies in the inferomedial portion of the acetabulum and is filled with the triangular-shaped ligamentum teres and the pulvinar (fat and connective tissue). The fovea capitus (bare area) is a small depression on the medial femoral head, which is the insertion site for the ligamentum teres.

Labrum

The torn acetabular labrum has been identified as a cause for hip discomfort in young athletes. (Figure 15.1.) Clinical features include a painful click in the inguinal area that radiates toward the gluteus, and symptoms of catching or giving way at the hip joint. In general, athletes will remember an antecedent traumatic event that often involves sports, such as karate, which require forceful hip flexion and abduction, and forceful knee extension. On physical examination, the painful click can be reproduced by a Thomas flexion-to-extension maneuver.

Radiographic measures have been unreliable and have had low diagnostic yields in labral tears. Arthroscopy has been an

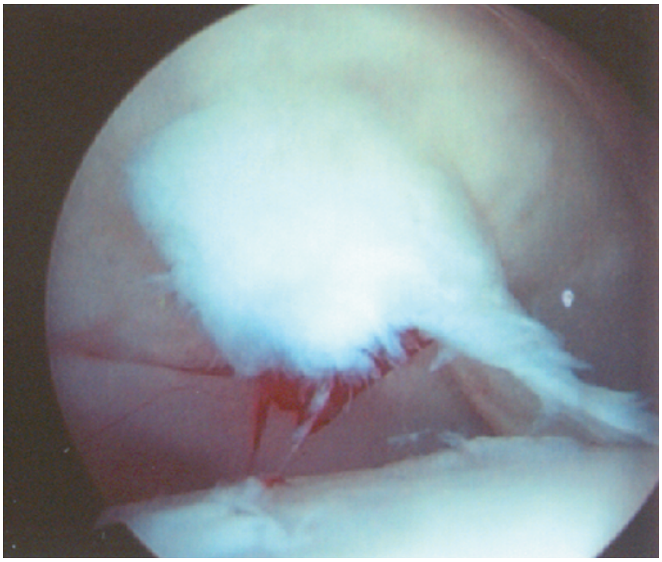


FIGURE 15.1. A labral tear in an adolescent athlete.

excellent diagnostic tool in this group of young patients with refractory hip pain of unknown origin, reproducible physical findings, and equivocal or negative radiographic studies.[5,6]

Slipped Capital Femoral Epiphysis

Slipped capital femoral epiphysis (SCFE) is the posterior slippage of the proximal femoral epiphysis relative to the femoral neck. The clinical presentation of SCFE is of pain in the hip that is often worse with ambulation. The classic physical exam finding is loss of internal rotation of the affected hip. Clinical classification of SCFE is based on the duration of symptoms. SCFE is considered acute if symptoms have been present less than 3 weeks, and chronic if the symptoms have progressed beyond 3 weeks. Acute on chronic SFCE describes a preexisting chronic displacement with a superimposed acute slip. Radiographically, slipped capital femoral epiphysis is classified according to the percentage the epiphysis has displaced on the neck of the femur.

The objective of treatment for SCFE is to prevent progression of the slip and to close the epiphyseal plate, while avoiding the complications of osteonecrosis and chondrolysis. When the patient presents with a short history of pain and acute findings on radiographs, a careful reduction may be gently instituted. In all other cases, attempts at reduction should be avoided.

The main complications associated with SCFE are osteonecrosis and chondrolysis. Avascular necrosis can occur as a result of damage to retinacular vessels from the initial acute trauma or from forceful manipulation. Chondrolysis, or loss of articular cartilage, occurs as a result of pin penetration of the articular cartilage during fixation. Patients present with a decrease in range of motion and an increase in hip pain. Proper adherence to reduction techniques and fixation will minimize both complications.

Hip arthroscopy has been found to be clinically helpful for SCFE patients. Futami et al performed hip arthroscopy in five patients with either acute or chronic SCFE, and all five patients experienced pain relief postoperatively. Arthroscopic findings included synovitis, intra-articular hematoma, erosion of anterosuperior acetabular cartilage, and posterolateral damage to the acetabular region. (Figure 15.2.) Authors felt that arthroscopy with pinning in situ could help early postoperative motion due to reduction of pain.[7]

Legg-Calvé-Perthes Disease

Avascular necrosis of the skeletally immature femoral head, or Legg-Calvé-Perthes disease, is characterized by osteonecrosis of the ossific nucleus of the femoral head secondary to occlusion of the arterial or venous blood supply. After infarction, healing occurs by a process of creeping substitution and resorption of the dead bone, with deposition of new bone. The deformity of the femoral head and acetabulum may be extensive and can exceed the remodeling and healing capacity of the developing epiphysis. In general, younger children with small areas of involvement have a better prognosis.

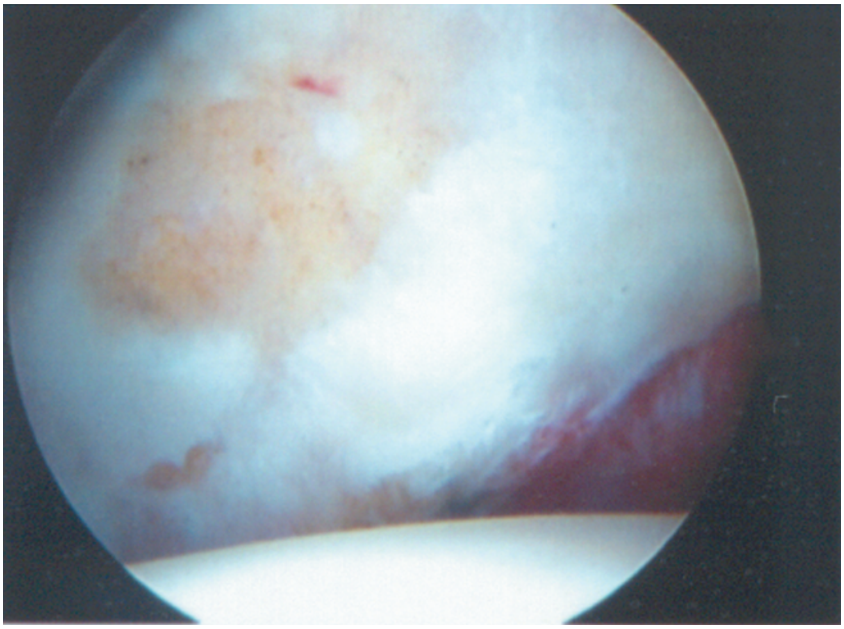
Patients with Legg-Calvé-Perthes disease will present with pain in the groin, thigh, or knee region. Onset is usually insidious, and the patient has usually been symptomatic prior to presentation. Most children have a positive Trendelenburg gait. Range of motion in the affected hip may be decreased on internal rotation, abduction, and extension. Muscles may show evidence of spasm, and graduated muscular atrophy is often present.

Treatment is based on containment of the avascular femoral head within the acetabulum to allow healing and remodeling of the affected cartilage. The single most important prognostic factor for healing is age. Younger patients have a better chance of normal cartilage development. Another important factor in healing is the extent of femoral head involvement.

Hip arthroscopy has been shown to be therapeutic for patients with Legg-Calvé-Perthes disease. In one study of eight patients with osteochondritis dissecans following Legg-Calvé-Perthes disease, patients who had removal of a loose body during hip arthroscopy experienced an improvement of symptoms postoperatively.[8] (Figure 15.3.) LeChevallier et al also demonstrated the therapeutic benefit of loose body removal as well as cartilage flaps. Nine patients with Legg-Calvé-Perthes disease were asymptomatic at a mean follow-up of 3 years after arthroscopic removal of loose bodies and cartilage flaps.[9]

Hip arthroscopy has also been used to diagnosis anterior impingement of the femoral head on the anterior edge of the acetabulum after Legg-Calvé-Perthes disease. Snow et al performed four hip arthroscopies in patients with Legg-Calvé-Perthes disease, and found a depressed defect in the anterior

FIGURE 15.2. SCFE patient with erosion of anterior acetabular cartilage.



portion of the femoral head in each case. Three of the 4 patients had osteocartilaginous fragments debrided. Three of the four patients had improved pain postoperatively, and all of the patients experienced increased range of motion.[10]

Suzuki et al used hip arthroscopy to examine pathologic changes of the synovium and joint surface in children with Legg-Calvé-Perthes disease. Hip arthroscopy was performed, accompanied by biopsy of the synovium and copious joint irrigation. Findings included proliferation of the synovium in the acetabular fossa and hypervascularity of the labrum. The authors stated that the synovium, or excess fluid generated by the synovium, may cause the femoral head to become compressed. Hip arthroscopy had a therapeutic benefit even without loose body removal, as all patients had pain relief and increased range of motion postoperatively.[11]

Further description of the sequelae of Legg-Calvé-Perthes disease was performed recently with the help of hip arthroscopy. Kuklo et al described a case report of a 7-year-old boy who was found to have a prominent island of superficial epiphyseal ossification at the time of hip arthroscopy. The lesion was debrided successfully, and the patient experienced a decrease in pain and increase in range of motion postoperatively.[12]

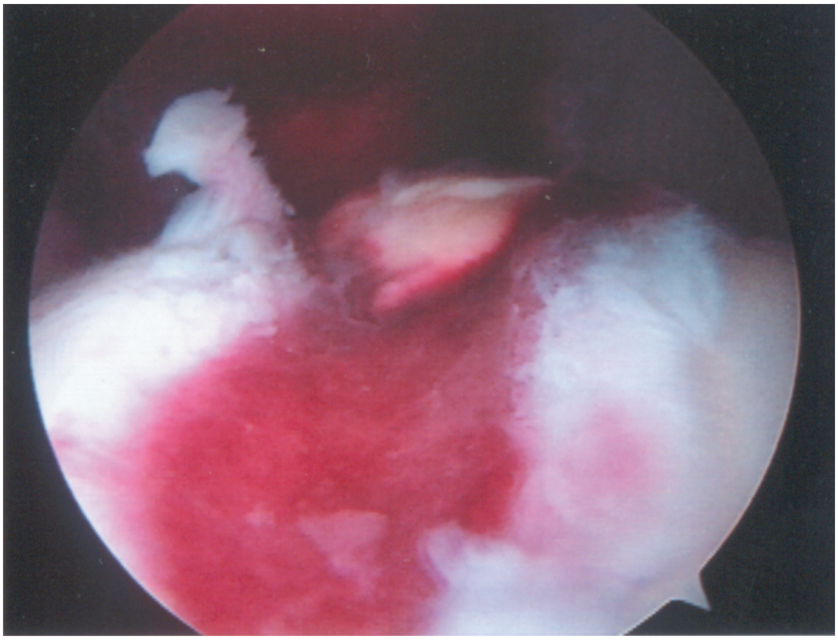


FIGURE 15.3. Legg-Calvé-Perthes patient with secondary OCD.

Septic Hip

Septic arthritis of the hip joint can be a devastating problem, and is primarily a pediatric disease. Septic arthritis of the hip joint develops secondary to hematogenous introduction of bacteria through the synovium, or from the proximal femoral metaphysis. The most common organisms found are group B streptococci, *Staph. aureus, Strept. pneumoniae,* and *H. influenza* type B.[13] Destruction of articular cartilage may ensue if prompt drainage is not performed.

Clinically, the child may present with pain, limp, or refusal to move the affected joint. The pain is usually found on the anterior aspect of the hip joint and may radiate to the knee. The child often holds the hip flexed, externally rotated, and abducted to maximize the joint space. Fever may or may not be present.

Laboratory workup should include white blood cell count with differential, ESR, C-reactive protein, and blood cultures. Plain radiographs may be inconclusive. Ultrasound may help with diagnosis in unclear cases.

The goals of treatment of septic arthritis of the hip are decompression of the joint capsule, joint debridement, reduction of bacterial load, and dismantling of loculations. Hip arthroscopy is an excellent alternative to arthrotomy. The surgeon may obtain culture and sensitivities, debride the joint, and place a drain, all without creating a large incision. Chung et al performed arthroscopic lavage in nine patients, age 2–7 years old, who had positive cultures of the hip joint. Each patient received a total of 3–6 weeks of antibiotic treatment postoperatively. The patients experienced no recurrences requiring additional surgical intervention. The authors emphasized large-bore arthroscopy intrumentation, high-volume lavage, and postoperative suction drainage.[14]

Conclusions

Hip arthroscopy in children is not an entirely benign procedure. Potential complications include many of the adult complications, with a special concern for the epiphyses. But, given the alternative of hip arthrotomy, with a large wound, increased soft tissue disruption, and longer recovery time, hip arthroscopy is a welcome alternative in the pediatric population.

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16
Trauma

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Traumatic injuries to the hip are commonplace in orthopaedic practice. Even though the evolution of surgical practice has allowed increased operative intervention, the morbidity of arthrotomy substantially affects outcome. Arthroscopy of the hip is becoming an alternative to open procedures in the treatment of some traumatic injuries of the hip. As arthroscopic skills improve and large clinical series are accumulated, arthroscopy may play an even larger role.

Hip Dislocation and Fracture Dislocation

Traumatic hip dislocation is a high-energy injury that usually results from a motor vehicle accident[1,2] in an unrestrained individual.[2,3] The treatment requires emergent relocation in addition to a thorough trauma evaluation, due to the high incidence of additional injuries.[1] If closed relocation is not achieved, then open reduction is indicated. Thompson and Epstein[4] type III or IV fractures are unstable and need to be openly reduced and repaired. The treatment of reducible dislocations and stable fracture dislocations, however, remains controversial.

Epstein's experience showed poor results associated with the retention of loose bodies.[5] Jaskulka used the presence of intra-articular loose bodies as an indication for arthrotomy.[2] However, the morbidity of a hip arthrotomy has been well noted. Fitzgerald was successful in his treatment of labral tears through a hip arthrotomy, but a large number of patients required additional surgery for symptoms related to the transtrochanteric approach he used.[6] Others have noted significant increases in the incidence of heterotopic ossification[7,8] and avascular necrosis with arthrotomy compared with nonoperative treatment.[9]

The advantage of arthroscopy is the decrease in morbidity compared with arthrotomy, while still providing the ability to remove loose bodies. Arthroscopy avoids redislocation of the hip, which is an additional vascular insult to the already compromised femoral head.[4] In addition, by avoiding the muscular dissection, one does not damage the soft tissue envelope, which will assist with stability. This also allows earlier rehabilitation and return to work.

Arthroscopy has also been shown to be effective for the diagnosis and treatment of labral tears.[10–14] Despite some claims in support of arthrography,[15] there are numerous reports of the inadequacy of arthrography[16–20] to diagnose labral pathology. In addition, there is evidence that computed tomography[16,20] and magnetic resonance imaging[16,17,20] also do not effectively diagnose labral tears. Although there have been some promising reports of the ability of MR arthrography to diagnose labral tears,[21–24] arthroscopy remains the best diagnostic tool. Labral tears need to be treated by debridement to facilitate healing and to alleviate symptoms.[18,19] Labral visualizaton and debridement can be achieved arthroscopically with good results.[16] While the diagnosis and treatment of labral pathology is covered extensively in other chapters, the high incidence of labral lesions associated with dislocation or fracture dislocation warrants mention.

Hip arthroscopy is associated with rare complications.[5] The most commonly reported injuries are nerve traction neuropraxias.[12,17,25,26] Despite a report of direct nerve transection at a portal site,[25] a cadaveric study showed that the procedure is relatively safe from the direct nerve injury standpoint.[15] Also reported are pressure injuries to the perineum from poor post setup[25,27] and one case of reflex sympathetic dystrophy of the lower extremity.[28] One catastrophic occurrence has been reported involving intra-abdominal fluid extravasation causing cardiopulmonary arrest.[29] This emphasizes the need to allow adequate time for the capsule to heal prior to attempting arthroscopy. The authors recommend waiting at least 3 weeks after dislocation in order to avoid fluid extravasation.

Closed reduction is the accepted treatment of type I dislocations.[1] If reduction is successful and the postreduction CT scan is normal, no further intervention is indicated. If loose bodies are present, they should be removed. This has been achieved arthroscopically, but traditionally has been performed with an arthrotomy. At our institution, type I dislocations are treated arthroscopically if there are loose bodies visualized on CT. (See Chapter 3.) Given the poor quality of all currently accepted radiological modalities for diagnosis of labral pathology and chondral loose bodies,[16,20,30] the question of diagnostic arthroscopy for all type I dislocations remains unanswered. Based on the high incidence of intra-articular pathology associated with this injury,[9] further study is indicated; however, we recommend arthroscopy for all patients who are symptomatic after having sustained a type I dislocation.

Type II fracture dislocations contain a single fragment off the posterior wall of the acetabulum. The size of the fragment correlates with the instability of the dislocation after reduction.[31] While some authors such as Epstein[5] and DeLee[1] recommend arthrotomy for all type II fractures, others promote open fixation only if the reduction is unsuccessful, loose fragments are present, or the hip is unstable after reduction.[9] This is the approach used at our institution, with arthroscopy replacing arthrotomy for loose bodies. Given the high incidence of labral pathology associated with this injury, the authors recommend arthroscopy for all symptomatic type II fractures.

Type V fracture dislocations are treated based upon the Pipken subclassification.[32] DeLee recommends primary closed reduction of Pipken type I injuries.[1] Once again, the authors recommend arthroscopy for all symptomatic type V fractures that would not otherwise require surgery.

Arthroscopic loose body removal after traumatic dislocation of the hip has been reported in the literature,[27,33–35] yet large series are lacking. One review at our institution revealed that 11 patients with traumatic dislocations and fracture dislocations between 1996 and 1997 were treated with hip arthroscopy. All patients had loose bodies documented on CT. There were eight male and three female patients with an average age of 25.8 years (range, 17–35). The mechanism in all but one patient (fall from height) was a motor vehicle accident. Eight patients either reduced spontaneously or were reduced at a referring hospital; the remaining three were closed-reduced emergently at our institution. Six patients had a type I injury without acetabular fracture, three patients sustained a type II injury, and 2 patients had a type V injury with a Pipken subtype I fracture of the femoral head caudad to the fovea centralis. All patients were diagnosed with intra-articular loose bodies by computed tomography. The average time to surgery was 4.1 weeks (range, 3–6). Seven patients were diagnosed with labral tears at surgery, and the remaining 4 had labral fraying. All were debrided arthroscopically. All loose bodies were removed arthroscopically, and no patient required arthrotomy.

All patients were available for follow-up at an average time of 24 months. Seven patients had full range of motion. According to the classification set forth by Epstein et al,[5] there were five excellent and six good results. Four patients lost 10 degrees of external rotation and 5 degrees of internal rotation. This group of four included the two Piplen fracture and two of the four type II fractures. There were no sciatic nerve injuries. There were no cases of heterotopic ossification. There was no incidence of avascular necrosis of the femoral head. No patients had recurrent instability. The average return to work was in 5 months.

Arthroscopy for hip dislocations and stable fracture dislocations has shown excellent results. This approach provides the ability to diagnose and address the intra-articular pathology associated with this injury.

Penetrating Trauma

Although the incidence of penetrating trauma to the hip joint is low, the removal of penetrating objects (bullets) has been reported.[36,37] These two case reports suggest that although these injuries are rare, they do occur, and hip arthroscopy allowed foreign body extraction through a minimally invasive approach.

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Section IV
Functional Outcomes

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17
Rehabilitation After Hip Arthroscopy

Susan Dirocco, Joseph C. McCarthy, Brian D. Busconi, Bruce Dick, and Kevin Flaherty

The primary goals for many patients undergoing hip arthroscopy are relief of pain and a return to their premorbid level of activity. Oftentimes these patients have a history of pain, muscle inhibition, altered gait, and impaired function for varying lengths of time. As the hip is an integral part of the lumbo–pelvic–hip complex, dysfunction or derangement of the hip can also lead to compensatory lumbar movements. Typically, candidates for hip arthroscopy have undergone some form of preoperative treatment intervention directed toward relief of pain and restoration of mobility, strength, and function. For those patients whose symptoms have not responded to conservative care, hip arthroscopy has been shown to be effective in both the diagnosis and treatment of hip articular pathology. Whether the pain is due to synovitis, septic arthritis, early osteoarthritis, or chondral pathology can be determined through arthroscopy. Surgical removal of a loose body or a torn labrum can then be performed to alleviate pain.[1] To fully rehabilitate these patients to their highest possible functional level, rehabilitation must address not only the postoperative sequelae but also the patient's preoperative compensations and faulty movement patterns.

Common key impairments following joint arthroscopic procedures are: inflammation, pain, swelling, decreased joint mobility, altered muscle extensibility, impaired muscle strength, altered proprioception, and decreased muscle endurance. These impairments result in reduced functional abilities, whereas studies have shown the efficacy of physical therapy intervention for postoperative arthroscopic meniscectomy patients.[2,3] Vervest et al found rehabilitated patients had improved performance on such functional measures as distance jumping and hopping.[2] St. Pierre showed that physical therapy intervention accelerated the recovery of muscle strength to preoperative levels.[3] Currently there are no studies investigating the effects of rehabilitation following hip arthroscopy. This chapter will provide clinical guidelines for the rehabilitation of patients who have undergone hip arthroscopy.

Initial Assessment

When setting treatment goals it is important to have a clear understanding of the nature of the hip pathology. Knowing if the hip pathology was related more to an inflammatory process than to mechanical forces such as load, friction, or blunt trauma is useful information in planning treatment interventions to restore mobility and strength.[4] Learning of the presence and extent of articular cartilage involvement is essential for exercise progression and for setting realistic functional outcomes. Patients with a resection of a labral tear, or removal of loose bodies without evidence of articular cartilage involvement, may progress more quickly to closed kinetic chain weightbearing exercise and return more quickly to sports or to physically demanding jobs. For those with concomitant articular pathology, nonweightbearing exercises such as supine or aquatic exercise are more indicated, and a return to prior activity level may take longer. Existence of comorbidities such as lumbopelvic dysfunction, associated joint involvement, collagen disorders such as Ehler-Danlos syndrome and disease processes such as arthritis and congenital hip dysplasia can guide the therapist in setting realistic treatment parameters. For example, joint mobilization to restore capsular extensibility in the middle phase of treatment would be contraindicated in a postoperative patient who had hyperlaxity resulting from Ehler-Danlos syndrome.

Other such variables as individual differences in healing time or quality, patient compliance, and motivation can impact the recovery from hip arthroscopy. For these reasons, rehabilitation phases cannot be time specific but need to be based on the presence of impairments. Achieving maximal functional outcome for the patient requires effective treatment planning based on his impairments coupled with realistic goal-setting. Good communication among the surgeon, physical therapist, trainer, and patient is essential for successful rehabilitation and will result in a higher level of patient satisfaction.

Phase I—Immediate Postoperative

Hip arthroscopy is usually done as an outpatient surgical day procedure. The primary role of the physical therapist is instructing the patient in pain management, ambulation with an appropriate assistive device, and home exercise. The key impairments are pain, swelling, limited soft tissue and joint mobility, decreased strength and muscle inhibition, and decreased proprioception.[5,6] The key functional limitations are difficulty with ambulation, lower extremity dressing, limited sitting tolerance, and difficulty driving.

A physical therapy examination includes assessment of, pain, sensation, range of motion, functional mobility, strength, and palpation.

Pain

Immediately following hip surgery there is swelling in the joint which distends the capsular–synovial complex. The hip capsule is innervated by the superior gluteal nerve, the femoral nerve, and the medial articular nerve. Edema causes stretch of the capsular tissue, which fires the nocioceptors and primary afferents of those nerves, giving rise to hip pain.[7] This pain is typically experienced in the inguinal and thigh area, which is the common referral site for hip pain. Transient hypesthesia or discomfort may also be present in the perineum or ipsilateral ankle region secondary to the stabilization and distraction devices used during the procedure.[1] Coexistent lumbar derangement of the L3–L4 segment can also refer pain to this area, as can organic pelvic disorders.[8] These areas as a source of the pain should be cleared prior to surgery, but it is important to keep in mind their possible contribution to the patient's complaint. Pain can be quantified through a pain diagram or visual analog scale.

Sensation

Postoperatively, in a small percentage of patients, there may be altered sensation or dysesthesia in the inguinal or perineal region from pressure on the pudendal nerve by the stabilization device. To date there have been no cases of major nerve injury with our arthroscopic technique. However, an assessment of light touch and pinprick of the peripheral nerve distributions of the sciatic and femoral nerves should be performed.

Range of Motion (ROM)

An assessment of both active and passive osteokinematic motion of the hip and associated joints is necessary. Patients will require good ankle mobility for safe ambulation. The presence of a capsular pattern of the hip as described by Cyriax is often found secondary to the postoperative effusion.[9] Characteristic of that pattern is a gross limitation of flexion, abduction, and medial rotation, and a minimal loss of extension and lateral rotation.

Strength

A formal strength evaluation of the operative extremity is deferred initially, however upper extremity strength is assessed for determination of the type of assistive device needed for ambulation. The therapist should evaluate the contralateral limb, and the associated joints of the operative limb, as well as the recruitment ability of the gluteal and quadriceps muscles.

Palpation

The treating therapist should palpate the operative joint for warmth, pain, and swelling. There may also be swelling noted in the operative foot and ankle.

Functional Mobility

The therapist should determine the patient's ability to perform transitional movements such as sit-stand-sit, bipedal balance, and ambulation ability with an assistive device.

Goals of Phase I

The goals of Phase I are to: Decrease pain, decrease effusion, prevent muscle inhibition, restore joint mobility, promote tissue nutrition and wound healing, maintain proper static joint alignment, increase awareness of joint protection, allow an independent and safe gait with assistive device on all level surfaces and elevations, and to increase sitting tolerance.

Treatment Interventions

The immediate postoperative phase is dominated by the acute vascular and inflammatory response to the surgery. Physical therapy intervention at this phase can best be summarized by the acronym: PRICEM[7] (Figure 17.1). This is the first tier of Fagerson's pyramid model of treatment intervention for the hip. The patient needs to protect the joint and ensure optimal loading by utilizing crutches with partial weightbearing. Crutches also allow for good postural alignment. The joint is protected further by avoiding painful ranges of movement, especially combined flexion/adduction and hyperextension. Patients are advised not to pivot or twist on the operative hip, as this causes increased compressive forces on the acetabular surface.

According to McCarthy, many labral tears are located on the anterior superior aspect of the joint.[1] Consequently patients who had labral resections may be reluctant to move in the direction of flexion and adduction postoperatively. They

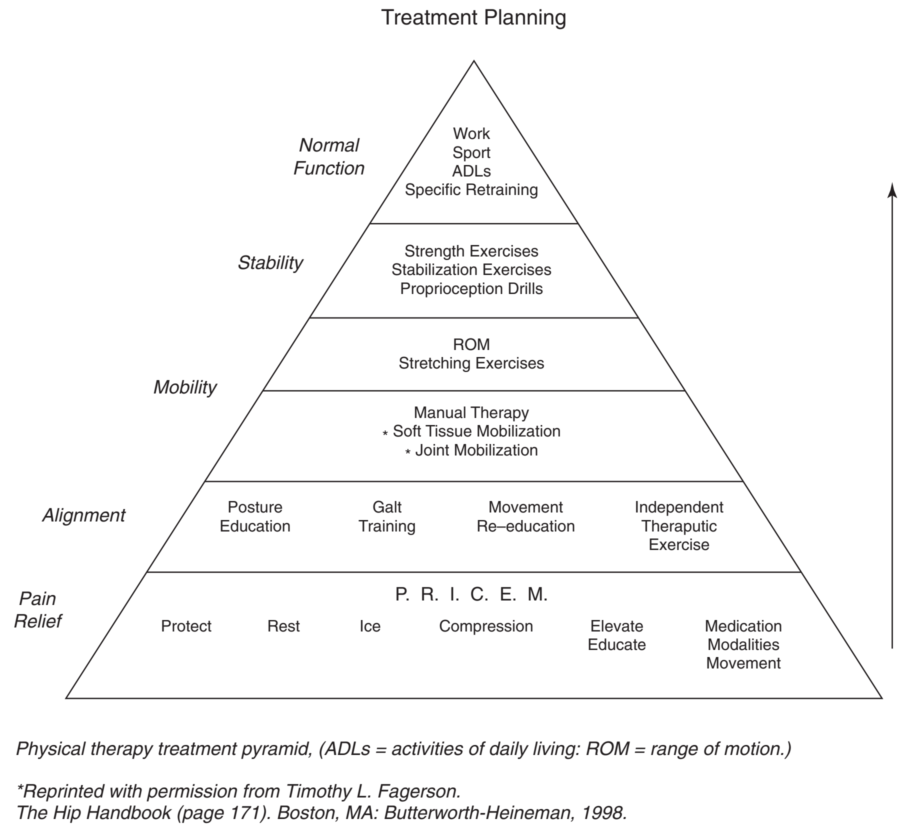

FIGURE 17.1. Physical therapy treatment pyramid (ADLs = activities of daily living; ROM = range of motion). (Reprinted with permission of Timothy L. Fagerson.)

should be reminded to move within a pain-free range and understand that full motion may initially be restricted due to the length of time they avoided this movement. In dysplastic hips there is a high incidence of articular degeneration on the anterior and superior acetabular surfaces.[10] Avoidance of hip hyperextension, coupled with limited weightbearing, should help to decrease pain and promote healing of that surface. Crutches are continued as long as the patient has pain or a limp. Patients are also advised to rest and limit their activities for the first few days.

Paramount during this phase is the control and reduction of postoperative joint swelling. The effects of inflammation coupled with immobilization on cartilage, muscle, tendon, ligament, and bone are well known.[11,12] Usually the acute vascular inflammatory phase is self-limiting. However, if it is prolonged there are negative effects on the tissue healing. Abnormal cross-linking of collagen, as well as the suppression of glucosoaminoglycans, can contribute to suboptimal repair and regeneration.[11] Providing an optimum condition for healing by decreasing the effusion can be accomplished through the use of ice, electrical stimulation,[13] gentle movement, and muscle contraction. Swelling has a negative effect on muscle tissue, commonly resulting in muscle inhibition.[14,15] Muscles may also react to pain by overactivation. Contracting the opposing or antagonistic muscle group may inhibit the overactive muscle and promote pain relief.[16] For example, gluteal isometrics can inhibit an overactive iliopsoas muscle. Maintaining good mobility and contractility of the associated muscles of the pelvis and trunk is important. Examples are the pelvic floor exercises, abdominal bracing, lower trunk rotation (Figure 17.2.) and double knee-to-chest (Figure 17.3.). Gentle movement helps in preventing abnormal cross-links and shortening of the collagen tissue (Figure 17.4.). Overstretching in this phase may lead to delayed tissue healing. Having the patient perform submaximal isometric contractions of the trunk, hip, and knee muscles can help to prevent the muscle inhibition, while promoting improved nutrition to the tissues through increased circulation (Figure 17.5.). Standing while performing subtle weight-shifting onto the affected extremity can help to facilitate stabilizing muscle contractions around the hip. This activity can prepare the lower extremity for the stance phase of gait.

Pain relief can be facilitated through the use of other electrotherapeutic modalities such as transcutaneous nerve stimulation (TENS) or interferential current.[17] By stimulating the release of endogenous opiates or by the stimulation of large

A

B

FIGURE 17.2. (A,B). Lower trunk rotation.

FIGURE 17.3. Maintenance of lumbo–pelvic mobility.

FIGURE 17.4. Early hip mobility ALT—Early phase hip flexor stretch.

sensory fibers, TENS can lessen the pain sensation and help to improve movement and reduce muscle guarding. The use of medications such as the newer COX-II inhibitors both preoperatively and postoperatively has been shown to greatly reduce the need for postoperative opiate analgesia.[18]

During this phase, much of the treatment intervention is focused on patient-related instruction. Many of the exercises can be performed independently. A written description of the exercises along with actual performance of the exercises can assist in carryover and patient learning. It must be stressed that the movements and activities during this phase should be gentle. Table 17.1. lists other exercises that can be performed during this phase.

To progress to the next phase of rehabilitation, swelling should be resolving, muscles should be able to contract well isometrically, movements should be coordinated and relatively pain-free, and ambulation should be without apprehension. In many instances there may be some residual swelling, muscle inflexibility, and weakness. Pain may alter movement patterns and lead to muscle imbalances and faulty movement.[16] As the patient is subacute, care must be taken to select appropriate exercises in the middle phase of rehabilitation.

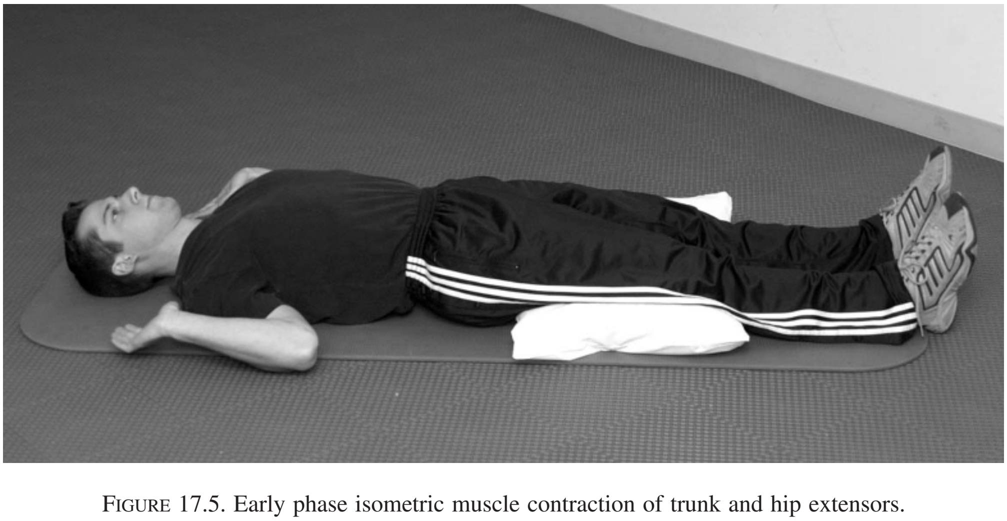

FIGURE 17.5. Early phase isometric muscle contraction of trunk and hip extensors.

Table 17.1. Hip Arthroscopy Guidelines

	Post Op Week							
	Phase I		Phase II			Phase III		
Range of Motion	1	2	3	4	5	6	7	8
Avoid Hyperextension								
Ankle Pumps, Circles								
Active IR/ER—Seated								
Active Abd/Add								
AA Flexion—Heel Slides								
Seated A/P, Lateral Weight Shift								
Single Knee to Chest								
Seated Trunk Flexion								
Hip Flexor Stretch to Neutral						*Begin to Stretch Beyond Neutral*		
Pelvic Tilts								

	Post Op Week							
	Phase I		Phase II			Phase III		
Resistance Training	1	2	3	4	5	6	7	8
Isometrics and Abdominals (level I)—Supine								
Standing Isometric Abduction								
Bridging								
Unilateral Bridging								
Three-way SLR (flex, abd, add)						4-way		
Prone Knee Flexion								
Seated Knee Extension								
Nautilus Knee Extension								
Seated Hip Flexion	*—-Pain Free Range—-*							
Abdominal bracing								
PNF Pelvic Patterns								
Upperbody Strengthening								
PNF Diagonals—(full Range) LE patterns								
Stairmaster								
Closed Kinetic Chain Exercises								
Heel Raises, 1/4 Squats								
Lunges, Full Squat								
Step-ups						retro		
Multi-Hip Machine Operative Leg					*—-ABD, ADD, Flex Only—-*			
Operative Leg Hip Extension								
Nonoperative leg					*—-All Directions—-*			

	Post Op Week							
	Phase I		Phase II			Phase III		
Balance/Coordination	1	2	3	4	5	6	7	8
Unilateral Stance								
Rebounder								
BAPS—Bilateral to Unilateral								

	Post Op Week							
	Phase I		Phase II			Phase III		
Conditioning	1	2	3	4	5	6	7	8
Stationary Bicycle								
Swimming—Flutter Kick Only								
Running								
Upper Body Cycle								

	Post Op Week							
	Phase I		Phase II			Phase III		
Pool Activities—Wounds Must be Completely Healed	1	2	3	4	5	6	7	8
Deep Water Walking with Float								
Buoyancy Assisted ROM								
Buoyancy Resisted ROM								
Shallow Water Walking	*—-Increase speed. Increase stride length as tolerated.—-*							
Plyometrics								

	Post Op Week							
	Phase I		Phase II			Phase III		
Sport-Specific Activities	1	2	3	4	5	6	7	8
Fitter								
Slide								
Plyometrics								
Cutting Drills								
Sport Cords								

Return to sports dependent on full pain free ROM, strength 90% of opposite limb, complete run/jog program

Indicates Timeframe in Which Exercises Should Not be Performed

Phase II—Middle-Phase Rehabilitation

Usually 7–10 days after surgery, the patient returns to the surgeon for reevaluation. A majority of the patients have progressed off of the crutches, the portal scars are healed, pain and swelling are diminishing, and mobility and muscle contraction are improving. At times, patients may still present with continued impairments such as pain, swelling, altered mobility and muscle length, poor static alignment, impaired muscle strength and endurance, diminished proprioception, and decreased cardiovascular endurance resulting in functional limitations. These key impairments may warrant referral to formal physical therapy for direct intervention. Physical therapy examination should include: Pain, posture, range of motion, both arthrokinematic and osteokinematic, muscle length and flexibility, strength, proprioception, and gait.

Posture

The therapist should examine the patient's static posture, noting any deviation from optimal alignment. Compare the height of the iliac crests, greater trochanters, pelvic inclination, knee and foot position, and spinal curves. Assess symmetry from an anterior–posterior, lateral and, oblique view. A postural deviation such as genu recurvatum due to tight heel cords or weak quadriceps can transmit excessive forces to the anterior aspect of the acetabulum. This would increase focal loading on an area that is unable to tolerate it. A pronated foot may be due to weak hip lateral rotators. Excessive anterior pelvic tilt may be due to weak abdominals coupled with a tight quadratus lumborum. Postural deviations may be structural or functional. Examination of joint mobility, muscle length, and strength will determine what is causing the misalignment.

Range of Motion

Both passive and active osteokinematic mobility of the hip and associated joints, including the lumbosacral spine, sacroiliac and iliosacral articulations, and the contralateral limb should be assessed. Note the amount and the quality of the movements.

Arthrokinematic assessment involves passive joint-play movements, such as traction and translatory gliding of the opposing joint surfaces. These movements help differentiate whether the noncontractile structures of the joint such as the capsule and ligaments are restricted or painful. This in turn will determine the type, duration, and frequency of the joint mobilization technique to utilize.[19]

Muscle Length

Muscle length should be examined utilizing standardized tests such as the Thomas test, Ely test, Ober test, SLR, or the adductor length test as described by Kendall and Sarhman.[20,21] Muscle imbalance is often present both pre- and postoperatively due to pain or prolonged poor posture. Certain patterns of muscle imbalance are commonly found at the lumbo–pelvic–hip complex. Janda described certain muscles as being prone to either tightness or lengthening. This tightness may be associated with or without weakness. Lengthening is associated with stretch weakness.[16] Muscles prone to tightness are the iliopsoas, rectus femoris, hamstrings, quadratus lumborum, hip adductors, low back extensors, hip external rotators, and the gastroc–soleus. Muscles prone to lengthening and weakness are the opposing or antagonistic muscle groups such as the abdominals, hip extensors, and abductors. On preoperative examinations, McCarthy also found that hip flexors are often shortened in patients with labral tears.[1] Pain can lead also to adaptive shortening of the hip flexor muscle and inhibition of the hip extensors and abductors.

Muscle Strength

At this time it may be more appropriate to perform a formal muscle strength assessment. This could be done through manual muscle testing.[20,22] where the motions are performed against gravity and graded. More functional assessments could be performed, such as lifting different weights for a certain number of repetitions. The patient could perform functional tests of strength and stability, such as the one-legged stance (Trendelenberg test), sit-stand-sit, stepping, and partial squatting. It should be also noted which muscles or movements are painful with resistance. If a muscle is strong but painful with resistance and painful on stretch, it may indicate a muscle strain. Weakness and pain with resisted muscle testing would indicate a more serious muscle lesion and would impact the progression of exercises.[9] Assess related areas, in particular the trunk muscles, knee, and ankle.

Proprioception/Balance

Proprioception is the neuromuscular ability to detect position of the joint. The nerve initiates a reflex muscle contraction once information is relayed centrally from the afferent fibers of the muscles, ligaments, and joints. Patients with joint pathology, altered muscle function, or overstretched ligaments and capsules often present with diminished proprioception. Researchers have found decreased proprioceptive function in arthritic knee patients and postoperative knee replacement patients.[5,6] Current research is inconclusive for proprioceptive loss following hip arthroscopy.[23,24] It is common clinical belief, however, that such proprioceptive training as weightbearing activities and perturbation/balance activities stimulate muscle joint receptors. The goal of proprioceptive training is to enhance afferent proprioceptive information to elicit an increased neuromuscular response of the affected limb.

Normally, proprioception interplays with the visual and vestibular systems to achieve postural control and balance.[25]

Hypofunction of any of these systems can result in altered motor responses and impaired balance. Balance should be assessed with the patient standing in unilateral stance with the presence and then absence of vision. Thirty seconds of the patient maintaining balance is considered a normal response. Alter the base of support by having the patient assume tandem stance. Assess further by altering the vestibular input with head turning.[26]

Gait

As the hip is an integral part of the kinematic chain, deviations may appear either higher or lower in this chain. Examine the patient from both a sagittal and a coronal view. The therapist should check for the possible presence of Trendelenburg gait during midstance and early knee or trunk flexion in mid to terminal stance due to limited or painful hip extension.

Goals of Phase II

The goals of Phase II are to: Further decrease pain and swelling; restore full joint mobility; restore full muscle extensibility; increase muscle strength and endurance; ambulate with a normal gait pattern; improve proprioception and balance; and increase cardiovascular endurance.

Treatment Intervention

Restoration of the normal tissue relationships must be regained in this phase. Normal length-tension of the muscle will help to ensure optimal function. Before initiating strengthtening exercises, the shortened muscles must regain their length. For health of the articular cartilage and extensibility of the noncontractile tissue such as the capsule, joint mobilization may also be indicated. (See Figure 17.1.)

Mobility

Stretching the hip flexors in prone lying (Figure 17.6.) may be initiated, as well as more combination movements that gently stretch the piriformis and hip external rotators (Figure 17.7.). As mentioned earlier, other shortened muscles include the hamstrings, rectus femoris, gastroc and soleus, hip adductors, and the quadratus lumborum. Most research on stretching has been conducted on healthy muscle tissues. The optimal duration of static stretching has been variable, but many studies recommend a 30-second stretch. Injured muscles may need a longer stretch stimulus.[27] Different patients may require different amounts of stretch duration. Patients should be advised to stretch to the point of tension and maintain that position until relaxation occurs. The stretch can then be progressed. Soft tissue mobilization to restore muscle extensibility and play are also indicated at this phase. Proprioceptive neuromuscular facilitation (PNF) such as hold–relax and contract–relax are also effective in regaining normal tissue length.[28,29]

Restoring capsular extensibility helps to normalize joint range of motion. In the early degenerative hip there is often a loss of flexion and internal rotation, due in part to a hypomobile posterior capsule. Performing manual techniques such as joint distraction both laterally and caudally may help to restore arthrokinematic movements in all planes.[19] Specific translatory mobilizations such as inferior and posterior glide can help increase mobility in flexion, adduction, and internal rotation. Preoperatively these motions are often avoided due to pain, contributing to limited capsular extensibility. Joint

FIGURE 17.6. Progression of hip flexor stretch.

FIGURE 17.7. Home exercise for piriformis flexibility.

mobilization has been shown to be helpful in the treatment of early DJD of the hip.[30] Healthy cartilage requires freedom of movement and equitable loading.

Once mobility is restored, the therapy should be directed towards the reeducation of the muscles and movements that have been impaired. The muscles may continue to be inhibited due to pain; have difficulty maintaining strength through the range of motion; have poor endurance; and have a poor pattern of recruitment. The most effective way to recruit muscles and reeducate movements is through the use of proprioceptive neuromuscular facilitation (PNF). This exercise technology incorporates manual resistance to muscles in diagonal patterns. Different techniques can be applied to the pelvis and lower extremity to elicit isometric and/or isotonic contractions, both concentric and eccentric. Resistance can be graded and the movement can be controlled, avoiding end ranges of movement that may be painful, such as hip hyperextension. Another benefit to this type of exercise is that it involves multiple joints and muscles in a functional movement pattern. Initially, the exercise should be with low resistance and high repetition to increase the quality of contraction and muscle endurance.

The ability to dissociate hip movement from vertebral movement is also important. These areas tend to move together in common substitution patterns. Critical to the successful rehabilitation of the lumbopelvic complex is isolated hip movement with abdominal control of the pelvis.[31] (Figure 17.8.) Manually resisted pelvic patterns can then be uti-

FIGURE 17.8. Isolated hip movements with abdominal control of pelvis.

lized to coordinate movement between the pelvis and lumbar spine. These motions are necessary for a smooth gait.

As long as there is full wound healing, aquatic exercise is now encouraged. At this phase the water can provide assistance to movements through the hydrodynamic property of buoyancy. While standing in the shallow end, the patient can have buoyancy assist hip and knee flexion, medial and lateral rotation, and hip abduction and extension. Gait activities may be initiated as 50% of the weight is reduced in waist-height water and the patient is able to maintain partial weightbearing status if that is still indicated.[32] Deepwater exercises such as slow walking with a floatation device, bilateral leg exercises, and trunk exercises help with total body flexibility and endurance.

Stability

Once the patient can move smoothly through the range of motion it is time to further strengthen the affected muscles. Restoring strength to the hip-stabilizing muscles should begin in their shortened range. The gluteus medius functions primarily eccentrically in the initial contact to the midstance phase of gait to stabilize the pelvis on the femur in the frontal plane. Before developing eccentric strength, the gluteus medius must achieve isometric and concentric strength. Isometric contractions can be elicited in the hips during a lateral-push wall exercise. (Figure 17.9.) Isometric exercise duration should begin at 5–10 seconds. Isotonic strength can be attained through a side-lying leg lift. This exercise is often done incorrectly with the patient rotating the hip externally to substitute for the weak gluteus medius with the tensor fascia lata and hip flexor muscles. (Figure 17.10.) Leg lifts can also be performed into hip extension and hip adduction. Active hip extension in the prone position has the added benefit of stretching the hip flexors dynamically as the hip extensor is strengthening isotonically. The exercise can be

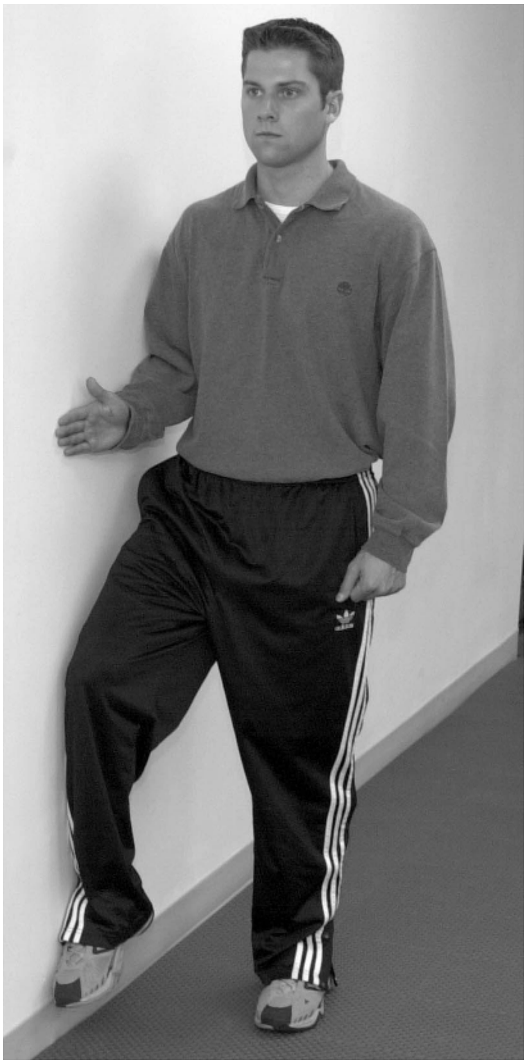

FIGURE 17.9. Isometric hip abduction with stabilizing contraction of weight bearing leg.

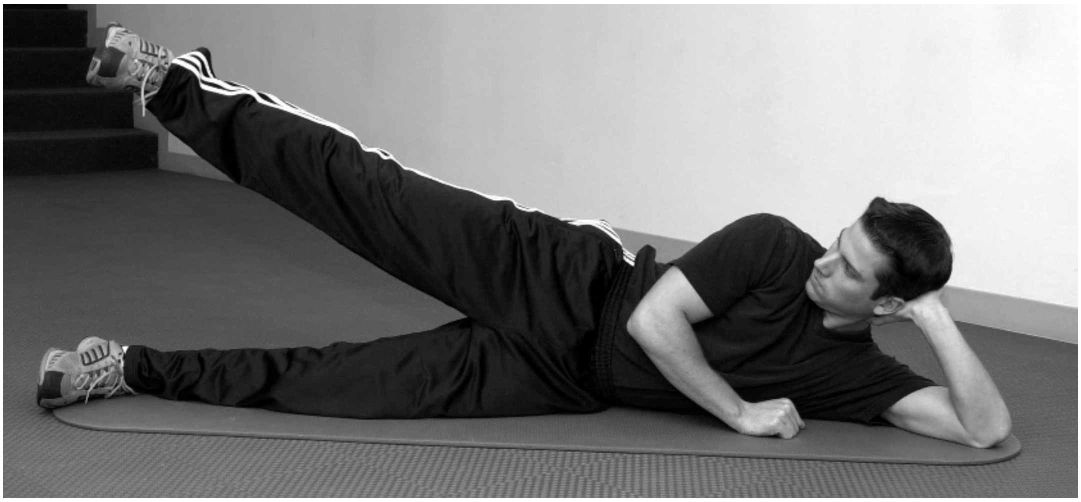

FIGURE 17.10. Isotonic hip abduction.

FIGURE 17.11. Dynamic trunk extensor strengthening.

further advanced to incorporate an opposite arm lift, recruiting the trunk extensor muscles. The patient should be told to contract the abdominal muscles simultaneously to stabilize the pelvis, which prevents lordosis and avoids excess compression of the posterior facets of the lumbar spine. (Figure 17.11.) Bridging is also good for dynamic trunk stabilization while strengthening the hip extensors and stretching the hip flexors. (Figure 17.12.) To increase the level of difficulty, bridging can be progressed from bilateral to unilateral. A resistive band may be placed around the knees or pelvis.

FIGURE 17.12. Progression of hip flexor stretch.

Closed kinetic-chain exercises in bilateral stance help to increase both strength and proprioception. Bilateral heel raises and partial squats develop whole lower limb strength. (Figure 17.13.) As the patient improves, the duration of the squat should increase, followed by increasing the depth of the squat. Another progression would be to move away from the wall thereby increasing the weight, or to place a physioball behind the trunk against the wall to make an unstable surface. (Figure 17.14.) Resistive exercises using weight machines can be initiated for the quadriceps and hamstrings. In the pool, more advanced closed kinetic-chain exercises be can be initiated, such as unilateral stance, lunge, or unilateral squat. All of these exercises can prepare the patient for more efficient gait on land.

FIGURE 17.13. Early phase closed kinetic chain strengthening.

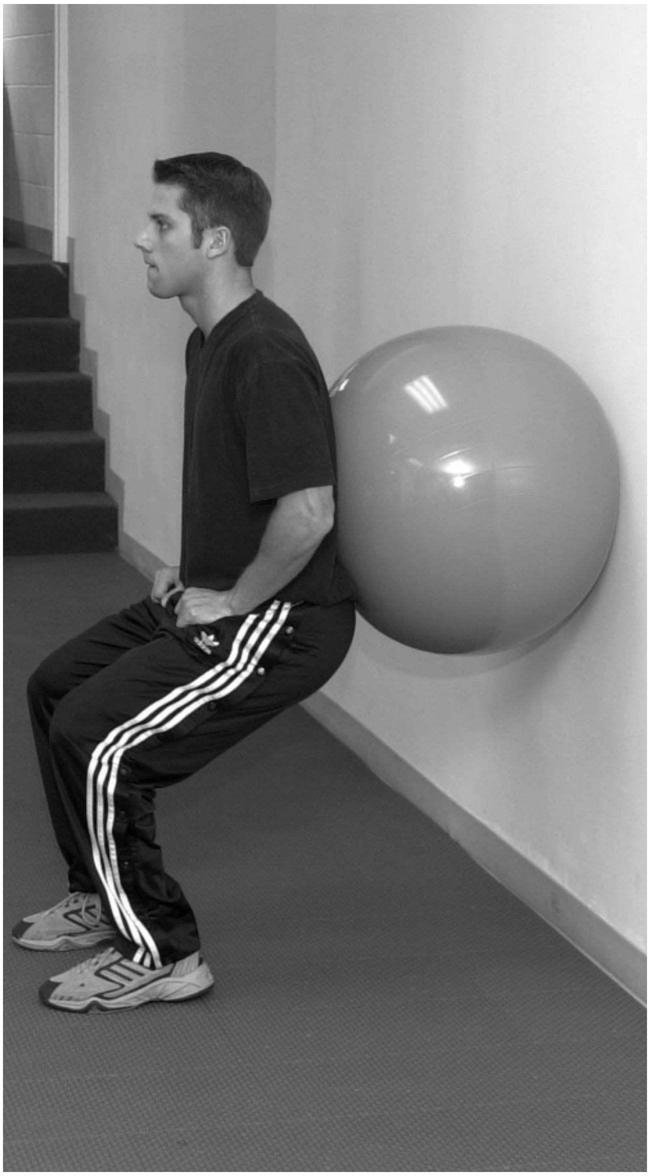

FIGURE 17.14. Progressive wall squat with physioball.

Gait Training

Progression to full weightbearing with restoration of an efficient gait pattern is not advised if the Trendelenburg test is still positive. These patients may require a cane used in the contralateral upper extremity to help reduce torque at the pelvis and minimize the demand on the gluteus medius, minimus, and tensor fascia lata. Stability in unilateral stance is the most difficult activity for these muscles to perform and is essential for progression to more challenging and functional gait activities.[7] (Figure 17.15.) Patient's gait should have an even step length with good pelvic stability, push-off, and cadence.

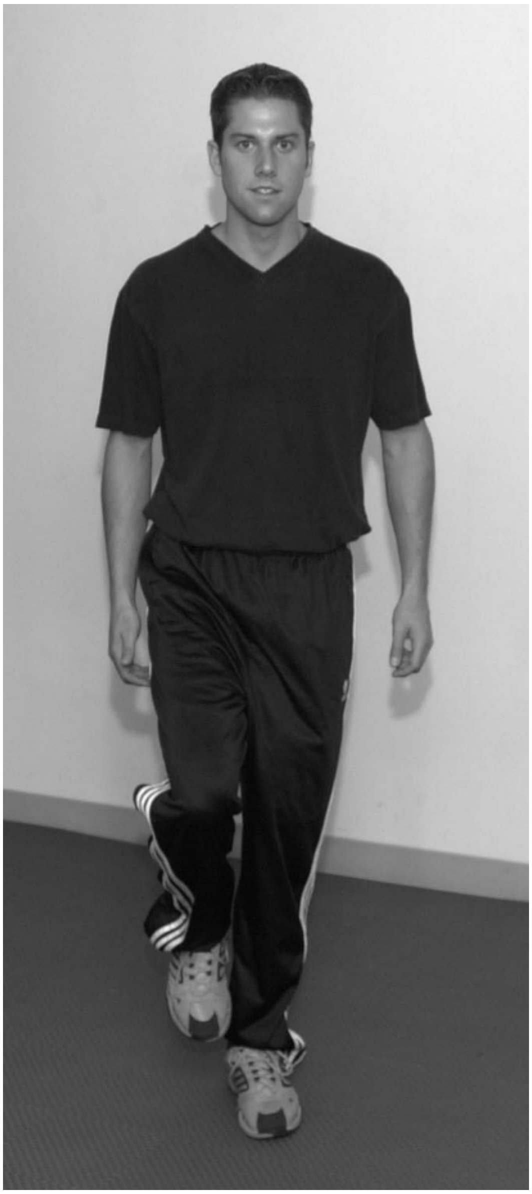

FIGURE 17.15. Unilateral stance with emphasis on keeping pelvis level with isometric gluteal contraction.

Endurance

Cardiorespiratory endurance activities can be initiated in Phase I with upper body ergometry. In Phase II, other aerobic activities can include stationary cycling, deepwater walking, swimming, elliptical walking, or supported stepping. The cross-country skiing motion needs to be avoided, as it may place the hip into hyperextension in one direction and overload the hip flexors in the other direction. In swimming, the flutter kick is preferred over the frog kick, which may elicit pain.

Phase III–Return to Function and Late Rehabilitation

The majority of patients are ready for Phase III activities after 4–6 weeks, however some athletes may be back to sport by this time, having accelerated through Phase II. Again, progression to this phase is possible when joint motion is normalized, baseline strength is restored, and gait is efficient. The time frame can vary for different patients. Impairments may include decreased muscle extensibility; impaired muscle strength, power, and endurance; diminished proprioceptive sense; and decreased cardiovascular endurance. Functional limitations apparent at this time are inability to squat, stoop, lunge, or pivot; and inability to participate in sports and moderate to heavy physical work duties, such as climbing, lifting, jumping, and carrying.

The goals for Phase III are to: Normalize muscle and joint mobility; increase muscle strength, power, and endurance; improve neuromuscular control; and return to sport and full work activitites.

Treatment Intervention

This phase brings us toward the top of Fagerson's treatment pyramid.[7] With proprioceptive drills and specific training, the patient should be able to return to normal function. Therapy intervention involves designing exercises to produce the desired joint motions and muscle contractions. Utilization of the SAID principle is indicated throughout the course of treatment, but is essential in this phase. SAID is the acronym for specific adaptations to imposed demands.[4] This principle allows the tissues to adapt and remodel according to the stresses placed on them. Training should reflect the specific demands of the functional task. For example, if the patient's job involves jumping, plyometric training needs to be included. If the patient is a dancer, stretching needs to be both static and ballistic.

Mobility

More advanced and sustained stretching may now be incorporated to regain full functional flexibility. Static stretching

FIGURE 17.16. Stretching of the iliopsoas.

of the iliopsoas beyond neutral hip extension can be performed in a variety of positions: half-kneeling (Figure 17.16.), and standing or supine with the leg lowered beyond the level of the table. Three-dimensional, sport-specific, and yoga-type stretches can allow for more functional mobility.

Stability

Building upon baseline strength through a variety of resistive devices helps return the muscles to more normal power. Muscles also need to be trained in the range of movement where they will be used. Resistive weight training can include using machines such as the rotary hip, leg press, and calf raise. Leg pulleys or resistive band exercises are more high level, as there is less stability inherent in the position. With unilateral leg pulley or resistive band exercise, performing an isotonic contraction on one side requires a strong stabilizing contraction of the contralateral weightbearing limb. (Figure 17.17.) These hip exercises should include straight plane extension, adduction, and flexion, as well as combined movement or diagonal patterns. Single-leg stance exercises can be made more challenging and functional with activities such as lateral step-ups, step-downs, and retro-steps. (Figure 17.18.). These should be performed slowly and with good eccentric control. Forward or backward lunging often presents a challenge to the post–hip arthroscopy patient with articular wear in the anterior superior acetabular surface. However, control and full excursion of this movement are essential for higher-level functional and sport activities. (Figure 17.19.) Other closed kinetic-chain-type exercises with the slide board or Fitter prepare the patient for return to sport, as they mimic skating and skiing, respectively.

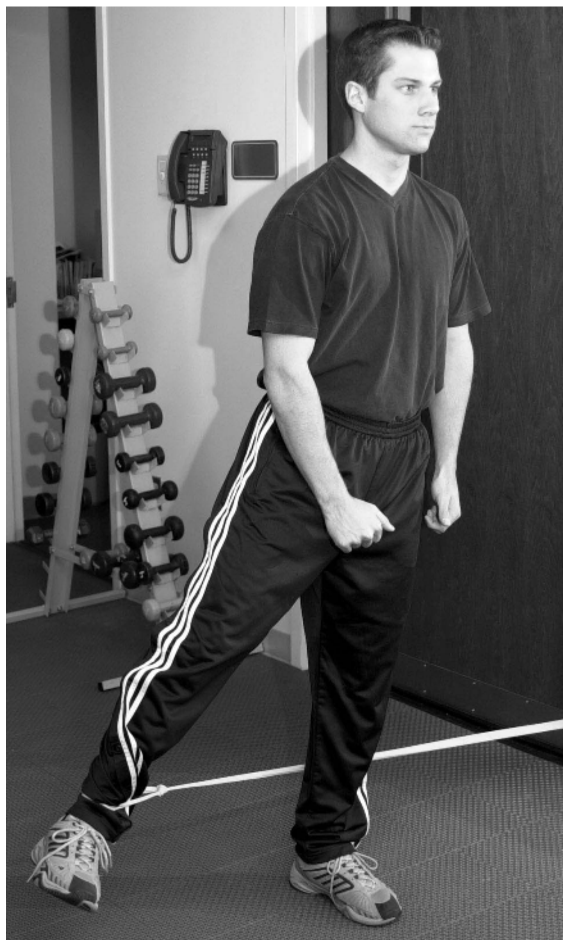

FIGURE 17.17. Isotonic right hip strengthening with simultaneous left hip stabilization.

FIGURE 17.18. Forward step down keeping optimum alignment.

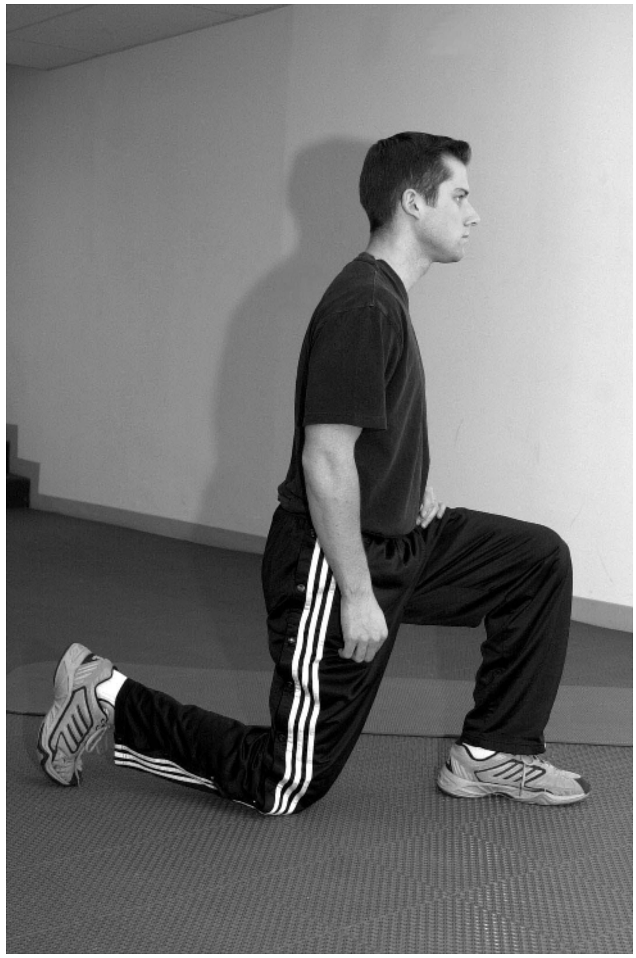

FIGURE 17.19. Advanced forward lunge.

Proximal control and trunk stability are essential to any sport or physical activity. More advanced physioball exercises, such as hip extension with the legs supported on the ball, facilitate much muscle overflow to the trunk. Push-ups, sit-ups, and double leg lifts also target the trunk musculature in a stabilizing contraction. Holding a medicine ball while performing multijoint movements such as squatting further challenges the trunk musculature while promoting balance reactions.

Plyometrics are exercises that enable a muscle to generate explosive power by utilizing the stretch–shortening cycle of muscle contraction. They begin with a rapid stretch or eccentric contraction that increases muscle tension and facilitates the subsequent concentric contraction of the targeted muscle group. This type of training begins with simple activities such as walking or running, and then progresses to hopping and jumping bilaterally, then unilaterally. Due to the high physiological demand of plyometric training, this should be performed only one to three sessions per week with low repetition and low intensity initially.[33] These activities are not recommended if the patient was diagnosed through arthroscopy with significant degenerative joint disease of the hip.

Restore Neuromuscular Control

Proprioceptive training has been included in all the phases of rehabilitation. In this phase of training, more difficult activities should be introduced. Standing-on such devices as balance boards, wobble boards, and mini trampolines while performing squats or upper extremity exercise further challenges the patient's neuromuscular system. Dynamic joint stabilization exercises, such as diagonal lunging or reaching, create self-perturbations of balance. Agility training programs such as backwards running, lateral stepping, cutting, and pivoting and stopping movements will further train the patient to return to their sport or functional activity.[34]

Conclusion

For full recovery to function, the post hip arthroscopy patient should undergo an individualized rehabilitation program based on perioperative impairments, intra-articular pathology, and functional limitations. Treatment interventions should address the postoperative sequelae and any preoperative movement compensations. The focus of treatment begins with the reduction of pain and swelling, progresses to increasing mobility and strength, and concludes with recovery of function. Return to full function after hip arthroscopy progresses best when the faulty movement patterns are normalized, and normal proprioception and use of the hip are restored. Programs should allow for individual differences and should not be time-based. More research needs to be done to assess the efficacy of these treatment interventions in returning patients to full function. As the utilization of hip arthroscopy continues to grow, so should the understanding and development of rehabilitation protocols and techniques.

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18
Complications of Hip Arthroscopy

John J. Wixted, Brian D. Busconi, and Brett D. Owens

Hip arthroscopy is a technically challenging procedure even for experienced surgeons. The procedure has advanced in recent years from a diagnostic to a theraputic modality with applications in the treatment of labral tears, loose bodies, and chondral injuries, among others.[3,7,5,12] Inherent difficulties related to hip anatomy, coupled with the technical limitations of the current equipment, make careful consideration of the complications of hip arthroscopy an important part of preoperative planning and sucessful operative execution. Understanding the anatomy of portal placement can help limit direct nerve or vessel injury while entering the joint. Other complications in this procedure can be broadly grouped into traction-related injuries, fluid extravasation complications, iatrogenic intraoperative complications, and postoperative complications.

Anatomic Considerations

The inherent structure of the hip as a constrained ball-and-socket joint poses unique challenges in hip arthroscopy. As noted by Sampson,[13] the deep nature of the joint and the dense surrounding muscle, tendon, fascia, and fat make access to the joint difficult. The generally accepted portals for hip arthroscopy include the anterior, anterolateral, and posterolateral.[14] The nerves and vessels at risk while establishing these portals bear special consideration.

The anterolateral portal is generally accessed first, as it is felt to be most centrally located in the "safe zone."[3] The entry site, at the anterior margin of the greater trochanter with the leg in neutral rotation, puts only the superior gluteal nerve at risk. Anatomic studies by Bryd et al[4] indicate the nerve to be 4 cm or more away from the correct portal position. Placing the anterolateral portal at the anterior margin of the trochanter takes advantage of femoral anteverison to allow for anterior access to the joint near its lateral margin. The superior gluteal nerve, running along the deep surface of the gluteus medius, is generally well away from the portal site.[4]

Prepositioning for the anterior portal is generally accomplished with the use of a spinal needle. Structures at risk during introduction of the anterior portal include the femoral nerve, branches of the lateral femoral cutaneous nerve, and the ascending branch of the lateral femoral circumflex artery, including terminal branches of the vessel.[4] To place a portal, a line is drawn from the anterior superior iliac spine distally. A second line originating at the superior aspect of the greater trochanter is drawn, and the correct anterior portal postion lies at the intersection.[14] This keeps the portal lateral to the iliopsoas tendon, with the femoral nerve passing medial to this postion. Additionally, the portal remains superior to the ascending branch of the lateral circumflex femoral artery. The branches of the lateral femoral cutaneous nerve are felt to be at highest risk from the skin incision for the portal.[4,14]

Finally, the posterolateral portal is established by entering at the superolateral margin of the greater trochanter and accessing the joint along the neck of the femur.[14] Anatomic studies of portal placement indicate this to be 3 cm away from the sciatic nerve, which is most closely at risk during establishment of the posterolateral portal. The posterolateral portal should be generally parallel to the anterolateral portal, which can be helpful in avoiding potential nerve injury.

Traction-Related Injuries

Most of the reported complications in the literature regarding hip arthroscopy have been related to traction-induced neuropraxias. Byrd found 20 complications in a meta-analysis of

1491 cases, half of which were neuropraxias.[2] In Sampson's recently reported series, 20 neuropraxias were noted in 530 cases.[13] The nature of the hip joint requires greater traction on the limb than is used for other arthroscopic procedures, and effective traction is critical for success of the procedure. Byrd has reported using 25–50 pounds of traction,[3] while Glick reports using 50–75 pounds.[7] In Sampson's series of 530 patients, all cases of neuropraxias occurred from prolonged traction times of 5–6 hours on complex cases, and Sampson recommends using less than 50 pounds of traction, for less than 2 hours, as a general rule.[13]

In general, neuropraxias can be a result of either distraction or compression. Distraction neuropraxias have been reported[2,6,13] in the femoral, sciatic, and lateral femoral cutaneous nerves. These neuropraxias are generally transitory, resolving within hours to days. Careful attention to small technical points may decrease the incidence of these nerve distraction injuries. Both Byrd[3] and Glick et al[8] recommend use of a tensiometer to measure relative traction to the limb. Glick also notes that in performing the procedure from the lateral position on the fracture table, care should be exercised not to flex the leg forward around the vertical post, thus placing the sciatic nerve in extreme stretch.[7] Sampson also notes that patients present with varying amounts of baseline laxity in their soft tissues. Failing to recognize this in patients with a great deal of laxity can lead to overdistraction and subsequent neuropraxia.[13]

Compression-type neuropraxias and soft tissues injuries are also recognized complications of hip arthroscopy. Most commonly, the pudendal nerve is compressed by the perineal post. Lyon et al[11] recommend the perineal post be at least 9 cm in diameter to distribute the compressive force more evenly and to limit the chances of direct nerve compression injury. Funke and Munzinger[6] reported several complications related to the perineal post, including pudendal nerve palsy, perineal fluid extravasation, and labial hematomas. Most authors[3,6,7,11,13] advocate using a wide and well-padded post as the most effective method to reduce these complications.

Fluid Extravasation

Complications related to fluid extravasation are uncommon, but this has been reported to occur in the perineum and the thigh, as well as intra-abdominally. Sampson's series included nine fluid-related complications; the author recommends close monitoring of outflow to minimize complications.[13] Byrd's review of 1491 patients included three patients who required paracentesis from intra-abdominal fluid extravasation.[2] He recommends high-flow, low-pressure fluid systems to avoid this problem.[3] In one particularly severe instance, Bartlett et al[1] reported a case of cardiac arrest resulting from fluid extravasation, causing prolonged asystole in a patient who had had arthroscopy for loose bodies following an acetabular fracture. While the incidence of complications related to fluid extravasation is small, careful monitoring of outflow and fluid volume may help to limit this potentially serious problem.

Iatrogenic Intraoperative Complications

Labral damage and perforation have been among the most commonly reported iatrogenic complications. These can occur with errant placement of portals.[14] If portal placement is not accurate or not done under proper visualization, it is possible to place the cannula directly through an otherwise uninjured labrum. Careful prepositioning of portals with spinal needles, inserting the cannula under direct visualization, and maintaining sufficient traction can all aid in limiting this potentially serious complication.

Manipulation of instruments within the hip joint can lead to either scuffing of the femoral head or breakage of the instruments.[6,9,13] While excessive traction has clearly been shown to increase the risk of neuropraxias, inadequate traction or poor arthroscopic technique can lead to inadvertant damage to articular cartilage. This can occur on either the femoral or the acetabular side.

Third-body damage can also occur during hip arthroscopy from broken instruments. Use of plastic cannulae can contribute to this problem, and for that reason the author advocates using only metallic sheaths. Furthermore, given the depth of the hip joint and its surrounding soft tissues, the arthroscopic instruments are subject to forces not commonly encountered in other joints. All instruments should be passed through metallic sheaths to minimize damage to the instruments and the hip.

Finally, careful attention must be paid to patients whose hips may be unstable. One of the indications for hip arthroscopy is removal of loose bodies.[3,12] If the loose bodies result from a fracture dislocation of the joint, early arthroscopy can result in redislocation of the joint from the distraction necessary to perform the procedure. The senior author recommends waiting a minimum of 3 weeks following dislocation and reduction in these situations to allow for early repair of the capsule and soft tissue stabilization around the joint.

Postoperative Complications

The majority of postoperative complications with hip arthroscopy are similar to those seen with other arthroscopic procedures. While deep venous thrombosis is a potential complication of surgery to almost any extremity, it has not been reported to date. One case of reflex sympathetic dystrophy was also reported as a late complication.[10]

Some late postoperative complications appear to be unique to the hip. Byrd reported one case of myositis ossificans around a portal tract.[3] Of more concern was a case reported by Sampson of avascular necrosis of the femoral head. The patient, who had fallen off a roof and had undergone routine hip arthroscopy with partial labrectomy and debridement for minor arthritis, presented 7 months later with avascular necrosis and subsequently underwent core decompression.[13] How much the partial labrectomy and distraction of his hip during arthroscopy contributed to his condition is unclear; nonetheless, late-presenting avascular necrosis must be considered a theoretical risk of the procedure.

Discussion

While hip arthroscopy is challenging to perform well, modifying established techniques to minimize associated complications can improve outcomes. Byrd,[3] Sampson,[13] and Funke et al[6] report complications related to neuropraxias; pudendal nerve damage, scrotal swelling, and labial tears are among the complications reported from use of the traction post. The author has modified his position technique and currently uses the lateral position, with the patient positioned using a beanbag. The patient's torso is taped at multiple points to the beanbag and the operating room table, and the down leg is padded and taped as well. This secures the patient to the table at multiple points, minimizing the effect of traction at any one point and eliminating the need for a traction post against the perineum. Adequate distraction can still be obtained, and in a recent review of the author's cases there were no neuropraxias.

Fluid extravasation complications are also commonly reported.[1,2,6] Both Byrd[3] and Sampson[13] suggest close monitoring of the fluid system to minimize this complication. In the authors' experience, this complication is best minimized by limiting the time of surgery. Sampson also notes that this is likely a time-dependent phenomenon;[13] Glick[7] recommends treating traction like a tourniquet, with a maximum of 2 hours' duration. The author generally keeps the procedure to less than an hour and a half; with experience in timely and accurate portal placement, nearly all procedures can be kept to this time frame.

Last, iatrogenic complications also commonly occur. Some, such as portal placement through the labrum, can be avoided with accurate and careful technique. Some scuffing of the head or articular surface may be unavoidable, given the constrained nature of the joint. On the other hand, instrument breakage is clearly avoidable. Passing all instruments through cannulae and strictly avoiding disposable, plastic cannulae can help to minimize this problem.

Summary

Hip arthroscopy has been shown to be safe and effective, and to have a very low complication rate. By far the most common complication is transient neuropraxia, generally understood to be traction-related. Other potential complications include intra-abdominal or intracompartmental fluid extravasation, iatrogenic mechanical damage to the joint, and other more infrequent, late complications. Careful attention to patient positioning, accurate portal placement, and proper arthroscopic technique, including judicious fluid management, can all contibute to limiting the complication rate to an absolute minimum.

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19
Outcomes

Christian P. Christensen, Joseph C. McCarthy, Murray A. Mittleman, Peter Althausen, and Jo-ann Lee

During the past half century, multiple scoring systems have been devised to evaluate arthritic hip pain and measure improvement after arthroplasty. The D'Aubigne and Postel hip score[5] often is used in hip evaluation in Europe, whereas the Harris hip score[8] is the most frequently used method of quantifying hip arthritis in the United States. These scores focus on evaluating hip pain and function in elderly patients with degenerative joint disease. These two hip scores are relatively simple and continue to be used in modified forms to evaluate advanced arthritis of the hip.

The emergence of hip arthroscopy has required clinicians to struggle to find a way to communicate with patients and other physicians about hip pain and function in a younger, more athletic population. Some surgeons have applied the Harris or the D'Aubigne hip scores to this younger population.[15] Some clinicians measure outcome by whether or not the young patient has been able to return to sport or resume an activity following hip rehabilitation or arthroscopy.[6] Others have simply asked the patient whether or not they were better after physical therapy or operative intervention.[6]

As the authors' experience involving young, active patients with activity-limiting hip pain increased, we decided that a new scoring system was needed to assess these patients. This score was needed to measure improvement after treatment, to facilitate communication with other physicians, and to offer patients a more accurate prognosis before surgery. The Harris hip score was not appropriate for these patients because, although many have severe pain, all of them can go up and down stairs, cut their toenails, and take public transportation, and rarely do any of them require supplemental devices for ambulation. The Short Form-36 Health Survey (SF-36) and Short Form-12[9] Health Survey (SF-12)[11,16] are excellent measures of global wellness and function, but these tools were not specific enough to measure the condition and subsequent improvement of these patients. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[2] is an excellent scoring system that is used for measuring pain, stiffness, and physical function in patients with arthritis. Although this test is self-administered, simple, reliable, and validated, it is geared toward older patients with advanced degenerative joint disease and is too nonspecific for younger patients. The MODEMS Hip/Knee Questionnaire,[1] created by the American Academy of Orthopaedic Surgeons and the American Association of Hip and Knee Surgeons, was thought to be too long and also too focused on arthritis and degenerative joint disease for the purpose of younger patients.

Materials and Methods

Questionnaire Development

Recognizing the importance of the aforementioned scoring systems, yet realizing their limitations, we created a new system to measure preoperative and postoperative hip pain and function in a younger, more athletic population. The scoring system is self-administered so that patients can complete it without physician or nursing bias. The score is symptom-related only, requiring no physical examination parameters that could introduce bias to the score. Only unweighted questions were included, because weighting the questions automatically introduces a preconceived bias from the medical staff. The questionnaire is concise in order to maximize patient compliance. It also is easily computed by the medical staff to maintain usefulness and accuracy. Patients are given clear choices that are mutually exclusive, collectively exhaustive, and ordered in a hierarchical manner to cut down on patient confusion and improve accuracy.[3]

Input from patients, surgeons, physical therapists, and epidemiologists was synthesized to understand what was necessary to create an appropriate scoring system. Ultimately, a modified Western Ontario and McMaster Universities Osteoarthritis Index was created called the nonarthritic hip score. (See Appendix 1.) This scoring system includes 20 multiple-choice questions, each having the same five responses. Similar to the Western Ontario and McMaster Universities Osteoarthritis Index, each of the answers corresponds to a particular numerical value, and the values are added up at the end of the test and multiplied by 1.25 to arrive at a final score. The maximum score is 100, indicating normal hip function. This score is divided into four domains: pain, mechanical symptoms, physical function, and level of activity. All 10 questions measuring pain and physical function come directly from the Western Ontario and McMaster Universities Osteoarthritis Index. Four additional questions deal exclusively with mechanical symptoms involving the hip, because it has been reported that painful clicks and locking episodes of the hip are associated with labral injuries and loose bodies.[12] The fourth set of questions measures activity level. In this section, the levels of activity that the patient participates in before and after intervention are identified.

The nonarthritic hip score is designed to be extremely sensitive in order to discriminate among high levels of activity. This scoring scheme is aimed at 20- to 40-year-old patients with hip pain without obvious radiographic diagnosis.

Pilot testing initially was done with the questionnaire being given to patients of varying educational levels, and to health professionals. The questions and answers were then discussed with the participants to ensure that all the questions were clear. This preliminary testing affected the manner in which a few of the questions were asked, but it did not affect the content of the questionnaire. The results of this pilot phase are not included in this report.

Statistical Analysis

Similar to prior studies validating scoring systems, it was hypothesized that the scales were reproducible, internally consistent, and valid because these properties are necessary for a scoring system used to measure health status.[10] Reproducibility assesses the stability of the outcome measure by checking test and retest reliability. It reflects the ability of the instrument to give the same result when the test is administered to the same patient at different times. The test and retest reliability was assessed from data on a random sample of 17 patients using the Pearson correlation coefficient.[13] A Pearson correlation coefficient of zero indicates no correlation (no reproducibility), whereas a coefficient of 1.0 indicates perfect agreement (exact reproducibility).[14] Each of these patients received a nonarthritic hip score questionnaire 1–2 weeks before their appointment. After completing the form and dating it, they mailed the questionnaire back to the office. When they arrived at the office for their clinic appointment, they were instructed to complete another nonarthritic hip score before seeing the physician. The test and retest data from all 17 patients were then used to calculate the Pearson correlation coefficient using a Microsoft Excel spreadsheet.

Internal consistency reflects the ability of a series of questions to measure a similar concept. In the nonarthritic hip questionnaire, pain, mechanical symptoms, physical function, and the ability to participate in varying levels of activity are the four concepts that are measured. The internal consistency of the scales was assessed for each of the four domains with Cronbach's coefficient alpha[4] on cross-sectional data from all 48 patients. A Cronbach's coefficient alpha of 1.0 indicates that there is perfect correlation between all the questions included in the series, and that they all measure one coherent concept. A value of 0.8 is considered good, and a value of 0.9 is excellent.[7]

Validity refers to whether the instrument is actually assessing what it is intended to measure. Ideally, validity is checked by comparing the new outcome measure with a gold standard that is easily quantified and corresponds to a known outcome. In this study, validity was assessed on 48 patients using a Pearson correlation coefficient and comparisons between the nonarthritic hip score, the Harris hip score, and the Short Form-12, respectively. The Harris hip score was chosen because it is a well-accepted measure of hip performance in the orthopedic literature, even though it is not validated and its answers are arbitrarily weighted.[15] The Short Form-12 was chosen because it is short, reliable, validated, and is a well-accepted measure of global health status.[16]

Prospective Cohort

The internal consistency and validity were checked by prospectively studying 48 consecutive patients (29 females and 19 males) with an average age of 33 years (range, 16–45 years) who were referred with intractable hip pain. Reproducibility was studied prospectively on another 17 consecutive patients (11 females and 6 males) with a mean age of 32 years, who also were referred with intractable hip pain. Plain radiographs, including an anteroposterior (AP) view of the pelvis and an AP and lateral view of the affected hip, showed no abnormalities in any patients. There were 100 points available per patient, with 20 questions broken into 4 domains regarding pain, current symptoms, physical function, and the ability to participate in varying levels of activity.

Results

Reproducibility

The mean length of time between the test and the retest was 5.5 days (range, 1–16 days). The reproducibility, or test and retest reliability, was 0.96 overall and ranged from 0.87 to 0.95 for each of the four sections. Specifically, the Pearson correlation coefficient for the pain subset was 0.92, the mechanical symptom section was 0.87, the physical function portion was 0.92, and the coefficient was 0.95 for the questions pertaining to the ability to perform certain levels of exercise (Table 19.1.). The minimum Pearson correlation coefficient for any question in the pain section was 0.63, for the mechanical symptom section 0.72, for the physical function section 0.84, and for the ability to perform certain levels of exercise section, 0.81. (Table 19.1.)

Table 19.1. A. Pearson value for pain questions.

P1	P2	P3	P4	P5	Mean
.90	.89	.63	.79	.76	.92

Table 19.1. B. Pearson Value for Mechanical Symptoms Questions

Sx1	Sx2	Sx3	Sx4	Mean
.97	.72	.73	.86	.87

Table 19.1. C. Pearson value for physical function questions.

Pf1	Pf2	Pf3	Pf4	Pf5	Mean
.93	.87	.87	.88	.84	.92

Table 19.1. D. Pearson Value for Level of Activity Questions

Ex1	Ex2	Ex3	Ex4	Ex5	Ex6	Mean
.89	.89	.93	.82	.81	.88	.95

Internal Consistency

The internal consistency ranged from 0.69 to 0.92 for each of the four sections. Specifically, the Cronbach alpha was 0.87, 0.69, 0.85, and 0.92 for the pain, mechanical symptom, physical function, and type-of-activity subsets, respectively. (Table 19.2.) This indicates good interquestion correlation on the mechanical symptom section and excellent interdependence of the items in each of the other three domains. This reflects that all of the questions within each subset are consistently directed at measuring a similar underlying concept.

Validity

Of the 48 patients asked to complete all three scores to validate the nonarthritic hip score, 48 successfully completed the nonarthritic hip score, 46 the Harris hip score, and 43 the Short Form-12. The preoperative mean nonarthritic hip score was 56.0 ± 18.1 (range, 12.5–92.5). For the same patients, the Harris hip score was 61.2 ± 16.6 (range, 24–96) and the SF-12 had a mean score of 81.9 ± 10.9 (range, 22 ± 56). The Pearson correlation coefficients were 0.82 and 0.59 between the nonarthritic hip score and the Harris hip score and Short Form-12, respectively. This shows excellent correlation with the Harris hip score and good correlation with the Short Form-12. The correlation of the nonarthritic hip score and the physical and emotional portions of the SF-12 was 0.37 and 0.51, respectively. The Pearson correlation coefficient between the Harris hip score and each subset of the nonarthritic hip score was 0.73 for pain, 0.61 for mechanical symptoms, 0.73 for physical function, and 0.76 for the ability to participate in varying levels of activity. (Table 19.3.)

Table 19.2. Cronbach alpha for internal consistency.

Pain	Mechanicals symptoms	Physical function	Activity level
.87	.69	.85	.92

Table 19.3. Pearson correlation harris hip score.

Pain	Mechanical symptoms	Physical function	Activity level
.73	.61	.73	.76

Discussion

The application of arthroscopy to the hip and the development of magnetic resonance imaging (MRI) with contrast of the hip during the past decade have provided the orthopedic surgeon with the opportunity to treat a previously underserved subset of patients. Previously, young patients with hip pain and normal radiographs were treated with nonsteroidal anti-inflamatory drugs, physical therapy, and, occasionally, a cortisone injection. Patients in whom these modalities failed often were told that nothing was wrong, but were left with activity-limiting hip discomfort.

Today's hip arthroscopist has the opportunity not only to diagnose the source of pain for these patients using advanced MRI technology, but also to successfully treat these people at the time of arthroscopy. The development of this technology has created a need for a way to measure outcomes after conservative therapy and operative intervention. A measuring tool is needed to document outcomes, facilitate communication between physicians, and, most important, to allow the treating physician to give the patient an accurate prognosis.

The existing instruments for measurement of outcomes pertaining to the nonarthritic hip are not specific or concise enough for application to young and active patients. The nonarthritic hip score is short and easy to understand, to maximize compliance. The questionnaire takes approximately 5 minutes to complete, consisting of only 20 multiple-choice questions, all with the same five potential answers. It is self-administered, and all of the questions are equally weighted, therefore reducing the bias that can be introduced by the health care team. Finally, the nonarthritic hip score is similar to the Western Ontario and McMaster Universities Osteoarthritis Index, so the instrument is easily reproducible, internally consistent, valid, and responsive to clinical change.

Reproducibility reflects the ability of the measuring tool to give the same result when the test is given at different times, assuming no clinical change between test administrations. The high level of reproducibility in this study would likely have been higher if a shorter interval had been used between test administrations than the mean of 5.5 days in this study, because some patients may actually have experienced a true clinical change (a reduction in pain) between tests. However, with shorter intervals between tests, there is an increasing risk that reproducibility may be elevated falsely, because the patient may actually recall the answers given during the initial test administration.

The lowest Pearson correlation coefficient for any question was 0.63 for the third question in the pain subset, which queries the amount of pain that the patient is having at night while in bed. This question is similar to one on the Western Ontario and McMaster Universities Osteoarthritis Index, differing only in that it refers specifically to hip pain. The next lowest value was 0.72 for the second question in the mechanical symptom section.

Internal consistency reflects the ability of a series of questions to measure a similar, consistent concept, and it is measured using the Cronbach alpha. This study had good internal consistency within the questions comprising the mechanical symptom section, and excellent internal consistency within the items in each of the other three subsets. After reexamining the data and the questionnaire, it was not surprising that the internal consistency of the questions in the mechanical symptoms subset was not as great as that of the other subsets. This section asks four fairly different questions reflecting the most frequent complaints reported by this patient population. It is possible that a patient with a labral tear could have severe locking or catching in the hip, but also have normal motion and little or no stiffness in the hip. Likewise, it is possible for a patient with synovitis to have stiffness and reduced motion without any catching or locking. Although these questions are not completely consistent and interrelated, they are necessary to completely evaluate this patient population. Furthermore, the questions in this section are somewhat related, and a low score in this section reflects intense symptomatology.

Validity refers to whether the instrument is actually assessing what it is intended to measure. The high Pearson correlation coefficient of 0.82 between the nonarthritic and the Harris hip scores shows that both scores measure similar characteristics. This close relationship validates the nonarthritic hip score using the American gold standard in hip assessment. Despite the similarities between the two scores, these two outcome measures are structured quite differently, and the questions are directed at very different populations.

The Pearson correlation coefficient between the Harris hip score and each subset of the nonarthritic hip score was 0.73 for pain, 0.61 for mechanical symptoms, 0.73 for physical function, and 0.76 for ability to participate in varying levels of activity. The high correlation between the pain subset and the Harris hip score was expected, since the latter allocates 44 points out of 100 possible points (44%) to one question regarding pain. The lowest correlation exists between the mechanical symptoms subset and the Harris hip score, because the latter does not ask questions pertaining to the hip catching, locking, or giving way.

The correlation of the nonarthritic hip score with the Short Form-12 was similar to the correlation of the Harris hip score with the Short Form-12. The coefficients were 0.59 and 0.63, respectively. This level of correlation was expected, because the nonarthritic and Harris hip scores measure hip function and the Short Form-12 measures global wellness. The correlation of the nonarthritic hip score and the physical and emotional portions of the Short Form-12 were 0.37 and 0.51, respectively. Greater congruency with the physical portion of the Short Form-12 would have been expected, because the questionnaire does not have any questions regarding feelings and emotions. The authors concluded that the relatively low correlation results from the fact that the physical portion of the Short Form-12 does not ask any questions pertaining specifically to the hip. Moreover, these patients often are frustrated and scared after having seen multiple physicians without significant improvement. This may explain the modest correlation between the nonarthritic hip score and the emotional portion of the Short Form-12.

Responsiveness to clinical change of the nonarthritic hip score is being studied and compared with the Harris hip score and the Short Form-12. Patients are being assessed before hip arthroscopy and again 6 months postoperatively. In addition to completing the three scores preoperatively and 6 months after surgery, the patients also must complete a short patient-satisfaction questionnaire postoperatively to help determine which score is the most sensitive to change. Once there is an instrument that is reliable, valid, and sensitive to clinical change, it will be possible to understand which diagnoses respond best to hip arthroscopy.

This short, self-administered questionnaire evaluating hip pain in young patients with increased activity demands and high treatment expectations is reproducible, internally consistent, and valid compared with previous measures of hip performance. This measurement device can be used to assess patients with nonarthritic hip pain both before intervention and after treatment. In addition, it can be used to record outcomes and facilitate communication between physicians who treat this challenging group of patients.

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Appendix 1:

Nonarthritic Hip Score

INSTRUCTIONS: The following five questions concern the amount of pain you are currently experiencing in the hip that you are having evaluated today. For each situation, please circle the response that most accurately reflects the amount of pain experienced in the past 48 hours. Please circle one answer that best describes your situation.

Question: How much pain do you have—

1. Walking on a flat surface?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
2. Going up or down stairs?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
3. At night while in bed?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
4. Sitting or lying?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
5. Standing upright?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme

INSTRUCTIONS: The following four questions concern the symptoms that you are currently experiencing in the hip that you are having evaluated today. For each situation, please circle the response that most accurately reflects the symptoms experienced in the past 48 hours. Please circle **one** answer that best describes your situation.

Question: How much trouble do you have with—

1. Catching or locking of your hip?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
2. Your hip giving out on you?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
3. Stiffness in your hip?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
4. Decreased motion in your hip?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme

INSTRUCTIONS: The following five questions concern your physical function. For each of the following activities, please circle the response that most accurately reflects the difficulty that you have experienced in the past 48 hours because of your hip pain. Please circle **one** answer that best describes your situation.

Question: What degree of difficulty do you have with—

1. Descending stairs?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
2. Ascending stairs?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
3. Rising from sitting?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
4. Putting on socks/stockings?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
5. Rising from bed?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme

INSTRUCTIONS: The following six questions concern your ability to participate in certain types of activities. For each of the following activities, please circle the response that most accurately reflects the difficulty that you have experienced in the past **month** because of your hip pain. *If you do not participate in a certain type of activity, please estimate how much trouble your hip would cause you if you had to perform that type of activity.* Please circle one answer that best describes your situation.

Question: How much trouble does your hip cause you when you participate in—

1. High-demand sports involving sprinting or cutting (for example, football, basketball, tennis, and exercise aerobics)
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
2. Low-demand sports (for example, golfing, and bowling)
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
3. Jogging for exercise?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
4. Walking for exercise?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
5. Heavy household duties (for example, lifting firewood and moving furniture)?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme
6. Light household duties (for example, cooking, dusting, vacuuming, and doing laundry)?
   4=none
   3=mild
   2=moderate
   1=severe
   0=extreme

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Conclusions and Future Directions

Joseph C. McCarthy

Application of arthroscopic techniques to the hip joint has been a long time in coming. The relative depth of the hip when compared to other joints, the curvilinear contours of the articular surfaces, the thickness of the capsule, and the intra-articular negative joint pressure have all contributed to making the hip joint, until recently, appear inaccessible. Improvements in distraction techniques, dedicated instruments for use in the hip, and developing surgical expertise, however, have surmounted the anatomic constraints such that now hip arthroscopy can, in skilled hands, be performed safely as an outpatient procedure.

The evolving body of knowledge regarding the acetabular labrum has clarified several previously unproven theorems. These facts include:

- Acetabular labral tears do occur.
- In the North American population, the tears are most frequently anterior and often associated with sudden twisting or pivoting motions. In the Asian population, tears are more frequently posterior, associated with hyperflexion or squatting motions.
- Labral tears may contribute to or can occur in association with articular cartilage lesions of the contiguous femoral head or acetabulum.
- No radiographic study, including high-contrast, gadolinium-enhanced arthro MRI scanning, is entirely sensitive or specific enough to diagnose a labral tear. Thus a high clinical suspicion in association with positive physical findings is paramount for the clinician to properly determine treatment for the suspected tear.
- Labral tears, especially those present for years, may indeed contribute to the progression of hip osteoarthritis. Patients at risk include those with developmental dysplasia, tears older than 5 years, and those with associated chondral full-thickness lesions.
- In the watershed lesion (a labral lesion associated with a contiguous acetabular chondral flap lesion), the concept of the effective joint space applies in the development of acetabular bony cysts. When a labral tear occurs at the watershed zone, it may destabilize the adjacent acetabular cartilage. When subjected to reciprocating loading conditions, joint fluid is pumped under pressure beneath the delaminating acetabular cartilage and eventually burrows beneath subchondral bone to form a subchondral cyst. The cyst, then, is tacit evidence of the intra-articular lesion.

Each of these factors regarding the acetabular labrum represent an evolving corpus of information that further defines and clarifies our understanding of earlier stages of hip disease. All of these factors are testament to the importance of minimally invasive techniques to visualize and treat hip joint disease at an early stage.

While advances of the past decade allowing safe arthroscopic entry into the hip joint have been impressive, further developments in several areas will be important. Distraction equipment, whether for the lateral or supine position, should become both readily available and cost-effective. Surgical cannulae for portal access and maintenance will be tapered to minimize articular cartilage scuffing, telescoping to facilitate loose body removal, and rigid or pliable to allow passage of straight or curved instruments. Hand instruments for labral resection, loose body removal, or synovial biopsy need to be in a specific and hip-dedicated set. Motorized instruments need to be mated to the corresponding cannulae in length and diameter to prevent breakage. In addition, the blade configuration and aggressiveness need to match its hip-tissue-specific use. When necessary, curved shavers need to be coaxial with the convexity of the femoral head.

The recent use of laser and electrothermal tools in arthroscopy has allowed considerable refinement in tissue resection techniques. These powerful tools must be used judiciously to avoid thermal necrosis. In addition their design, length, pliability, and energy delivery need to be optimized for hip-specific purposes.

Arthroscopic optical systems will also evolve. Advancements in fiberoptics will allow smaller-diameter, flexible, steerable, wide-angle visualization of the joint. This miniaturizaiton may allow mating to the treating instruments, thus eliminating triangulation parallax.

Most important, educational efforts will evolve and expand. It is incumbant on those with experience in hip arthroscopy to facilitate resident, fellow, and peer education. Workshops at the local, regional, and national levels allow hands-on experience to shorten the learning curve for this challenging procedure.

The ultimate role that hip arthroscopy will play in the armamentarium of orthopedic surgery will be predicated on the development and use of dedicated-outcome instruments, such as those presented in Chapter 19. In addition, articles published in peer-reviewed journals with sufficient patient volume and follow-up will refine patient and physician expectations. Books such as this provide a comprehensive resource, for all health care providers, of the ever-increasing advancements in diagnosing and treating early hip disease.

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