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Nonarthritic Hip Joint Pain

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Orthopaedic Section of the American Physical Therapy Association

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Recommendations*

RISK FACTORS: Clinicians should consider the presence of osseous abnormalities, local or global ligamentous laxity, connective tissue disorders, and nature of the patient's activity and participation as risk factors for hip joint pathology. (Recommendation based on expert opinion.)

DIAGNOSIS/CLASSIFICATION – NONARTHRITIC HIP JOINT PAIN: Clinicians should use the clinical findings of anterior groin or lateral hip pain or generalized hip joint pain that is reproduced with the hip flexion, adduction, internal rotation (FADIR) test or the hip flexion, abduction, external rotation (FABER) test, along with consistent imaging findings, to classify a patient with hip pain into the International Statistical Classification of Diseases and Related Health Problems (ICD) categories of **M25.5 Pain in joint**, **M24.7 Protrusio acetabula**, **M24.0 Loose body in joint**, and **M24.2 Disorder of ligament**, and the associated International Classification of Functioning, Disability and Health (ICF) impairment-based categories of hip pain (**b28016 Pain in joints**) and mobility impairments (**b7100 Mobility of a single joint**; **b7150 Stability of a single joint**). (Recommendation based on weak evidence.)

DIFFERENTIAL DIAGNOSIS: Clinicians should consider diagnostic categories other than nonarthritic joint pain when the patient's history, reported activity limitations, or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline or when the patient's symptoms are not diminishing with interventions aimed at normalization of the impairments of body function. (Recommendation based on expert opinion.)

EXAMINATION – OUTCOME MEASURES: Clinicians should use a validated outcome measure, such as the Hip Outcome Score (HOS), the Copenhagen Hip and Groin Outcome Score (HAGOS), or the International Hip Outcome Tool (iHOT-33), before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions in individuals with nonarthritic hip joint pain. (Recommendation based on strong evidence.)

EXAMINATION – PHYSICAL IMPAIRMENT MEASURES: When evaluating patients with suspected or confirmed hip pathology over an episode of care, clinicians should assess impairments of body function, including objective and reproducible measures of hip pain, mobility, muscle power, and movement coordination. (Recommendation based on moderate evidence.)

INTERVENTION – PATIENT EDUCATION AND COUNSELING: Clinicians may utilize patient education and counseling for modifying aggravating factors and managing pain associated with the nonarthritic hip joint. (Recommendation based on expert opinion.)

INTERVENTION – MANUAL THERAPY: In the absence of contraindications, joint mobilization procedures may be indicated when capsular restrictions are suspected to impair hip mobility, and soft tissue mobilization procedures may be indicated when muscles and their related fascia are suspected to impair hip mobility. (Recommendation based on expert opinion.)

INTERVENTION – THERAPEUTIC EXERCISES AND ACTIVITIES: Clinicians may utilize therapeutic exercises and activities to address joint mobility, muscle flexibility, muscle strength, muscle power deficits, deconditioning, and metabolic disorders identified during the physical examination of patients with nonarthritic hip joint pain. (Recommendation based on expert opinion.)

INTERVENTION – NEUROMUSCULAR RE-EDUCATION: Clinicians may utilize neuromuscular re-education procedures to diminish movement coordination impairments identified in patients with nonarthritic hip joint pain. (Recommendation based on expert opinion.)

*These recommendations and clinical practice guidelines are based on the scientific literature accepted for publication prior to January 2013.

Introduction

AIM OF THE GUIDELINES

The Orthopaedic Section of the American Physical Therapy Association (APTA) has an ongoing effort to create evidence-based practice guidelines for orthopaedic physical therapy management of patients with musculoskeletal impairments described in the World Health Organization's International

Introduction *(continued)*

Classification of Functioning, Disability and Health (ICF).[200]

The purposes of these clinical guidelines are to:

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention, and assessment of outcome, for musculoskeletal disorders commonly managed by orthopaedic physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization's terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of the individual
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payers and claims reviewers regarding the practice of orthopaedic physical therapy for common musculoskeletal conditions
- Create a reference publication for orthopaedic physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of orthopaedic physical therapy

STATEMENT OF INTENT

These guidelines are not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made in light of the clinical data presented by the patient; the diagnostic and treatment options available; and the patient's values, expectations, and preferences. However, we suggest that significant departures from accepted guidelines should be documented in the patient's medical records at the time the relevant clinical decision is made.

Methods

Content experts were appointed by the Orthopaedic Section, APTA as developers and authors of clinical practice guidelines for musculoskeletal conditions of the hip that are commonly treated by physical therapists. These content experts were given the task to identify impairments of body function and structure, activity limitations, and participation restrictions, described using International Classification of Functioning, Disability and Health (ICF) terminology, that could (1) categorize patients into mutually exclusive impairment patterns on which to base intervention strategies, and (2) serve as measures of changes in function over the course of an episode of care. The second task given to the content experts was to describe the supporting evidence for the identified impairment-pattern classification as well as interventions for patients with activity limitations and impairments of body function and structure consistent with the identified impairment-pattern classification. It was also acknowledged by the Orthopaedic Section, APTA content experts that only performing a systematic search and review of the evidence related to diagnostic categories based on International Statistical Classification of Diseases and Related Health Problems (ICD)[199] terminology would not be sufficient for these ICF-based clinical practice guidelines, as most of the evidence associated with changes in levels of impairment or function in homogeneous populations is not readily searchable using the ICD terminology. Thus, the authors of this guideline independently performed a systematic search of MEDLINE, CINAHL, and the Cochrane Database of Systematic Reviews (1967 through January 2013) for any relevant articles related to classification, examination, and intervention strategies for nonarthritic hip joint pain. Additionally, when relevant articles were identified, their reference lists were hand searched in an attempt to identify other relevant articles. Articles from the searches were compiled and reviewed for accuracy by the authors. This guideline was issued in 2014 based on publications in the scientific literature prior to January 2013. This guideline will be considered for review in 2018, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Orthopaedic Section of the APTA website (www.orthopt.org).

LEVELS OF EVIDENCE

Individual clinical research articles were graded according to

Methods *(continued)*

criteria described by the Centre for Evidence-based Medicine, Oxford, UK (http://www.cebm.net) for diagnostic, prospective, and therapeutic studies.[154] If the 2 content experts did not agree on a grade of evidence for a particular article, a third content expert was used to resolve the issue. An abbreviated version of the grading system is provided below.

I	Evidence obtained from high-quality diagnostic studies, prospective studies, or randomized controlled trials
II	Evidence obtained from lesser-quality diagnostic studies, prospective studies, or randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, less than 80% follow-up)
III	Case-control studies or retrospective studies
IV	Case series
V	Expert opinion

GRADES OF EVIDENCE

The overall strength of the evidence supporting recommendations made in these guidelines was graded according to guidelines described by Guyatt et al,[66] as modified by MacDermid et al,[109] and adopted by the coordinator and reviewers of this project. In this modified system, the typical A, B, C, and D grades of evidence have been modified to include the role of consensus expert opinion and basic science research to demonstrate biological or biomechanical plausibility.

GRADES OF RECOMMENDATION	BASED ON	STRENGTH OF EVIDENCE
A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation
C	Weak evidence	A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies
E	Theoretical/foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic science/bench research supports this conclusion
F	Expert opinion	Best practice based on the clinical experience of the guidelines development team

REVIEW PROCESS

The Orthopaedic Section, APTA also selected consultants from the following areas to serve as reviewers of the early drafts of these clinical practice guidelines:

- Claims review
- Coding
- Rheumatology
- Hip pain rehabilitation
- Medical practice guidelines
- Manual therapy
- Movement science
- Orthopaedic physical therapy residency education
- Orthopaedic physical therapy clinical practice
- Orthopaedic surgery
- Outcomes research
- Physical therapy academic education
- Physical therapy patient perspective
- Sports physical therapy residency education
- Sports rehabilitation

Comments from these reviewers were utilized by the authors to edit these clinical practice guidelines prior to submitting them for publication to the *Journal of Orthopaedic & Sports Physical Therapy*. In addition, several physical therapists practicing in orthopaedic and sports physical therapy settings volunteered to provide feedback on initial drafts of these clinical practice guidelines related to the guidelines' usefulness, validity, and impact.

CLASSIFICATION

The primary ICD-10 codes associated with nonarthritic hip pain are **M25.5 Pain in joint**, **M24.7 Protrusio acetabula**, **M24.0 Loose body in joint**, and **M24.2 Disorder of ligament**.[199]

The corresponding ICD-9-CM codes and conditions are: **719.45 Joint pain**, **718.65 Unspecified intrapelvic protrusion of acetabulum**, **718.15 Loose body in joint**, and **718.5 Other derangement of joint pelvic region and thigh**.

Other ICD-10 codes that may be associated with nonarthritic hip joint pain are:

- M21.0 Valgus deformity, not elsewhere classified
- M21.1 Varus deformity, not elsewhere classified
- M21.2 Flexion deformity
- M24.3 Pathological dislocation and subluxation of joint, not elsewhere classified
- M24.4 Recurrent dislocation and subluxation of joint

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- M24.5 Contracture of joint
- M24.6 Ankylosis of joint
- M24.9 Joint derangement, unspecified
- M25.0 Hemarthrosis
- M25.3 Other instability of joint
- M25.4 Effusion of joint
- M25.6 Stiffness of joint, not elsewhere classified
- M25.7 Osteophyte
- M25.8 Other specified joint disorders
- M25.9 Joint disorder, unspecified
- Q65.6 Unstable hip
- R29.4 Clicking hip
- S73 Dislocation, sprain and strain of joint ligaments of hip

The primary ICF body function codes associated with nonarthritic hip joint pain are **b28016 Pain in joints**, **b7100 Mobility of a single joint**, and **b7150 Stability of a single joint**. Other ICF body function codes that may be associated with this condition are **b7300 Power of isolated muscles and muscle groups**, **b7401 Endurance of muscle groups**, **b7603 Supportive functions of arm and leg**, **b770 Gait pattern functions**, and **b7800 Sensation of muscle stiffness**.

The primary ICF body structure code associated with nonarthritic hip joint pain is **s75001 Hip joint**. Other ICF body structure codes associated with this condition are **s7402 Muscles of pelvic region** and **s7403 Ligaments and fasciae of pelvic region**.

The primary ICF activities and participation codes associated with nonarthritic hip joint pain are **d4103 Sitting**, **d4104 Standing**, **d4151 Maintaining a squatting position**, **d4153 Maintaining a sitting position**, **d4552 Running**, **d4500 Walking short distances**, and **d4501 Walking long distances**.

Other ICF activities and participation codes that may be associated with nonarthritic hip joint pain are:

- d2303 Completing the daily routine
- d4101 Squatting
- d4154 Maintaining a standing position
- d4302 Carrying in the arms
- d4303 Carrying on shoulders, hip and back
- d4351 Kicking
- d4502 Walking on different surfaces
- d4551 Climbing
- d4553 Jumping
- d4600 Moving around within the home
- d4601 Moving around within buildings other than home
- d4602 Moving around outside the home and other buildings
- d465 Moving around using equipment
- d5204 Caring for toenails
- d5400 Putting on clothes
- d5401 Taking off clothes
- d5402 Putting on footwear
- d5403 Taking off footwear
- d5701 Managing diet and fitness
- d9201 Sports
- d9209 Recreation and leisure

CLINICAL GUIDELINES

Impairment/Function-Based Diagnosis

INTRODUCTION

For the purposes of these guidelines, nonarthritic hip joint pain refers to a collection of hip pain conditions proposed to involve intra-articular structures of the hip, including femoroacetabular impingement, structural instability, labral tears, chondral lesions, and ligamentous teres tears. Recent advances in imaging and surgical techniques have resulted in better identification of potential contributors to hip joint pain; however, evidence to definitively associate pathology noted on imaging with hip joint pain and related activity limitations has not been established. Diagnoses of nonarthritic hip joint conditions are made by clinicians based on a combination of imaging and clinical findings, even though there is no consensus on the diagnostic criteria to rule in or rule out a specific condition. Despite this limitation, surgical intervention to address nonarthritic hip joint pain has grown exponentially, although evidence to suggest that surgical intervention is superior to nonsurgical management is not available. Given these limitations, clinicians must be disciplined in their evaluation to verify the presence of a relevant relation between the patient's reported activity limitations and his or her examination findings.

The scope of these guidelines is limited to literature specific to nonarthritic hip joint conditions. Although recognized that other examination and intervention procedures reported to be useful in other musculoskeletal disorders of the pelvis and hip region may be appropriate for patients with nonarthritic hip pain, the focus of these clinical guidelines is to analyze the literature and make recommendations specifically related to nonarthritic hip joint pain. It is also acknowledged that there is a growing body of research on pain science, and this literature may be appropriate for patients with nonarthritic hip joint pain.

PATHOANATOMICAL FEATURES

Understanding the complex relationship among the labrum, the bony architecture of the acetabulum and femur, as well as the proximate soft tissues, such as the ligaments and muscles, is important for diagnosis and optimal treatment of individuals with mechanical hip pain.

The proximal femur articulates with the acetabulum to form the hip joint. The femoral head is two thirds of a sphere covered with hyaline cartilage and enclosed in a fibrous capsule.[49,176] The femoral head is connected to the femoral shaft via the femoral neck. In the frontal plane, the femoral neck lies at an angle to the shaft of the femur. This "angle of inclination" is normally 120° to 125° in the adult population.[147] In the transverse plane, the proximal femur is oriented anterior to the distal femoral condyles as a result of a medial torsion of the femur, with a normal range between 14° and 18° of anteversion.[29] The hip joint is a "ball and socket" synovial joint with articular cartilage and a fully developed joint capsule, allowing movement in all 3 body planes.[176]

The articular cartilage of the femoral head is thickest in the anterior-superior region, except where it is absent at the fovea capitis. In normal individuals, the cartilage is thickest in the central portion around the ligamentum teres.[136] This corresponds to the area of maximum weight-bearing forces. The articular cartilage of the acetabulum is horseshoe shaped and thickest superiorly. It is continuous with the cartilage that lines the acetabular labrum. Articular cartilage is avascular and aneural.

The joint capsule attaches around the acetabular rim proximally and distally at the intertrochanteric line. Along with the labrum, the capsule provides passive stability to the hip joint. The iliofemoral, ischiofemoral, and pubofemoral ligaments assist the capsule in providing stability to the joint.[112] These 3 strong ligaments reinforce the joint capsule, the iliofemoral and pubofemoral ligaments anteriorly, and the ischiofemoral ligament posteriorly.[49,187]

Control of the hip during movement involves complex interactions between the nervous, muscular, and skeletal systems.[196] The 27 muscles that cross the hip joint act as primary movers and dynamic stabilizers of the hip and lower extremity.[1,56,139] The gluteus medius is the primary source of dynamic stabilization for the hip joint in the frontal plane.[1] Weakness of this muscle has been traditionally implicated as playing a role in functional impairments. The iliopsoas complex is the primary hip flexor and may play a role in stabilizing the femoral head anteriorly, given its location across the anterior hip joint. The gluteus maximus is the most powerful hip extensor. The hip external and internal rotators' role in stabilization may become more crucial when the acetabular labrum is torn secondary to the subsequent loss of passive rotational stability.[108]

Nonarthritic hip joint pain may be related to numerous underlying causes, such as femoroacetabular impingement,[80,138,169,181] structural instability,[165] acetabular labral tears,[13,21] osteochondral lesions,[170,181] loose bodies, ligamentum teres injury, and septic conditions.[12,14,22,86,88,90,129,146,164,173,177,178,189] It should be noted that these conditions are not necessarily mutually exclusive, and at times may be related to each other. Recently, an increased focus has been placed on identifying acetabular labral tears as one cause of hip pain and on understanding the underlying mechanisms in the development of labral tears. These underlying mechanisms may be related to variations in joint anatomy combined with specific activities, or of traumatic onset. Two anatomical variants have been described: femoroacetabular impingement[102,104] and structural instability.[151,170]

Femoroacetabular Impingement

Structural variations of the proximal femur or acetabulum may result in a femoroacetabular impingement, which is described as abnormal contact between the femoral head/neck and the acetabular margin and has been associated with labral and chondral damage.[148] Osseous abnormalities proposed to contribute to labral tears due to femoroacetabular impingement include bony malformations in the proximal femur or the acetabulum, resulting in premature abutment of the femoral neck into the acetabulum during the motion of hip flexion with internal rotation.[4] The presence of a slipped capital femoral epiphysis has also been noted to cause femoroacetabular impingement.[106] With repetitive motions into the position of impingement, the acetabular labrum will undergo excessive shear and compressive forces, which may lead to eventual injury.[78] Femoroacetabular impingement has been further classified into 3 categories, based on the specific osseous abnormality present. Cam impingement is the result of asphericity of the femoral head, which is often related to a slipped capital femoral epiphysis or other epiphyseal injury[106,160] or protrusion of the head-neck junction occurring at the proximal femur.[60,79] Pincer impingement is the result of acetabular abnormalities, such as general (protrusia) and localized anterosuperior acetabular overcoverage of the femur (acetabular retroversion), which are described in more detail in the Imaging section.[78,102] Excessive acetabular coverage anteriorly may result in premature abutment of the femoral neck on the anterior acetabular rim. Impingement may be more pronounced when relative femoral retroversion and anteversion are, respectively, combined with acetabular retroversion and anteversion. The third category is a combination of the cam and pincer impingement, which is likely the most common category.[9,59] Radiographic evidence of femoroacetabular impingement is common in active patients with hip complaints.[146] Studies have suggested that the abnormal movement at the hip joint occurring secondary to femoral acetabular impingement may lead to labral lesions and cartilage damage.[7,33] The end stage of this process may lead to the development of secondary hip joint osteoarthritis (OA).[9,59,126,148,149]

Gender differences have been described in individuals with labral tears secondary to osseous abnormalities.[102] Cam impingement morphology is twice as prevalent in males than in females.[67,84] Pincer lesions are more common in middle-aged, active women. In the North American population, the most common area of labral tears occurs in the anterior-superior (weight-bearing) region of the labrum.[41,55] In 2 studies with limited sample sizes ($n \leq 8$), labral tears in the Japanese population have been reported at a greater frequency in the posterior region.[77,182]

Structural Instability

Hip instability may be defined as extraphysiologic hip motion that causes pain with or without the symptom of hip joint unsteadiness.[16,174] Hip instability may be traumatic, atraumatic, or secondary to bony or soft tissue abnormality. Factors related to structural instability of the joint include a shallow acetabulum and an excessive femoral anteversion.[63] Excessive acetabular anteversion or retroversion, inferior acetabulum insufficiency,[111] and a neck shaft angle greater than 140° may also be a component of structural instability. Determination of femoral version is further described in the Imaging section of this guideline. These conditions, particularly when combined with repetitive forceful activities, have been associated with the development of labral tears.

A shallow acetabulum (acetabular dysplasia) has been associated with labral tears due to structural instability. In a hip with structural instability, insufficient coverage of the femoral head may result in repetitive shear stresses to the acetabular labrum as it attempts to maintain the congruent relationship between the femur and the acetabulum. Insufficient coverage may present as decreased anterior coverage with excessive acetabular anteversion or decreased posterior coverage with acetabular retroversion. Continued repetitive stresses may result in further instability of the hip joint. Structural instability due to dysplasia is thought to be more common in females.[6]

The presence of dysplasia in adult individuals with hip pain has been discussed. In a cross-sectional study by Jacobsen and Sonne-Holm,[80] the prevalence of hip joint dysplasia ranged from 5.4% to 12.8%. Birrell et al[13] found the prevalence of dysplasia in patients with an initial complaint of hip pain to be 32%. They also found no difference in the prevalence of acetabular dysplasia between men and women in the symptomatic population.[13] In a prospective multicenter study utilizing clinical and radiographic examination of the hip joint for 292 patients between the ages of 16 and 50 years, the rate of dysplasia was 35%.[143]

Femoral Version

Excessive anteversion of the femur is characterized by an increased amount of femoral internal rotation range of motion and a limitation in femoral external rotation range of motion. Excessive retroversion of the femur will result in the opposite limitation: increased femoral external rotation range of motion and decreased femoral internal rotation range of motion. A significant limitation in femoral rotation range of motion due to excessive femoral anteversion or retroversion may place an individual at risk for labral injury[79] and increase their risk for developing hip OA.[192]

Acetabular Labral Tears

The acetabular labrum is a fibrocartilaginous structure that extends from the osseous rim of the acetabulum and serves multiple functions. The labrum structure deepens the socket of the hip joint[184] and acts as a buffer, decreasing forces transmitted to the articular cartilage.[52,53] In addition to deepening the socket component of the hip joint, the acetabular labrum also creates an environment of negative intra-articular pressure, creating a seal.[183] The labrum also contains free nerve endings that have been suggested to play a potential role in proprioception and potential sources of pain.[92]

Acetabular labral tears have recently been identified as a potential source of hip pain[18,87,137] and a possible precursor to hip OA.[126,127,172] Although true estimates of the prevalence of labral tears are not currently available, in patients with mechanical hip pain, the prevalence of labral tears has been reported to be as high as 90%.[55,125,140] In their review of studies examining individuals with hip or groin pain, Groh and Herrera[63] found prevalence to be 22% to 55%.

Acetabular labral tears may occur as the result of acute trauma or of insidious onset. Traumatic mechanisms described involve rapid twisting, pivoting, or falling motions.[41,55] A common mechanism in the athletic population includes forceful rotation with the hip in a hyperextended position.[122] Other mechanisms of injury consist of a combination of anatomical variants with repetitive forces. Tears may also be insidious. Groh and Herrera[63] found that up to 74% of labral tears are not associated with any specific event.

An increased incidence of acetabular labral tears has been described in a number of specific populations, in particular those individuals who subject the hip joint to specific repetitive stress. Narvani et al[137] found acetabular labral tears to be the cause of symptoms in 20% of athletes presenting with groin pain.

Labral tears may be seen in individuals throughout the age span[40,127]; however, increasing age may be associated with the prevalence of labral tears. Tears have been observed in up to 96% of older individuals.[123,172] In another study, 88% of patients older than 30 years were found to have labral detachment from the articular cartilage.[19]

The diagnosis of a labral tear is often delayed, and it is often misdiagnosed.[18,87] Recent advances in imaging have resulted in better identification of labral tears.[88] Lage et al[100] described a system of classifying acetabular labral tears. The 4 classifications are: radial flap, radial fibrillated, longitudinal peripheral, and abnormally mobile (partially detached). Radial flap tears, where the free margin of the labrum is disrupted, are the most commonly observed.[100] Radial fibrillated tears involve characteristic fraying of the free margin of the labrum.[100,123] Abnormally mobile tears are partially detached from the acetabular surface. The least common noted were longitudinal peripheral tears, which involve a tear along the acetabular-labral junction.[100] Criteria to classify acetabular labral tears have been established; however, more research is needed to establish the association between labral tears and hip joint pain and to determine if labral tears are a risk factor for hip OA.

Ruptured Ligamentum Teres

The ligamentum teres originates from the edges of the acetabular notch and transverse acetabular ligament and attaches onto the fovea capitis of the femoral head. Though traditionally thought to play a minimal role in joint function, more recent findings suggest that this structure may play a role in stabilization.[24,162] The ligamentum teres may be a strong intrinsic stabilizer that resists hip joint subluxation forces.[8,27] It has the potential to act as a strong intra-articular ligament and an important stabilizer of the hip, particularly when the hip is externally rotated in flexion or internally rotated in extension.[117] Several theories have been proposed to describe the exact function of the ligamentum teres, including a role in providing a "sling-like" stabilization of the hip joint as it wraps around the femoral head.[26,93] Martin et al[117] utilized a ball-and-string model to demonstrate these potential functions of the ligamentum teres. Patients with tears of the ligamentum teres may develop hip microinstability. This condition of compromised stability, when combined with recreational and sports activities, may result in damage to the labrum and cartilage. This process may possibly explain the high association rate between tears of the ligamentum teres, labral tears, and cartilage injury.[64,152] Injuries to the ligamentum teres are generally considered rare.[88] Rao et al[162] found ligamentum teres injury in less than 8% of arthroscopy cases. Orthopaedic surgeons have reported a ruptured ligamentum teres as a significant arthroscopic finding in individuals reporting hip pain and dysfunction.[88] Acute tearing of this structure has been described[39,162]; however, the correlation between injuries to the ligamentum teres and clinical presentation is not well understood.

Chondral Lesions

Little is known about the prevalence of isolated chondral lesion (focal loss of cartilage on the articular surfaces); however, McCarthy et al[126] found that 73% of patients with fraying or tearing of the labrum also had chondral damage. Anterior-superior cartilage lesions have been associated with dysplasia, anterior joint laxity, and the presence of femoroacetabular impingement.[102,105,144] The combination of labral tears present greater than 5 years and full-thickness chondral lesions in those with higher alpha angles correlates with a greater magnitude of decreased hip range of motion, chondral damage, labral injury, and progression of OA.[83,123,126]

Chondral lesions have been reported in younger, more active individuals as a source of hip pain.[21,169] A traumatic injury pattern involving acute overloading through impact sustained by a blow to the greater trochanteric region has been described.[88] This clinical hypothesis has been supported by arthroscopic findings.[20,169]

Loose Bodies

The presence of loose bodies (small fragments of bone or cartilage within the joint) has been implicated as a disrupter of joint function in individuals presenting with hip pain.[88] Numerous underlying mechanisms have been described. Though the specific mechanisms underlying their presence may vary, their potential for being a cause of pain and/or mechanical disruption should be considered. Loose bodies, ossified and nonossified,[88] may be present in the joint secondary to a number of factors. Single fragments typically occur in the case of dislocation or osteochondritis dissecans. Multiple fragments are more common in conditions such as synovial chondromatosis.[88]

RISK FACTORS

With the exception of traumatic injury, the specific cause of nonarthritic hip disorders is not clearly understood. Potential risk factors have been proposed. However, there is only minimal evidence to substantiate the relationship of these potential risk factors to nonarthritic hip joint disorders.

Femoroacetabular Impingement

Genetics

III Previous investigation has established the genetic influence on severe osseous abnormalities, such as slipped capital femoral epiphysis[163] and acetabula protrusio,[195] but limited evidence exists specific to milder abnormalities. In 1 study, Pollard et al[156] compared the radiographs of patients with symptomatic femoroacetabular impingement to 2 groups: 1 group included the patient's siblings, and the second group included spouses of the patients and the siblings. Compared to the spouse controls, the siblings demonstrated a greater relative risk for cam and pincer deformity, respectively, suggesting that genetics is a possible risk factor for femoroacetabular impingement.

Sex

III The individual's sex may influence the type of osseous abnormality. Hack et al[67] studied 200 asymptomatic volunteers and found that the prevalence of cam deformities was higher in men (25%) than in women (5.4%). In a cross-sectional, population-based study, a substudy of the Copenhagen City Heart Study I-III, Gosvig et al[61] reported the prevalence estimates of osseous abnormalities by sex. More women (19%) demonstrated a deep acetabular socket (pincer deformity) than men (15%). More men (20%) demonstrated a pistol-grip (cam) deformity than women (5%).

Structural Instability

Genetics

V Genetic factors have long been recognized in the etiology of dysplasia, particularly in the more severe cases such as congenital hip dislocation.[25,201] Although studies are not available to demonstrate the genetic influence on milder forms of acetabular dysplasia thought to contribute to structural instability, it is likely that genetic factors play a role in structural instability.

Ligamentous Laxity

V Ligamentous laxity of the hip joint, global or focal,[170] has been proposed as a risk factor for the development of acetabular labral tears. Global ligamentous laxity due to connective tissue disorders, such as Ehlers-Danlos, Down, and Marfan syndromes, has been implicated as a risk factor in the development of acetabular labral tears.[113]

A correlation between acetabular labral tears and focal rotational laxity has been suggested.[88,151] The focal laxity most commonly occurs as anterior capsular laxity secondary to repetitive movements involving hip external rotation and/or extension, possibly resulting in iliofemoral ligament insufficiency.[150,170] Although uncommon, repeated, forced hip internal rotation in flexion may also be a harmful repetitive movement. When insufficiency is present, the ligament's ability to absorb stress is compromised, potentially subjecting the labrum to abnormal stress and pathology.[151]

Intra-articular Injury (Acetabular Labral Tear, Ruptured Ligamentum Teres, Loose Bodies, Chondral Lesions)

III

Osseous Abnormalities

While osseous abnormalities of the femur or acetabulum have been proposed to contribute to intra-articular hip disorders, causation has not been demonstrated. Many believe osseous abnormalities precede intra-articular pathology. Others hypothesize that intra-articular pathology precedes osseous abnormalities.[148] Studies to demonstrate the temporal relationship between osseous abnormalities and intra-articular lesions are not available; however, there is evidence to suggest a relationship between osseous abnormalities and intra-articular lesions. Descriptive studies based on retrospective observations report that osseous abnormalities were present in up to 87% of patients presenting with labral tears.[18] Guevara et al[65] assessed the radiographs of people with labral tear and compared the bony morphology of the involved hip to the uninvolved hip. Compared to the uninvolved side, hips with labral tears had a higher prevalence of osseous abnormalities associated either with dysplasia (structural instability) or femoroacetabular impingement.

Osseous Abnormalities Associated With Femoroacetabular Impingement

Visual assessment and computer modeling have been implemented to assess location of injury and femoroacetabular impingement. Through intraoperative visual assessment, labral and articular cartilage damage has been shown at the site of impingement, where the femoral neck abuts the acetabular rim. In a retrospective study, Tannast et al[185] used computer simulation to predict the impingement zone in 15 subjects and compared their predicted impingement zone to the location of labral and cartilage damage in 40 different subjects. They found the computer-predicted impingement zone to be similar to the location of labral and cartilage damage in the sample of 40 subjects. The most severe damage was located in the zone with the highest probability of impact related to femoroacetabular impingement, the anterosuperior area of the acetabulum. Sink et al[178] used visual inspection of hip motion intraoperatively and determined that the anterosuperior cartilage damage coincided with the area of impingement when the hip was positioned into flexion and internal rotation.

Other observational studies suggest a relationship between intra-articular lesions and cam impingement specifically. Anderson et al[3] performed a multivariable logistic regression to assess the correlation between radiographic findings and articular cartilage delamination. The study sample included 62 patients with the preoperative diagnosis of femoroacetabular impingement or related disorder. Delamination was found to be associated with femoral-side (cam) findings (odds ratio = 11.87); however, delamination was not associated with acetabular overcoverage (pincer) findings (odds ratio = 0.16). These findings suggest that cam impingement increases the risk of articular cartilage delamination; however, pincer impingement may be protective of the cartilage. This study, however, did not assess the association of the bony morphology with the other intra-articular lesions, such as labral tears. Ito et al[79] also showed a link between femoral-side findings and intra-articular lesions. In their study, patients with the clinical presentation of femoroacetabular impingement and a labral tear demonstrated a reduced head-neck offset anteriorly compared to asymptomatic controls.

Osseous Abnormalities Associated With Structural Instability

There are no known studies to demonstrate an association between structural instability and nonarthritic or intra-articular hip disorders. However, the presence of acetabular retroversion in a person with dysplasia may place the hip joint structures at risk. Fujii et al[58] reported that individuals with acetabular retroversion, defined in their study as localized anterosuperior acetabular overcoverage of the femur, had an earlier onset of hip pain.

Other Osseous Abnormalities

Although femoral version has been studied extensively in the pediatric population, little research has been performed in the adult population. Abnormal version of the femur, either excessive anteversion or retroversion, may result in abnormal stresses on the hip joint. Ito et al[79] reported that patients with the clinical presentation of femoroacetabular impingement and confirmed labral tears demonstrated a significantly reduced femoral version (retroversion) compared to asymptomatic control subjects.

V

Activity and Participation

Activities such as distance running, ballet, golf, ice hockey, and soccer have been implicated in acetabular labral tears.[64,135,181] Some authors have proposed that a specific direction of hip motion related to the suspected activities may be responsible for the increased risk; these directions include rotational stresses,[96] hyperextension,[64,108] and hyperflexion.[78,168]

F Clinicians should consider the presence of osseous abnormalities, local or global ligamentous laxity, connective tissue disorders, and nature of the patient's activity and participation as risk factors for hip joint pathology.

DIAGNOSIS/CLASSIFICATION

III The diagnosis of femoroacetabular impingement and the associated International Classification of Functioning, Disability and Health (ICF) diagnosis of joint pain and mobility impairment can be suspected when the patient presents with the following clinical and radiographic findings:

- Pain in the anterior hip/groin[153] and/or lateral hip/trochanter region[115] is reported
- Pain is described as aching or sharp[34]
- The reported hip pain is aggravated by sitting[34]
- The reported pain is reproduced with the hip flexion, adduction, internal rotation (FADIR) test
- Hip internal rotation is less than 20° with the hip at 90° of flexion[99]
- Hip flexion and hip abduction are also limited[34,83,153,186]
- Mechanical symptoms such as popping, locking, or snapping of the hip are present[34]
- Conflicting clinical findings are not present
- Radiographic findings
  - Cam impingement
    - Increased femoral neck diameter that approaches the size of the femoral head diameter
      - Alpha angle greater than 60°[2,157]
      - Head-neck offset ratio less than 0.14[157]
  - Pincer impingement
    - Increased acetabular depth[9]
      - Coxa profunda (lateral center-edge angle greater than 35°)
      - Acetabular protrusion
    - Decreased acetabular inclination
      - Tönnis angle[190] less than 0°[34]
    - Acetabular retroversion
      - Crossover sign indicating localized anterosuperior overcoverage[48]
      - Ischial spine projection into the pelvis[85]

The diagnosis of structural instability and the associated ICF diagnosis of joint pain and stability impairment can be suspected when the patient presents with the following clinical and radiographic findings:

- Anterior groin, lateral hip, or generalized hip joint pain is reported
- The reported pain is reproduced with the FADIR test or the hip flexion, abduction, external rotation (FABER) test
- Hip apprehension sign is positive
- Hip internal rotation is greater than 30° when the hip is at 90° of flexion
- Mechanical symptoms such as popping, locking, or snapping of the hip are present
- Conflicting clinical findings are not present
- Radiographic findings:
  - Increased acetabular inclination
- Tönnis angle[190] greater than 10°[35]
- Decreased femoral head coverage
  - Lateral center edge of Wiberg less than 25°[18,191]
  - Anterior center-edge angle less than 20°

III The diagnosis of intra-articular injury (labral tear, osteochondral lesion, loose bodies, and ligamentum teres rupture) and the associated ICF diagnosis of joint pain can be provided when the patient presents with the following clinical and imaging findings:

- Anterior groin pain or generalized hip joint pain[18,34,76,88]
- Pain is reproduced with the FADIR test or the FABER test
- Mechanical symptoms such as popping, locking, or snapping of the hip are present[18,34,76,124,137]
- May report feelings of instability (ligamentum teres)[111] and the sensation of instability when squatting
- Conflicting clinical findings are not present
- Imaging findings:
  - Labral tear
    - Magnetic resonance arthrography (MRA)[18,38,57,75,87,206]

C Clinicians should use the clinical findings of anterior groin or lateral hip pain or generalized hip joint pain that is reproduced with the FADIR or FABER test, along with corroborative imaging findings, to classify a patient with hip pain into the International Statistical Classification of Diseases and Related Health Problems (ICD) categories of **M25.5 Pain in joint**, **M24.7 Protrusio acetabula**, **M24.0 Loose body in joint**, and **M24.2 Disorder of ligament**, and the associated ICF impairment-based category of hip pain (**b28016 Pain in joints**) and mobility impairments (**b7100 Mobility of a single joint**; **b7150 Stability of a single joint**).

DIFFERENTIAL DIAGNOSIS

Potential differential diagnoses for nonarthritic hip joint pain are:

- Referred pain from lumbar facet disorders
- Referred pain from lumbar disc disorders
- Sacroiliac joint dysfunction
- Pubic symphysis dysfunction

- Lumbar spinal stenosis
- Nerve entrapment (lateral femoral cutaneous, obturator)
- Hip osteoarthrosis
- Iliopsoas tendinitis/bursitis
- Adductor strain
- Obturator internus strain
- Inguinal hernia
- Athletic pubalgia (sports hernia)
- Osteonecrosis of femoral head
- Stress fracture (proximal femur or pelvic)
- Avulsion injury (sartorius or rectus femoris tendon)
- Myositis ossificans
- Heterotopic ossification of hip joint
- Gynecological disorders
- Neoplasm
- Legg-Calvé-Perthes disease
- Slipped capital femoral epiphysis
- Osteomyelitis
- Psoas abscess
- Septic arthritis
- Rheumatoid arthritis
- Prostatitis
- Metabolic bone disease

F Clinicians should consider diagnostic categories other than nonarthritic joint pain when the patient's history, reported activity limitations, or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline or when the patient's symptoms are not diminishing with interventions aimed at normalization of the impairments of body function.

IMAGING STUDIES

Imaging studies are used in conjunction with clinical findings to rule out serious diagnoses such as a cancer, osteonecrosis, or fracture. Imaging may also provide information regarding the bony structure of the femur and acetabulum as well as related soft tissue. Information from imaging studies should be evaluated in the context of the entire clinical presentation, where the clinician should have an understanding of imaging applications, associated results, and how these applications and results affect clinical decisions related to patient management—acknowledging that, often, findings from imaging are incidental and impact patient management only to the extent of providing education and reassurance to the patient.

Plain radiographs are the first imaging study in the differential diagnostic procedures. Radiographs are useful in detecting femoral and acetabular abnormalities associated with nonarthritic hip joint pain. Plain radiographs do not provide adequate detail regarding soft tissue morphology. Noncontrast magnetic resonance imaging (MRI) provides better detail for assessing soft tissue integrity; however, it has not been used extensively to assess intra-articular structures. MRA is commonly used to detect changes of the intra-articular structures. Techniques such as computed tomography and delayed gadolinium-enhanced MRI of cartilage have recently been implemented to assess articular cartilage integrity[91] and assist with presurgical planning.[91,97,186]

To detect osseous abnormalities, specific radiographic views are needed in addition to the standard hip protocol. Specific images to consider include[32] (1) cross-table lateral view,[44] (2) 45° or 90° Dunn view,[42,128] (3) "frog" lateral view,[36] and (4) false-profile view.[103] These specific views allow the diagnosis of osseous abnormalities, such as femoroacetabular impingement and structural instability, proposed to be associated with nonarthritic hip joint pain. The osseous abnormalities are described below. The clinician is encouraged to refer to Clohisy et al[32] for a thorough description of the measurement methods and representative figures. An alternative view has recently been introduced to measure the distance between the femoral neck and the acetabular rim when the hip is in 90° of flexion.[17] It should be noted that variations of suggested normal measurements exist within the literature. In addition, the relationship between pain and bony abnormalities has not been fully established.

Measurements may be taken to evaluate for hip dysplasia, including the Tönnis angle (abnormal, greater than 10°), the lateral center-edge angle of Wiberg (abnormal, less than 25°), and the anterior center-edge angle of Lequesne (abnormal, less than 25°), as measured on a false-profile radiograph. The neck-shaft angle of the proximal femur is considered normal between 120° and 140°. Radiographic images for hip femoroacetabular impingement and structural instability have been published.[97]

Radiographic findings that support the clinical diagnosis of pincer femoroacetabular impingement include increased acetabular depth, decreased acetabular inclination, and acetabular retroversion. Acetabular depth, inclination, and retroversion are all assessed on the anterior/posterior view. Acetabular depth is determined by observing the relationship of the floor of the acetabulum and femoral head. Acetabular protrusion represents a deep acetabulum and is suggestive of pincer femoroacetabular impingement.[9] Acetabular inclination is assessed using the Tönnis angle.[190] Acetabuli having a Tönnis angle of 0° to 10° are considered normal, whereas those having an angle greater than 10° or less than 0° are considered increased and decreased, respectively. Hips with an increased Tönnis angle were considered to be at risk for structural instability, whereas those having a decreased inclination were considered at risk for pincer impingement.[35] Pincer-type femoroacetabular impingement (acetabular retroversion or protrusio) is identified using the presence of a crossover sign, lateral center-edge angle greater than 39°, or an acetabular index less than or equal to zero.[138]

Acetabular retroversion may also contribute to pincer impingement. Acetabular retroversion has been described as either local or general retroversion. Local retroversion results in overcoverage of the femoral head in the anterosuperior region of the acetabulum. On the anterior/posterior radiograph, this appears as the crossover sign or the figure-of-eight sign.[48] The crossover sign occurs if the line representing the anterior acetabular wall crosses the line representing the posterior acetabular wall, resulting in an "X" appearance. Radiographic assessment of ischial spine projection into the pelvis has been suggested as another method of identifying acetabular retroversion.[85] Kalberer et al[85] noted that the ischial spine sign is not only a periacetabular phenomenon but also could represent a malrotation of the whole hemipelvis. The general type of retroversion[164] results in a more generalized overcoverage of the femoral head anteriorly.

The radiographic finding to support cam impingement is an increased thickness of the femoral head-neck junction. The most commonly reported measure to represent the femoral head-neck junction is the alpha angle,[145] which may be measured on the frog-leg lateral view[36] or the 90° Dunn view.[2] A large alpha angle, greater than 60° is suggestive of a cam impingement.[2,157] Head-neck offset ratio, measured on the cross-table lateral view, is another measure to represent the femoral head-neck junction.[45] A head-neck offset ratio less than 0.14 is suggestive of femoroacetabular impingement.[157]

The radiographic finding to support the clinical diagnosis of structural instability is an increased acetabular inclination. Acetabular inclination may be assessed using the Tönnis angle[190] or the lateral center-edge angle of Wiberg,[197] both assessed from the anterior/posterior view. A Tönnis angle greater than 10° or a lateral center-edge angle less than 25° may indicate inadequate acetabular coverage of the femoral head.[18,191]

MRI is useful in detecting musculotendinous pathology, such as iliopsoas tendinopathy. Although MRI is not used widely to detect intra-articular injury, some investigators report high accuracy (89%-95%) in detecting labral tears.[82,130] Currently, the most common imaging procedure used to confirm the diagnosis of intra-articular pathology, such as labral tears or chondral lesions, is MRA.[75,206] Contrast is injected into the hip joint to allow better visualization of the intra-articular structures. Compared to the gold standard of arthroscopic visual inspection, MRA has a sensitivity of 71% to 100%[18,38,57,87] and a specificity of 44% to 71%[38,87] in detecting a labral tear. All subjects in these studies had a clinically suspected labral tear. In a small cadaveric study, MRA demonstrated 60% sensitivity, 100% specificity, and 70% accuracy.[155] In the same study, conventional MRI with a large field of view was 8% sensitive in detecting labral tears compared with findings at the time of arthroscopy. Diagnostic sensitivity was improved to 25% with a small-field-of-view MRA. In addition to soft tissue integrity, MRI or MRA may be used to detect osseous abnormalities previously described, such as the alpha angle[161] or acetabular retroversion.[145,193]

Computed tomography may be used to determine the osseous architecture of the hip. Current technologies allow for 3-D reconstruction of the hip anatomy and thus provide additional information that is useful in presurgical planning. Due to significantly higher radiation exposure with computed tomography as compared to other imaging modalities, it has not been widely used in the diagnosis of nonarthritic hip joint pain and is most often reserved just for presurgical planning.[97,186]

The use of image-guided injections for the purpose of diagnosis has been described. The injections consist of a local anesthetic and possibly a corticosteroid. Preinjection and postinjection levels of pain are examined, with a notable and immediate decrease of pain considered indicative of chondral damage within the hip joint. With this approach, Kivlan et al[94] found that individuals with chondral damage displayed a greater relief of pain compared to their counterparts without chondral damage. This was found to be independent of the presence of extra-articular pathology. The clinician should consider the role of injection therapy in patient management, particularly if improvement in pain is delayed or impacting the ability to restore optimal functioning.

CLINICAL COURSE

The clinical course of nonarthritic hip joint disorders has not been described. Femoroacetabular impingement[9] and labral tears[126] are both proposed to contribute to OA. A shallow acetabulum and resulting acetabular dysplasia have been shown to be associated with OA of the hip joint in relatively younger patients.[69,133] Further research is needed to understand the clinical course of nonarthritic hip disorders.

CLINICAL MANAGEMENT

The management of nonarthritic hip joint disorders is highly variable. A period of nonsurgical management is recommended, of at least 8 to 12 weeks, prior to consideration of surgical intervention.[63,88] Nonsurgical management includes physical therapy as well as medication and, later, if indicated, ultrasound/fluoroscopic-guided[179] therapeutic injections. If symptoms do not improve with nonsurgical care, surgical intervention may be considered.

Recent advances in imaging and surgical techniques have led to an increase in surgical management for nonarthritic hip joint disorders. Although evidence related to favorable surgical outcomes is growing, the literature is limited primarily to observational studies with small sample sizes and short-term outcomes. The presence of pathology on imaging in individuals with nonarthritic hip pain, which is refractory to nonsurgical management, needs careful patient selection if surgery is contemplated to optimize the potential for a favorable outcome.

Anti-inflammatory agents are often recommended for pain relief and inflammation; however, evidence to support this intervention in patients with nonarthritic hip pain is lacking. Both over-the-counter and prescribed anti-inflammatory agents, including nonsteroidal anti-inflammatory drugs and COX-2 inhibitors, may be prescribed as part of a treatment program. However, it should be noted that this class of drugs is not without risk for serious adverse events, including increased gastrointestinal bleeding.

Common surgical options include arthroscopic procedures such as labral tear resection or repair, capsular modification, osteoplasty to address femoroacetabular impingement, ligamentum teres tear debridement, and loose-body removal. In addition, a periacetabular osteotomy procedure may be performed to address acetabular dysplasia.[111] The purpose of this open procedure is to surgically separate the acetabulum from the innominate, then reattach the structure in a position that provides ideal coverage of the femoral head, providing closer-to-normal stability of the hip joint.[194]

Of the available arthroscopic procedures, labral tear resection has the most supporting evidence. This procedure is typically utilized for fraying or peripheral tears of the labrum.[23,50,55,63,88,158] Studies have shown clinical improvement following labral resection.[18,166] Intrasubstance tears of the labrum may be repaired. More recently, labral repair in combination with osteoplasty of the acetabular rim and/or the femoral head-neck junction has become a common surgical procedure for treating femoroacetabular impingement and its associated intra-articular abnormalities.[37]

Limited evidence is available to support favorable outcomes in individuals undergoing resection of labral tears combined with capsular modification.[151] An osteoplasty procedure may be performed to remove the excessive bone present in the case of impingement. Early results for this procedure have been promising. A systematic review by Ng et al[141] found that surgical treatment of femoroacetabular impingement reliably improved patients' symptoms.

Arthroscopic debridement of ligamentum teres tears has been described.[63] The goal of the surgery is to resect the tear to a stable remnant, preventing potential painful disruption of joint mechanics.[63] Promising results have been reported in patients with isolated injury who do not have other concurrent conditions, such as osteochondral defects.[162] Microfracture techniques have been described for medium-size, full-thickness chondral defects.[88] No current studies exist examining the outcomes for microfracture procedures of the hip joint.

CLINICAL GUIDELINES

Examination

OUTCOME MEASURES

Hip Outcome Score

I The Hip Outcome Score (HOS) is a self-report measurement tool consisting of 2 separate subscales for activities of daily living (ADL) and sports.[116,118,119] The HOS was developed specifically to assess the ability of young individuals with acetabular labral tears and address the ceiling effect of the Harris Hip Score (HHS)[23,70] and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).[11] The ADL subscale contains 17 items; examples include walking on level surfaces, hills, stairs, getting in and out of a car, deep squat, heavy work, and recreational activities. The sports subscale contains 9 items; examples include running, jumping, cutting, and swinging a golf club. Each item is scored from 4 to 0, with 4 being "no difficulty" and 0 being "unable to do." There is a "nonapplicable" option that is not counted in scoring. The total number of items with a response is multiplied by 4 to get the highest potential score. An individual's score is divided by the highest potential score, then multiplied by 100 to get a percentage. A higher score is representative of a higher level of physical function for each subscale.

The HOS subscales have high test-retest reliability (intraclass correlation coefficient [ICC] = 0.98 and 0.92 for the ADL and sports subscales, respectively).[118] The minimal detectable change (MDC) is an increase or decrease of 3 points,[118] and the minimal clinically important difference is 9 points on the ADL subscale and 6 points on the sports subscale.

Each subscale of the HOS demonstrated construct validity when compared to the Medical Outcomes Study 36-Item Short-Form Health Survey questionnaire.[118] In patients with labral tears, the correlation coefficients between the ADL subscale and the Medical Outcomes Study 36-Item Short-Form Health Survey physical function and physical component scores were 0.76 and 0.74, respectively.[116] The correlation coefficients between the sports subscale and the Medical Outcomes Study 36-Item Short-Form Health Survey physical function and physical component scores were 0.72 and 0.68, respectively.[116]

Copenhagen Hip and Groin Outcome Score

I The Copenhagen Hip and Groin Outcome Score (HAGOS)[188] was developed in 2011 to assess a patient's hip and groin disability in a young, active patient. The HAGOS is a disease-specific self-report questionnaire with the following 6 separately scored subscales: pain, other symptoms, physical function in daily living, function in sport and recreation, participation in physical activities, and hip-related quality of life. Each item is scored using standardized answer options ranging from 0 to 4. A normalized score, with 100 indicating no symptoms, is calculated for each subscale.

The HAGOS has substantial test-retest reliability, with ICCs ranging from 0.82 to 0.91 for the 6 subscales.[188] The smallest detectable change for the subscales ranges from 2.7 to 5.2, indicating that changes greater than 5.2 in any scale would be detectable.[188] Construct validity and responsiveness were confirmed, with statistically significant correlation coefficients from 0.37 to 0.73 ($P<.01$) for convergent construct validity and, for responsiveness, from 0.56 to 0.69 ($P<.01$).[188]

International Hip Outcome Tool

I The International Hip Outcome Tool (iHOT-33)[132] was developed in 2012 by the Multicenter Arthroscopy of the Hip Outcomes Research Network specifically for young, active adults with symptomatic hip disease. The iHOT-33 is a disease-specific self-report questionnaire with questions related to the following domains: symptoms and functional limitations; sports and recreational physical activities; job-related concerns; and social, emotional, and lifestyle concerns. Each item on the iHOT-33 is scored using a 100-point visual analog scale, where 100 indicates the best possible score.

The iHOT-33 has moderate to good test-retest reliability (ICC = 0.78 for the overall score).[132] Convergent construct validity was confirmed, with a statistically significant correlation coefficient of 0.81 compared to the Nonarthritic Hip Score.[132] The minimal clinically important difference after hip arthroscopy is 6 points. The properties of the subscales have not been assessed.[132]

Modified Harris Hip Score

V The Modified Harris Hip Score (MHHS)[23] is a disease-specific self-report questionnaire with questions related to pain and functional ability. The original HHS,[70] developed to assess patient function after total hip arthroplasty, was modified by excluding the clinician's judgment of deformity and range of motion. The modified HHS, therefore, allows the patient to complete the questionnaire independently. A single score is calculated, ranging from 0 to 100, where higher scores indicate better function. Approximately 48% of the modified HHS score is based on the patient's description of his or her pain, and the remaining 52% is based on the ability to complete basic activities, including walking, stairs, and donning/doffing shoes and socks. The modified HHS does not capture the patient's ability to perform higher-level tasks, such as heavy work or exercise activities. Although the modified HHS is the most commonly reported outcome measure in the current literature related to patients with nonarthritic hip joint pain, no studies have been reported on the reliability or validity of the measure in nonarthritic hip joint pain.

Western Ontario and McMaster Universities Osteoarthritis Index

V The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[11] is a self-report functional outcome questionnaire. A total score (score range, 0-96) and 3 scale scores representing pain (score range, 0-20), stiffness (score range, 0-8), and physical function (score range, 0-68) are generated. Lower scores represent better health or function. Scores for the scales and the total score may be normalized as a percentage. The WOMAC was originally developed to assess outcomes in patients after a total joint replacement and has limited validity for use in the individual with nonarthritic hip joint disease.[167] A modified version with improved validity has been recently introduced,[167] with further study needed to determine the reliability and responsiveness of the questionnaire.

Hip disability and Osteoarthritis Outcome Score

V The Hip disability and Osteoarthritis Outcome Score (HOOS)[95,142] was introduced in 2003 as a disease-specific self-report questionnaire that could be used for individuals with various types of hip pain. The HOOS includes all questions from the WOMAC, along with additional items thought to be useful in detecting limitations in higher-level activities, such as running, squatting, and pivoting. The current version of the HOOS (version 2) includes 40 items to assess 5 domains: symptoms (stiffness and range of motion), pain, function in daily living, function in sport and recreation, and hip-related quality of life. Each item is scored using standardized answer options scored from 0 to 4. A normalized score, with 100 indicating no symptoms, is calculated for each subscale. The HOOS may be preferred to the WOMAC due to its reduced ceiling effect compared to the WOMAC. Additionally, the WOMAC score can be calculated from the HOOS questionnaire if desired. The HOOS has been shown to have high test-retest reliability[95] and adequate construct validity when used with older individuals[142]; however, the psychometric properties of the HOOS in young adults are unknown. Recently, questions from the HOOS have been used to develop the HAGOS, a hip-specific score developed specifically for hip and groin disability in a young, active patient.[188]

A Clinicians should use a validated outcome measure, such as the HOS, the HAGOS, or the iHOT-33, before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions in individuals with nonarthritic hip joint pain.[71]

Physical Impairment Measures

Trendelenburg Sign

- ICF category: measurement of impairment of body function: power of isolated muscles and muscle groups and control of complex voluntary movements.
- Description: the purpose is to assess ability of the hip abductors to stabilize the pelvis during single-limb stance.
- Measurement method[68]: from standing, the patient performs single-limb stance by flexing the opposite hip to 30° and holding for 30 seconds. Once balanced, the patient is asked to raise the nonstance pelvis as high as possible. From the posterior view, the examiner observes the angle formed by a line that connects the iliac crest and a line vertical to the testing surface. Observation: the test is negative if the pelvis on the nonstance side can be elevated and maintained for 30 seconds. The test is positive if 1 of the following criteria are met: (1) the patient is unable to hold the elevated pelvic position for 30 seconds, (2) no elevation is noted on the nonstance side, (3) the stance hip adducts, allowing the pelvis on the nonstance side to drop downwardly below the level of the stance-side pelvis. A false negative may occur if the patient is allowed to shift his or her trunk too far laterally over the stance limb. The patient may use light touch with the ipsilateral upper extremity, or the examiner may provide gentle manual pressure to maintain balance and reduce the trunk shift. Objective measurement: a goniometer may be used to quantify the amount of pelvic movement. The axis of the goniometer is placed on the anterior superior iliac spine, the stationary arm along an imaginary line between the 2 anterior superior iliac spine landmarks, and the moving arm along the anterior midline of the femur.[204]
- Nature of variable: observation: nominal (positive/negative). Objective measurement: continuous.
- Units of measurement: observation: none. Objective measurement: degrees.

- Measurement properties: objective measurement: Youdas et al[204] measured intratester reliability in healthy subjects. They reported that the intratester reliability for measurement of the hip adduction angle was 0.58 and standard error of measurement (SEM) was 2°. The MDC_{95} was 4°.[204]

Hip Flexion, Abduction, External Rotation (FABER) Test

- ICF category: measurement of impairment of body function: pain in joints and mobility of a single joint
- Description: a test to determine the movement/pain relation (irritability) of hip movements and mobility at the hip joint
- Measurement method: position and motion: the patient is positioned in supine, with the heel of the lower extremity to be tested placed over the opposite knee. The hip joint is passively externally rotated and abducted while stabilizing the contralateral anterior superior iliac spine. The patient is asked what effect the motion has on symptoms. The test is considered positive if the patient reports the production of, or increase in, the anterior groin, posterior buttock, or lateral hip pain, which is consistent with the patient's presenting pain complaint. If no increase in pain is produced, pressure may be placed over the ipsilateral knee to determine the limit/end range of passive range of motion and to again assess for pain provocation. Measurement: after being zeroed against a wall, the inclinometer is placed on the medial aspect of the tibia of the tested lower extremity, just distal to the medial tibial condyle. The range-of-motion measurement is taken at the point of maximal passive resistance or at the point where the patient stopped the test secondary to pain.[31] Provocation: a positive test for hip pathology reproduces groin pain. Range of motion: side-to-side comparison is made.
- Nature of variable: (1) provocation: nominal; (2) range of motion: continuous
- Units of measurement: (1) provocation: none; (2) range of motion: degrees
- Measurement properties: specific to pathology or pain relief: Martin and Sekiya[120] assessed the intertester reliability of the FABER test in people seeking care for intra-articular, nonarthritic hip joint pain. The examiners demonstrated 84% agreement and a kappa value of 0.63 (95% confidence interval [CI]: 0.43, 0.83), indicating substantial[101] reliability. In a separate study, Martin et al[114] assessed the diagnostic accuracy of the FABER test. Using pain relief with a diagnostic injection as the comparison, the sensitivity and specificity of the FABER test were reported to be 0.60 (95% CI: 0.41, 0.77) and 0.18 (95% CI: 0.07, 0.39), respectively. The positive likelihood ratio was 0.73 (95% CI: 0.50, 1.1) and the negative likelihood ratio was 2.2 (95% CI: 0.8, 6).[120] In their study to detect intra-articular hip pathology, including OA, Maslowski et al[121] also assessed the diagnostic accuracy of the FABER test. Using pain relief with a diagnostic injection as the comparison, the sensitivity and specificity of the FABER test were reported to be 0.82 (95% CI: 0.57, 0.96) and 0.25 (95% CI: 0.09, 0.48), respectively.[120] The positive predictive value was 0.46 (95% CI: 0.28, 0.65) and the negative predictive value was 0.64 (95% CI: 0.27, 0.91).[120] Mitchell et al[131] reported a slightly higher sensitivity (88%) when compared to intraoperative findings; however, there was no correlation to a specific hip joint pathology, such as labral or chondral lesions. Specific to range of motion: no studies were located reporting the measurement properties of the FABER for range of motion in people with nonarthritic hip joint pain. In a study of people with knee OA, Cliborne et al[31] reported the reliability of range-of-motion measurements to be excellent (ICC = 0.87; 95% CI: 0.78, 0.94).

Hip Flexion, Adduction, Internal Rotation (FADIR) Impingement Test[110]

- ICF category: measurement of impairment of body function: pain in joints and mobility of a single joint
- Description: a test to assess for painful impingement between the femoral neck and acetabulum in the anterosuperior region. The FADIR test has also been used to assess for specific pathology of the acetabular labrum
- Measurement method: the patient is positioned in supine. The hip and knee are flexed to 90°. Maintaining the hip at 90° of flexion, the hip is then internally rotated and adducted as far as possible. The patient is asked what effect the motion has on symptoms. The test is considered positive if the patient reports a production of, or increase in, the anterior groin, posterior buttock, or lateral hip pain consistent with the patient's presenting pain complaint. If the test is negative, the test is repeated with the hip placed in full flexion.
- Nature of variable: nominal (positive/negative)
- Units of measurement: none
- Measurement properties: Martin and Sekiya[120] assessed the intertester reliability of the FADIR test in people seeking care for intra-articular, nonarthritic hip joint pain. The examiners demonstrated 91% agreement; however, due to the high proportion of positive to negative test agreements, the kappa value was low at 0.58 (95% CI: 0.29, 0.87), indicating only moderate[101] reliability. Specific to pathology or pain relief: 2 studies reported the FADIR test characteristics specific to pain provocation. In both studies, the subjects were patients who reported pain consistent with intra-articular, nonarthritic hip joint pain. Compared to diagnostic injection, the sensitivity and specificity of the FADIR test were reported to be 0.78 (95% CI: 0.59, 0.89) and 0.10 (95% CI: 0.03, 0.29), respectively.[120] The positive likelihood ratio was 0.86 (95% CI: 0.67, 1.1) and the nega-

tive likelihood ratio was 2.3 (95% CI: 0.52, 10.4).[120] Compared to an MRA finding of labral lesion, the sensitivity and specificity of the FADIR test were 0.75 (95% CI: 0.19, 0.99) and 0.43 (95% CI: 0.18, 0.72).[137] In their study to detect intra-articular hip pathology, including OA, Maslowski et al[121] also assessed the diagnostic accuracy of a test that is similar to the FADIR test, called the internal rotation with overpressure test. Using pain relief with a diagnostic injection as the comparison, the sensitivity and specificity of the internal rotation with overpressure test were reported to be 0.91 (95% CI: 0.68, 0.99) and 0.18 (95% CI: 0.05, 0.40), respectively.[121] The positive predictive value was 0.88 (95% CI: 0.67, 0.98) and the negative predictive value was 0.17 (95% CI: 0.04, 0.40).[121] Specific to mechanism contributing to nonarthritic hip joint pain (femoroacetabular impingement): no studies reporting the test characteristics specific to femoroacetabular impingement were located. In their descriptive study, Beck et al[10] assessed 19 subjects with the clinical diagnosis of femoroacetabular impingement, based on clinical exam, radiographs, and MRA. They found that all 19 subjects had a positive FADIR test corresponding to intraoperative dynamic impingement and labral lesions in the anterosuperior region of the hip joint.

Log-Roll Test

- ICF category: measurement of impairment of body structure: fasciae and ligaments of the hip
- Description: a test to determine ligamentous laxity
- Measurement method: the patient is positioned in supine with the hip and knee in 0° of extension. The hip is passively rotated internally and externally. The examiner ensures the rotation is occurring at the hip and not at the knee or ankle. The examiner notes any side-to-side difference in external rotation range of motion. The test is positive for ligamentous laxity when the involved hip demonstrates greater external rotation range of motion than the uninvolved hip.
- Nature of variable: nominal
- Units of measurement: none
- Measurement properties: Martin and Sekiya[120] assessed the intertester reliability of the log-roll test in people seeking care for intra-articular, nonarthritic hip joint pain. The examiners demonstrated 80% agreement and a kappa value of 0.61 (95% CI: 0.48, 0.84), indicating substantial[101] reliability.

Passive Hip Internal and External Rotation

- ICF category: measurement of impairment of body function: mobility of a single joint and pain in joints
- Description: the amount of hip rotation range of motion measured with the hip in 90° of flexion (sitting) and 0° of flexion (prone). The patient is also asked to rate the amount of pain experienced during the movement on a 0-to-10 numeric pain rating scale (NPRS)
- Measurement method:
  - Hip internal and external rotation in 90° of flexion: position and motion: the patient is positioned sitting with the hip at 90° of flexion. The hip measured is placed in 0° of abduction, and the contralateral hip is placed in about 30° of abduction. The reference knee is flexed to 90°, and the leg is passively moved to produce hip rotation. The sitting position assists to stabilize the pelvis, and the pelvis should be closely monitored to avoid pelvic movement. The tibiofemoral joint must also be controlled to prevent motion (rotation or abduction/adduction), which could be construed as hip rotation.[73] The motion is stopped when the clinician reaches a firm end feel or when pelvic movement is necessary for additional movement of the limb. Measurement: the measurement may be taken with an inclinometer or a goniometer. The inclinometer is aligned vertically and along the shaft of the tibia, just proximal to the medial malleolus, for both internal and external rotation range of motion.[72] The axis of the goniometer is placed on the anterior aspect of the patella, the stationary arm is placed vertically so it is perpendicular to the supporting surface, and the movement arm is placed along the anterior midline of the lower leg.[47,175]
  - Hip internal and external rotation in 0° of flexion: position and motion: the patient is positioned prone with feet over the edge of the treatment table. The hip being measured is placed in 0° of abduction, and the contralateral hip is placed in about 30° of abduction. The reference knee is flexed to 90°, and the leg is passively moved to produce hip rotation. Manual stabilization is applied to the pelvis to prevent pelvic movement and also at the tibiofemoral joint to prevent motion (rotation or abduction/adduction), which could be construed as hip rotation.[73] The motion is stopped when the clinician reaches a firm end feel or when pelvic movement is necessary for additional movement of the limb. Measurement: the measurement may be taken with an inclinometer[38] or a goniometer. The inclinometer is aligned vertically and along the shaft of the tibia, just proximal to the medial malleolus, for both internal and external rotation range of motion.[72] The axis of the goniometer is placed on the anterior aspect of the patella, the stationary arm is placed vertically so it is perpendicular to the supporting surface, and the movement arm is placed along the anterior midline of the lower leg.[47,175]
- Nature of variable: continuous (range of motion), ordinal (pain)
- Units of measurement: degrees, 0-to-10 NPRS
- Measurement properties: limited internal rotation range of motion when the hip is flexed to 90° has been associated with bony impingement due to femoroacetabular impingement.[202] There are no known studies reporting the mea-

surement properties of hip range of motion in individuals with nonarthritic hip joint pain. Studies reporting tester reliability in healthy adults and individuals with other musculoskeletal pain provide evidence of excellent intrarater reliability of hip rotation range-of-motion measurements. Ellison et al[47] reported ICCs for hip internal and external rotation ranging from 0.96 to 0.99 in healthy individuals and 0.95 to 0.97 in people with low back pain. In patients with hip OA, Pua et al[159] reported ICCs of 0.93 (95% CI: 0.83, 0.97; SEM, 3.4°) and 0.96 (95% CI: 0.91, 0.99; SEM, 3.1°) for internal and external rotation, respectively. The clinically important difference for the NPRS, derived from patients with low back pain, has been shown to be a reduction of 2 points.[28,51]

Passive Hip Flexion and Passive Hip Abduction

- ICF category: measurement of impairment of body function: mobility of a single joint and pain in joints
- Description: measurement of the amount of passive hip flexion and hip abduction range of motion. The patient is also asked to rate the amount of pain experienced during the movement on a 0-to-10 NPRS
- Measurement method:
  - Hip flexion: position and motion: the patient is in the supine position and the hip in 0° of abduction, adduction, and rotation. With the knee flexed, the hip is passively flexed while the lumbar spine is monitored to avoid posterior pelvic tilt. The motion is stopped when the clinician reaches a firm end feel or when pelvic movement is necessary for additional movement of the limb. Measurement: the axis of the goniometer is placed at the greater trochanter, the stationary arm is placed along the midline of the pelvis, and the moving arm along the midline of the femur.
  - Hip abduction: position and motion: the patient is positioned in supine with the hip in 0° of flexion and rotation. With the knee extended, the hip is passively abducted. Manual stabilization is provided at the pelvis to prevent lateral pelvic tilt or pelvic rotation. The motion is stopped when the clinician reaches a firm end feel or when pelvic movement is necessary for additional movement of the limb. Measurement: the axis of the goniometer is placed on the anterior superior iliac spine of the tested side, the stationary arm along an imaginary line between the 2 anterior superior iliac spine landmarks, and the moving arm along the anterior midline of the femur.
- Nature of variable: continuous (range of motion), ordinal (pain)
- Units of measurement: degrees, 0-to-10 NPRS
- Measurement properties: there are no known studies reporting the measurement properties of hip range of motion in individuals with nonarthritic hip disorders. Studies reporting tester reliability in healthy adults and individuals with other musculoskeletal pain provide evidence of excellent intrarater reliability of hip flexion measurements. In patients with hip OA, Pua et al[159] reported ICCs of 0.97 (95% CI: 0.93, 0.99; SEM, 3.5°) and 0.94 (95% CI: 0.86, 0.98; SEM, 3.2°) for flexion and abduction, respectively. The MDC for hip flexion, determined using 22 participants with knee OA and 17 participants without lower extremity symptoms or known pathology, is 5°, meaning any change more than 5° is considered to be change beyond measurement error.[31] The MDC for pain for hip flexion is a change of 1.2 on the 0-to-10 NPRS.[31] The clinically important difference for the NPRS, derived from patients with low back pain, has been shown to be a reduction of 2 points.[28,51]

Hip Abductor Muscle and Posterior Gluteus Medius Strength Test

- ICF category: measurement of impairment of body function: power of isolated muscles and muscle groups
- Description: a test to determine the strength of the hip abductor muscles
- Measurement method:
  - Hip abductor strength: hip abductor strength is measured with the patient in sidelying on the nontested side. The patient is positioned with the trunk in neutral alignment and the pelvis perpendicular to the testing surface. The nontested hip and knee are flexed. The patient's tested limb is placed in hip abduction, neutral rotation, and neutral flexion/extension. The examiner then monitors for compensation as the patient holds the test position. If the patient can maintain the test position for 3 seconds without compensation, resistance may be applied. The examiner places 1 hand on the iliac crest to prevent the pelvis from rotating or tilting. Measurement: manual muscle test: the examiner uses the other hand to place resistance at the ankle in the direction of femoral adduction. A grade between 0 and 5 is given based on the patient's ability to move or hold the limb against gravity or to resist additional manual force provided by the clinician. Handheld dynamometer: the examiner places the dynamometer at the lateral aspect of the distal thigh. A "make" test[15] is performed by asking the participant to push maximally against the dynamometer, simulating their maximum isometric contraction. To eliminate the effect of tester strength,[180] it is best to perform the "make" test using straps to hold the dynamometer in place and to provide the resistance to the motion. A "break" test[98] is performed by the tester manually applying the resistance. The participant is asked to hold against the examiner's resistance. Maximum strength is assumed when the tester's force is able to overcome the participant's force. Using the dynamometer, force may be expressed as pounds, kilograms, or Newtons. The test may also be performed in supine.

- Posterior gluteus medius strength[89]: posterior gluteus medius strength is measured with the patient in sidelying on the nontested side. The patient is positioned with the trunk in neutral alignment and the pelvis rotated slightly forward. The nontested hip and knee are flexed. The patient's tested limb is placed in hip abduction, slight external rotation, and slight extension. The examiner monitors for compensation as the patient holds the test position. If the patient can maintain the test position for 3 seconds without compensation, resistance may be applied. The examiner firmly places 1 hand on the iliac crest to prevent the pelvis from rotating or tilting. Measurement: manual muscle test: the examiner uses the other hand to place resistance at the ankle in the direction of femoral adduction and flexion. A grade between 0 and 5 is given based on the patient's ability to move or hold the limb against gravity or to resist additional manual force provided by the clinician. Handheld dynamometer: the examiner places the dynamometer at the lateral aspect of the distal thigh. A "make" test[15] is performed by asking the participant to push maximally against the dynamometer, simulating their maximum isometric contraction. To eliminate the effect of tester strength,[180] it is best to perform the "make" test using straps to hold the dynamometer in place and to provide the resistance to the motion. A "break" test[98] is performed by the tester manually applying the resistance. The participant is asked to hold against the examiner's resistance. Maximum strength is assumed when the tester's force is able to overcome the participant's force. Using the dynamometer, force may be expressed as pounds, kilograms, or Newtons.

- Nature of variable: manual muscle test: ordinal. Dynamometer: continuous
- Units of measurement: manual muscle test: none. Dynamometer: force in pounds, kilograms, or Newtons
- Measurement properties: there are no known studies reporting the measurement properties of hip abductor or posterior gluteus medius strength testing in people with nonarthritic hip disorders. Studies reporting tester reliability in healthy adults and people with hip OA provide evidence of good to excellent intrarater reliability for testing the hip abductors. Hip abductors in the sidelying position using handheld dynamometer: the intratester reliability ($ICC_{2,1}$) of force measures in healthy subjects was 0.90 (95% CI: 0.74, 0.97).[198] The coefficient of variation was 3.67%.[197] Hip abductors in the supine position using handheld dynamometer: the intratester reliability ($ICC_{2,1}$) of force measures in healthy subjects was 0.83 (95% CI: 0.57, 0.94)[198] to 0.96.[203] The coefficient of variation was 6.11%.[198] The MDC_{95} determined from a sample of healthy subjects was 5.4% of body weight for males and 5.3% of body weight for females.[203] In subjects with hip OA, the intratester reliability ($ICC_{2,2}$) for hip abductor muscle torque was 0.84 (95% CI: 0.55, 0.94; SEM, 12.1 Nm).[159]

Hip Internal Rotator Muscle Strength Test With the Hip Flexed and the Hip Extended

- ICF category: measurement of impairment of body function: power of isolated muscles and muscle groups
- Description: a test to determine the strength of the hip internal rotator muscles
- Measurement method: hip internal rotators, hip flexed: the internal rotators are measured with the patient in sitting, with the knees flexed to 90°. The patient is positioned with the trunk in neutral alignment and the hip in 90° of flexion and 0° of abduction/adduction.[159] Hip extended: the internal rotators are measured with the patient in supine, with the knee flexed to 90° over the edge of the testing surface. The patient is positioned with the trunk in neutral alignment and the hip in 0° of flexion/extension and 0° of abduction/adduction. To assist in maintaining the trunk in neutral alignment, the opposite hip and knee are placed in flexion with the foot resting on the support surface. The patient's tested limb is placed at end-range internal rotation. The examiner then monitors for compensation as the patient holds the test position. If the patient can maintain the test position for 3 seconds without compensation, resistance may be applied. The examiner places one hand on the medial distal thigh to prevent hip abduction/adduction. Measurement: manual muscle test: the examiner uses the other hand to place resistance at the ankle in the direction of external rotation. A grade between 0 and 5 is given based on the patient's ability to move or hold the limb against gravity or to resist additional manual force provided by the clinician. Handheld dynamometer: the examiner places the dynamometer above the ankle on the lateral aspect. A "make" test[15] is performed by asking the participant to push maximally against the dynamometer, simulating their maximum isometric contraction. To eliminate the effect of tester strength,[180] it is best to perform the "make" test using straps to hold the dynamometer in place and to provide the resistance to the motion. A "break" test[98] is performed by the tester manually applying the resistance. The participant is asked to hold against the examiner's resistance. Maximum strength is assumed when the tester's force is able to overcome the participant's force. Using the dynamometer, force may be expressed as pounds, kilograms, or Newtons.
- Nature of variable: manual muscle test: ordinal. Dynamometer: continuous
- Units of measurement: manual muscle test: none. Dynamometer: force in pounds, kilograms, or Newtons
- Measurement properties: there are no known studies reporting the measurement properties of hip internal rotator strength testing in people with nonarthritic hip disorders.

Hip internal rotation with the hip flexed: in subjects with hip OA, the intratester reliability ($ICC_{2,2}$) for hip internal rotator muscle torque (force in Newtons × lever arm) was 0.98 (95% CI: 0.94, 0.99; SEM, 3.7 Nm).[159]

Hip External Rotator Muscle Strength Test With the Hip Flexed and the Hip Extended

- ICF category: measurement of impairment of body function: power of isolated muscles and muscle groups
- Description: a test to determine the strength of the hip external rotator muscles
- Measurement method: hip external rotators, hip flexed[159]: the external rotators are measured with the patient in sitting, with the knees flexed to 90°. The patient is positioned with the trunk in neutral alignment and the hip in 90° of flexion and 0° of abduction/adduction. Hip extended: the external rotators are measured with the patient in supine, with the knee flexed to 90° over the edge of the testing surface. The patient is positioned with the trunk in neutral alignment and the hip in 0° of flexion/extension and 0° of abduction/adduction. To assist in maintaining the trunk in neutral alignment, the opposite hip and knee are placed in flexion with the foot resting on the support surface. The patient's tested limb is placed at end-range external rotation. The examiner then monitors for compensation as the patient holds the test position. If the patient can maintain the test position for 3 seconds without compensation, resistance may be applied. The examiner places one hand on the lateral distal thigh to prevent hip abduction/adduction. Measurement: manual muscle test: the examiner uses the other hand to place resistance at the ankle in the direction of internal rotation. A grade between 0 and 5 is given based on the patient's ability to move or hold the limb against gravity or to resist additional manual force provided by the clinician. Handheld dynamometer: the examiner places the dynamometer above the ankle on the lateral aspect. A "make" test[15] is performed by asking the participant to push maximally against the dynamometer, simulating their maximum isometric contraction. To eliminate the effect of tester strength,[180] it is best to perform the "make" test using straps to hold the dynamometer in place and to provide the resistance to the motion. A "break" test[98] is performed by the tester manually applying the resistance. The participant is asked to hold against the examiner's resistance. Maximum strength is assumed when the tester's force is able to overcome the participant's force. Using the dynamometer, force may be expressed as pounds, kilograms, or Newtons.
- Nature of variable: manual muscle test: ordinal. Dynamometer: continuous
- Units of measurement: manual muscle test: none. Dynamometer: force in pounds, kilograms, or Newtons
- Measurement properties: there are no known studies reporting the measurement properties of hip external rotator strength testing in people with nonarthritic hip disorders. Hip external rotation with the hip flexed: in subjects with hip OA, the intratester reliability ($ICC_{2,2}$) for hip external rotator muscle torque (force in Newtons × lever arm) was 0.98 (95% CI: 0.96, 0.99; SEM, 3.2 Nm).[159]

Single-Joint Hip Flexor Muscle Strength Test

- ICF category: measurement of impairment of body function: power of isolated muscles and muscle groups
- Description: a test to determine the strength of the hip flexor muscles
- Measurement method: the hip flexors are measured with the patient in sitting, with the knee flexed to 90° over the edge of the testing surface. The patient is positioned with the trunk in neutral alignment and the hip in 0° of external/internal rotation and 0° of abduction/adduction. The patient's tested limb is placed at end-range flexion. The examiner then monitors for compensation as the patient holds the test position. If the patient can maintain the test position for 3 seconds without compensation, resistance may be applied. The examiner places one hand on the anterior shoulder to prevent trunk flexion. Measurement: manual muscle test: the examiner uses the other hand to place resistance at the anterior distal femur in the direction of hip extension. A grade between 0 and 5 is given based on the patient's ability to move or hold the limb against gravity or to resist additional manual force provided by the clinician. Handheld dynamometer: the examiner places the dynamometer just proximal to the knee on the extensor surface of the thigh. A "make" test[15] is performed by asking the participant to push maximally against the dynamometer, simulating their maximum isometric contraction. To eliminate the effect of tester strength,[180] it is best to perform the "make" test using straps to hold the dynamometer in place and to provide the resistance to the motion. A "break" test[98] is performed by the tester manually applying the resistance. The participant is asked to hold against the examiner's resistance. Maximum strength is assumed when the tester's force is able to overcome the participant's force. Using the dynamometer, force may be expressed as pounds, kilograms, or Newtons.
- Nature of variable: manual muscle test: ordinal. Dynamometer: continuous
- Units of measurement: manual muscle test: none. Dynamometer: force in pounds, kilograms, or Newtons
- Measurement properties: there are no known studies reporting the measurement properties of hip flexor strength in people with nonarthritic hip disorders. Hip flexion with the handheld dynamometer: in subjects with hip OA, the intratester reliability ($ICC_{2,2}$) for hip flexor muscle torque (force in Newtons × lever arm) was 0.87 (95% CI: 0.69, 0.95; SEM, 10.9 Nm).[159]

CLINICAL GUIDELINES

Interventions

These guidelines will address the major nonsurgical interventions of nonarthritic hip joint disorders. Because the available evidence examining nonsurgical management of individuals with nonarthritic hip pain is limited, all of the interventions discussed in these guidelines are based on expert opinion. Clinicians should consider a course of conservative management as the initial treatment approach for this population.

PATIENT EDUCATION AND COUNSELING

Griffin et al[62] described the importance of preoperative physical therapy for patients preparing to undergo arthroscopic procedures of the hip joint. Patients may be provided education in regard to joint protection strategies and avoidance of symptom-provoking activities. Individuals with an acetabular labral tear should be educated in regard to activities that could place the labrum at risk for further injury. Advice on activity modifications is indicated for all individuals with nonarthritic hip disorders and should be individually tailored to meet the functional demands and the diagnostic subgroup unique to the individual. Education recommendations based on the presence of specific osseous abnormalities are listed below.

DIAGNOSIS – SPECIFIC INSTRUCTION

Femoroacetabular Impingement

The patient should avoid activities that consistently place the hip joint in positions that create the impingement effect. Activities that place the hip joint in end-range flexion, internal rotation, and in some cases abduction are of particular concern.[43,168]

Structural Instability

Activities that place repetitive strain on the passive restraints of the hip should be limited. Such activities may include the motions of forced extension or rotational loading.

Activity Modification

Daily activities such as sitting, sit-to-stand, ambulation on level surfaces and stairs, and sleeping positions should be assessed to determine whether the patient is able to perform these activities without an increase in pain. The movement pattern and alignment of the hip demonstrated during the activities should be assessed to determine whether the movement pattern or alignment may be contributing to the pain problem.[108] If the movement pattern or alignment appears to be contributing to the pain problem, then instruction should be provided to modify the patient's performance. For example, a patient with a positive hip flexion, adduction, internal rotation (FADIR) test should be instructed to avoid assuming positions that place the hip in the impingement position, such as sitting in a low, soft chair. Sitting in a low, soft chair may place the hip in a flexed and internally rotated position and therefore contribute to impingement-related pain.

If pain is increased or the patient demonstrates a significant impaired movement pattern during ambulation, he or she may need to be instructed in the use of assistive devices, such as a walker, crutches, or a cane. Assistive devices, when used appropriately, will reduce the amount of force through the hip joint. When using a cane, the cane should be placed in the hand opposite the injured limb. Also, instructing patients in gait modification by emphasizing ankle and toe plantar flexion at the terminal stance and preswing phases of the gait cycle may be helpful.[107]

In addition to basic daily activities, activities that increase the patient's pain, such as work-related or fitness activities, should be assessed and modified as appropriate. The activity may be modified by changing the patient's movement or alignment, such as their sitting position at work, or by reducing the intensity of the activity. For instance, if the patient has femoroacetabular impingement, the flexibility routine may need to be modified to limit the use of aggressive end-range flexion or internal rotation stretches.

Any modifications of the physical environment that can decrease the overall amount of repetitive shear forces experienced at the hip joint should be made if feasible. As an example, a patient with femoroacetabular impingement may be instructed to use a higher seat position during work or fitness activities such as cycling. The higher seat position will result in the hips being positioned higher than the knees, and thus excessive hip flexion will be avoided.

Evaluation from a modern pain sciences perspective and patient education from a therapeutic neuroscience approach should be considered. As in OA pain, the exact cause of nonarthritic hip pain is unclear, and there may be changes in central pain processing and central sensitization, along with psychological and behavioral factors such as depression, fear-avoidance beliefs, pain catastrophizing, and low self-efficacy.[134]

F Clinicians may utilize patient education and counseling for modifying aggravating factors and managing pain associated with nonarthritic hip joint pain.

Manual Therapy

A progressive trial of manual therapy, which may include soft tissue or joint mobilization/manipulation, may be beneficial in pain reduction and restoration of motion. Utilization of manual therapy in an attempt to improve the rate of nutrient imbibition for the articular cartilage has been suggested.[171] Indications for mobilization/manipulation of the hip joint include hip pain and decreased passive range of motion with a capsular end feel. Indications for mobilization of the pelvis and hip soft tissue, such as myofascia that may be limiting normal hip mobility, include decreased passive range of motion with an elastic end feel and immediate positive gains in mobility following application of procedures to inhibit or relax the targeted myofascia.

Individuals with identified osseous abnormalities may be subject to specific concerns in regard to manual therapy.

Femoroacetabular Impingement

End-range physiologic techniques such as flexion and internal rotation should be avoided if the patient has cam or pincer impingement. Impingement may be suspected if a bony end feel is detected at the end of hip flexion and internal rotation.

Structural Instability

Joint mobilization, except for pain modulation, is contraindicated in individuals classified as hypermobile.

F In the absence of contraindications, joint mobilization procedures may be indicated when capsular restrictions are suspected to impair hip mobility, and soft tissue mobilization procedures may be indicated when muscles and their related fascia are suspected to impair hip mobility.

Therapeutic Exercises and Activities

Stretching

The clinician must evaluate patients to determine hip range of motion and assess the range of motion end feel to verify the likely cause of the range-of-motion limitation. Patients who display a limited range of motion with a hard (bony) end feel may not benefit from stretching, particularly if stretching aggravates the patient's pain. Patients who display a limited range of motion and a capsular end feel may benefit from stretching.

Two patterns of asymmetrical hip rotation may be found in patients with nonarthritic hip pain, including those with excessive hip external rotation with limited hip internal rotation and those with excessive hip internal rotation with limited hip external rotation. These asymmetries may be related to bony abnormalities or soft tissue restrictions. Impingement (cam or pincer) or femoral retroversion may be correlated with reduced hip internal rotation. Excessive femoral anteversion may be correlated with reduced external rotation. The evidence related to contributors to range-of-motion asymmetries due to soft tissue restrictions is limited.

A common pattern in patients with femoroacetabular impingement is where hip internal rotation is decreased while external rotation is increased.[5,99] Ejnisman et al[46] noted that adult patients (mean age, 35 years) with signs of hip impingement often have more hip external than internal rotation. Wyss et al[202] noted that patients who present with impingement have limited hip internal rotation. Some studies suggest that a loss of internal rotation in patients with impingement is associated with a bony restriction and is not from a shortening of soft (capsular or muscle) tissue.[45,81,99,205] Yuan et al[205] found that patients with a bony block often had significantly limited hip internal rotation, usually less than 10°. Besides limited hip internal rotation, another finding in patients with femoroacetabular impingement is reduced hip flexion and abduction.[81,99,205]

Stretching is contraindicated in those with structural instability, where patients often display an increased range of internal and external hip rotation as well as hip adduction and abduction.

We encourage future studies that will examine the effect of stretching/mobilization on hip joint rotation range of motion in those with limited hip motion or asymmetrical hip rotation and in patients with signs and symptoms of femoroacetabular impingement.

Strengthening

Strength impairments of the lower extremity and trunk identified through physical examination should be addressed. Cibulka et al[30] showed that those who have excessive hip external rotation range of motion when compared to internal rotation range of motion have weakness in their hip internal rotator muscles, whereas those who display excessive hip internal rotation range of motion compared to external rotation range of motion have weakness in the hip external rotator muscles. We recommend that any asymmetrical muscle weakness found in these patients should be addressed with a hip-strengthening program for the specific weakened muscles.

Particular attention should be placed on the strength of the hip abductors and hip rotators in patients with structural instability. It has been suggested that loss of rotational stability may be linked to acetabular labral tears.[151] Sufficient strength may be a particular concern in this population, reducing the ability to control the excessive range of motion that occurs at the hip joint.

Muscle Flexibility

Soft tissue restrictions of the lower extremity and trunk can be addressed through soft tissue mobilization, contract/relax stretching, and prolonged stretching that does not increase the patient's symptoms. Decreased motion secondary to soft tissue length will have a "muscular" end feel as compared to a "hard" end feel due to bony approximation. The most common shortened muscles around the hip include the 2-joint muscles, iliopsoas, rectus femoris, hamstrings, and tensor fascia latae-iliotibial band. Osseous conditions associated with range-of-motion limitations, such as femoroacetabular impingement, femoral retroversion, or excessive femoral anteversion, should not be treated with excessive flexibility exercises, as this may exacerbate symptoms.

Cardiorespiratory Endurance

Individuals with nonarthritic hip joint pain may be deconditioned secondary to decreased activity levels due to pain. Cardiorespiratory/aerobic conditioning is necessary to promote optimal health and prevent or remediate metabolic disorders such as obesity and diabetes. Activities that minimize shearing/frictional forces experienced at the hip joint are optimal. In addition, activities that increase pain should be modified. Activities that enable aerobic conditioning with limited stress to the hip include stationary cycling, swimming, and use of elliptical exercise equipment.

F Clinicians may utilize therapeutic exercises and activities to address joint mobility, muscle flexibility, muscle strength, muscle power deficits, deconditioning, and metabolic disorders identified during the physical examination of patients with nonarthritic hip joint pain.

Neuromuscular Re-education

Neuromuscular re-education, including proprioceptive/perturbation training, has been previously defined as "movement training progressions that facilitate the development of multijoint neuromuscular engrams that combine joint stabilization, acceleration, deceleration, and kinesthesia through intermittent protocols that progress from low intensity movements focused in a single plane to multiplanar power training."[74] Neuromuscular re-education has had some success for other lower extremity disorders[54,165] and may provide an effective intervention in nonarthritic hip pain. Kim and Azuma[92] suggested that nerve endings located within the acetabular labrum potentially have an effect on proprioception. Individuals with a compromised labrum may benefit from training to increase the efficiency of the musculature to provide dynamic stabilization.

F Clinicians may utilize neuromuscular re-education procedures to diminish movement coordination impairments identified in patients with nonarthritic hip joint pain.

CLINICAL GUIDELINES

Summary of Recommendations

F **RISK FACTORS**

Clinicians should consider the presence of osseous abnormalities, local or global ligamentous laxity, connective tissue disorders, and nature of the patient's activity and participation as risk factors for hip joint pathology.

C **DIAGNOSIS/CLASSIFICATION – NONARTHRITIC HIP JOINT PAIN**

Clinicians should use the clinical findings of anterior groin or lateral hip pain or generalized hip joint pain that is reproduced with the hip flexion, adduction, internal rotation (FADIR) test or the hip flexion, abduction, external rotation (FABER) test, along with consistent imaging findings, to classify a patient with hip pain into the International Statistical Classification of Diseases and Related Health Problems (ICD) categories of **M25.5 Pain in joint**, **M24.7 Protrusio acetabula**, **M24.0 Loose body in joint**, and **M24.2 Disorder of ligament**, and the associated International Classification of Functioning, Disability and Health (ICF) impairment-based categories of hip pain (**b28016 Pain in joints**) and mobility impairments (**b7100 Mobility of a single joint**; **b7150 Stability of a single joint**).

F **DIFFERENTIAL DIAGNOSIS**

Clinicians should consider diagnostic categories other than nonarthritic joint pain when the patient's history, reported activity limitations, or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline or when the patient's symptoms are not diminishing with interventions aimed at normalization of the impairments of body function.

A **EXAMINATION – OUTCOME MEASURES**

Clinicians should use a validated outcome measure, such as the Hip Outcome Score (HOS), the Copenhagen Hip and Groin Outcome Score (HAGOS), or the International Hip Outcome Tool (iHOT-33), before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions in individuals with nonarthritic hip joint pain.

B **EXAMINATION – PHYSICAL IMPAIRMENT MEASURES**

When evaluating patients with suspected or confirmed hip pathology over an episode of care, clinicians should assess impairments of body function, including objective and reproducible measures of hip pain, mobility, muscle power, and movement coordination.

F **INTERVENTION – PATIENT EDUCATION AND COUNSELING**

Clinicians may utilize patient education and counseling for modifying aggravating factors and managing pain associated with nonarthritic hip joint pain.

F **INTERVENTION – MANUAL THERAPY**

In the absence of contraindications, joint mobilization procedures may be indicated when capsular restrictions are suspected to impair hip mobility, and soft tissue mobilization procedures may be indicated when muscles and their related fascia are suspected to impair hip mobility.

F **INTERVENTION – THERAPEUTIC EXERCISES AND ACTIVITIES**

Clinicians may utilize therapeutic exercises and activities to address joint mobility, muscle flexibility, muscle strength, muscle power deficits, deconditioning, and metabolic disorders identified during the physical examination of patients with nonarthritic hip joint pain.

F **INTERVENTION – NEUROMUSCULAR RE-EDUCATION**

Clinicians may utilize neuromuscular re-education procedures to diminish movement coordination impairments identified in patients with nonarthritic hip joint pain.

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REFERENCES

1. Al-Hayani A. The functional anatomy of hip abductors. *Folia Morphol (Warsz)*. 2009;68:98-103.
2. Allen D, Beaulé PE, Ramadan O, Doucette S. Prevalence of associated deformities and hip pain in patients with cam-type femoroacetabular impingement. *J Bone Joint Surg Br*. 2009;91:589-594. http://dx.doi.org/10.1302/0301-620X.91B5.22028
3. Anderson LA, Peters CL, Park BB, Stoddard GJ, Erickson JA, Crim JR. Acetabular cartilage delamination in femoroacetabular impingement. Risk factors and magnetic resonance imaging diagnosis. *J Bone Joint Surg Am*. 2009;91:305-313. http://dx.doi.org/10.2106/JBJS.G.01198
4. Anderson SE, Siebenrock KA, Tannast M. Femoroacetabular impingement. *Eur J Radiol*. 2012;81:3740-3744. http://dx.doi.org/10.1016/j.ejrad.2011.03.097
5. Audenaert EA, Peeters I, Vigneron L, Baelde N, Pattyn C. Hip morphological characteristics and range of internal rotation in femoroacetabular impingement. *Am J Sports Med*. 2012;40:1329-1336. http://dx.doi.org/10.1177/0363546512441328
6. Bache CE, Clegg J, Herron M. Risk factors for developmental dysplasia of the hip: ultrasonographic findings in the neonatal period. *J Pediatr Orthop B*. 2002;11:212-218.
7. Banerjee P, McLean C. The efficacy of multimodal high-volume wound infiltration in primary total hip replacement. *Orthopedics*. 2011;34:e522-e529. http://dx.doi.org/10.3928/01477447-20110714-11
8. Bardakos NV, Villar RN. Predictors of progression of osteoarthritis in femoroacetabular impingement: a radiological study with a minimum of ten years follow-up. *J Bone Joint Surg Br*. 2009;91:162-169. http://dx.doi.org/10.1302/0301-620X.91B2.21137
9. Beck M, Kalhor M, Leunig M, Ganz R. Hip morphology influences the pattern of damage to the acetabular cartilage: femoroacetabular impingement as a cause of early osteoarthritis of the hip. *J Bone Joint Surg Br*. 2005;87:1012-1018. http://dx.doi.org/10.1302/0301-620X.87B7.15203
10. Beck M, Leunig M, Parvizi J, Boutier V, Wyss D, Ganz R. Anterior femoroacetabular impingement: part II. Midterm results of surgical treatment. *Clin Orthop Relat Res*. 2004:67-73.
11. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt L. Validation study of WOMAC: a health status instrument for measuring clinically-important patient-relevant outcomes following total hip or knee arthroplasty in osteoarthritis. *J Orthop Rheumatol*. 1988;1:95-108.
12. Bharam S. Labral tears, extra-articular injuries, and hip arthroscopy in the athlete. *Clin Sports Med*. 2006;25:279-292. http://dx.doi.org/10.1016/j.csm.2006.01.003
13. Birrell F, Lunt M, Macfarlane GJ, Silman AJ. Defining hip pain for population studies. *Ann Rheum Dis*. 2005;64:95-98. http://dx.doi.org/10.1136/ard.2003.018788
14. Blankenbaker DG. Update in hip imaging. *Semin Musculoskelet Radiol*. 2013;17:227-228. http://dx.doi.org/10.1055/s-0033-1348089
15. Bohannon RW. Isometric strength data. *Arch Phys Med Rehabil*. 1997;78:566-567.
16. Boykin RE, Anz AW, Bushnell BD, Kocher MS, Stubbs AJ, Philippon MJ. Hip instability. *J Am Acad Orthop Surg*. 2011;19:340-349.
17. Brunner A, Hamers AT, Fitze M, Herzog RF. The plain beta-angle measured on radiographs in the assessment of femoroacetabular impingement. *J Bone Joint Surg Br*. 2010;92:1203-1208. http://dx.doi.org/10.1302/0301-620X.92B9.24410
18. Burnett RS, Della Rocca GJ, Prather H, Curry M, Maloney WJ, Clohisy JC. Clinical presentation of patients with tears of the acetabular labrum. *J Bone Joint Surg Am*. 2006;88:1448-1457. http://dx.doi.org/10.2106/JBJS.D.02806
19. Byers PD, Contepomi CA, Farkas TA. A post mortem study of the hip joint. Including the prevalence of the features of the right side. *Ann Rheum Dis*. 1970;29:15-31.
20. Byrd JW. Hip arthroscopy. The supine position. *Clin Sports Med*. 2001;20:703-731.
21. Byrd JW. Lateral impact injury. A source of occult hip pathology. *Clin Sports Med*. 2001;20:801-815.
22. Byrd JW, Jones KS. Hip arthroscopy for labral pathology: prospective analysis with 10-year follow-up. *Arthroscopy*. 2009;25:365-368. http://dx.doi.org/10.1016/j.arthro.2009.02.001
23. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 2-year follow-up. *Arthroscopy*. 2000;16:578-587. http://dx.doi.org/10.1053/jars.2000.7683
24. Byrd JW, Jones KS. Traumatic rupture of the ligamentum teres as a source of hip pain. *Arthroscopy*. 2004;20:385-391. http://dx.doi.org/10.1016/j.arthro.2004.01.025
25. Carter CO, Wilkinson JA. Genetic and environmental factors in the etiology of congenital dislocation of the hip. *Clin Orthop Relat Res*. 1964;33:119-128.
26. Cerezal L, Arnaiz J, Canga A, et al. Emerging topics on the hip: ligamentum teres and hip microinstability. *Eur J Radiol*. 2012;81:3745-3754. http://dx.doi.org/10.1016/j.ejrad.2011.04.001
27. Chen HH, Li AF, Li KC, Wu JJ, Chen TS, Lee MC. Adaptations of ligamentum teres in ischemic necrosis of human femoral head. *Clin Orthop Relat Res*. 1996:268-275.
28. Childs JD, Piva SR, Fritz JM. Responsiveness of the numeric pain rating scale in patients with low back pain. *Spine (Phila Pa 1976)*. 2005;30:1331-1334.
29. Cibulka MT. Determination and significance of femoral neck anteversion. *Phys Ther*. 2004;84:550-558.
30. Cibulka MT, Strube MJ, Meier D, et al. Symmetrical and asymmetrical hip rotation and its relationship to hip rotator muscle strength. *Clin Biomech (Bristol, Avon)*. 2010;25:56-62. http://dx.doi.org/10.1016/j.clinbiomech.2009.09.006
31. Cliborne AV, Wainner RS, Rhon DI, et al. Clinical hip tests and a functional squat test in patients with knee osteoarthritis: reliability, prevalence of positive test findings, and short-term response to hip mobilization. *J Orthop Sports Phys Ther*. 2004;34:676-685. http://dx.doi.org/10.2519/jospt.2004.34.11.676
32. Clohisy JC, Carlisle JC, Beaulé PE, et al. A systematic approach to the plain radiographic evaluation of the young adult hip. *J Bone Joint Surg Am*. 2008;90 suppl 4:47-66. http://dx.doi.org/10.2106/JBJS.H.00756
33. Clohisy JC, Dobson MA, Robison JF, et al. Radiographic structural abnormalities associated with premature, natural hip-joint failure. *J Bone Joint Surg Am*. 2011;93 suppl 2:3-9. http://dx.doi.org/10.2106/JBJS.J.01734
34. Clohisy JC, Knaus ER, Hunt DM, Lesher JM, Harris-Hayes M, Prather H. Clinical presentation of patients with symptomatic anterior hip impingement. *Clin Orthop Relat Res*. 2009;467:638-644. http://dx.doi.org/10.1007/s11999-008-0680-y
35. Clohisy JC, Nunley RM, Carlisle JC, Schoenecker PL. Incidence and characteristics of femoral deformities in the dysplastic hip. *Clin Orthop Relat Res*. 2009;467:128-134. http://dx.doi.org/10.1007/s11999-008-0481-3
36. Clohisy JC, Nunley RM, Otto RJ, Schoenecker PL. The frog-leg lateral

radiograph accurately visualized hip cam impingement abnormalities. *Clin Orthop Relat Res*. 2007;462:115-121. http://dx.doi.org/10.1097/BLO.0b013e3180f60b53

37. Clohisy JC, Zebala LP, Nepple JJ, Pashos G. Combined hip arthroscopy and limited open osteochondroplasty for anterior femoroacetabular impingement. *J Bone Joint Surg Am*. 2010;92:1697-1706. http://dx.doi.org/10.2106/JBJS.I.00326

38. Czerny C, Hofmann S, Neuhold A, et al. Lesions of the acetabular labrum: accuracy of MR imaging and MR arthrography in detection and staging. *Radiology*. 1996;200:225-230. http://dx.doi.org/10.1148/radiology.200.1.8657916

39. Delcamp DD, Klaaren HE, Pompe van Meerdervoort HF. Traumatic avulsion of the ligamentum teres without dislocation of the hip. Two case reports. *J Bone Joint Surg Am*. 1988;70:933-935.

40. Domb BG, Martin DE, Botser IB. Risk factors for ligamentum teres tears. *Arthroscopy*. 2013;29:64-73. http://dx.doi.org/10.1016/j.arthro.2012.07.009

41. Dorfmann H, Boyer T. Arthroscopy of the hip: 12 years of experience. *Arthroscopy*. 1999;15:67-72. http://dx.doi.org/10.1053/ar.1999.v15.015006

42. Dunn DM. Anteversion of the neck of the femur; a method of measurement. *J Bone Joint Surg Br*. 1952;34-B:181-186.

43. Dy CJ, Thompson MT, Crawford MJ, Alexander JW, McCarthy JC, Noble PC. Tensile strain in the anterior part of the acetabular labrum during provocative maneuvering of the normal hip. *J Bone Joint Surg Am*. 2008;90:1464-1472. http://dx.doi.org/10.2106/JBJS.G.00467

44. Eijer H, Leunig M, Mahomed M, Ganz R. Cross-table lateral radiograph for screening of anterior femoral head-neck offset in patients with femoroacetabular impingement. *Hip Int*. 2011;11:37-41.

45. Eijer H, Myers SR, Ganz R. Anterior femoroacetabular impingement after femoral neck fractures. *J Orthop Trauma*. 2001;15:475-481.

46. Ejnisman L, Philippon MJ, Lertwanich P, et al. Relationship between femoral anteversion and findings in hips with femoroacetabular impingement. *Orthopedics*. 2013;36:e293-e300. http://dx.doi.org/10.3928/01477447-20130222-17

47. Ellison JB, Rose SJ, Sahrmann SA. Patterns of hip rotation range of motion: a comparison between healthy subjects and patients with low back pain. *Phys Ther*. 1990;70:537-541.

48. Ezoe M, Naito M, Inoue T. The prevalence of acetabular retroversion among various disorders of the hip. *J Bone Joint Surg Am*. 2006;88:372-379. http://dx.doi.org/10.2106/JBJS.D.02385

49. Fagerson T. *The Hip Handbook*. Boston, MA: Butterworth-Heinemann; 1998.

50. Farjo LA, Glick JM, Sampson TG. Hip arthroscopy for acetabular labral tears. *Arthroscopy*. 1999;15:132-137. http://dx.doi.org/10.1053/ar.1999.v15.015013

51. Farrar JT, Young JP, Jr., LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain*. 2001;94:149-158.

52. Ferguson SJ, Bryant JT, Ganz R, Ito K. An in vitro investigation of the acetabular labral seal in hip joint mechanics. *J Biomech*. 2003;36:171-178.

53. Ferguson SJ, Bryant JT, Ganz R, Ito K. The influence of the acetabular labrum on hip joint cartilage consolidation: a poroelastic finite element model. *J Biomech*. 2000;33:953-960.

54. Fitzgerald GK, Axe MJ, Snyder-Mackler L. The efficacy of perturbation training in nonoperative anterior cruciate ligament rehabilitation programs for physical active individuals. *Phys Ther*. 2000;80:128-140.

55. Fitzgerald RH, Jr. Acetabular labrum tears. Diagnosis and treatment. *Clin Orthop Relat Res*. 1995:60-68.

56. Flack NA, Nicholson HD, Woodley SJ. A review of the anatomy of the hip abductor muscles, gluteus medius, gluteus minimus, and tensor fascia lata. *Clin Anat*. 2012;25:697-708. http://dx.doi.org/10.1002/ca.22004

57. Freedman BA, Potter BK, Dinauer PA, Giuliani JR, Kuklo TR, Murphy KP. Prognostic value of magnetic resonance arthrography for Czerny stage II and III acetabular labral tears. *Arthroscopy*. 2006;22:742-747. http://dx.doi.org/10.1016/j.arthro.2006.03.014

58. Fujii M, Nakashima Y, Yamamoto T, et al. Acetabular retroversion in developmental dysplasia of the hip. *J Bone Joint Surg Am*. 2010;92:895-903. http://dx.doi.org/10.2106/JBJS.I.00046

59. Ganz R, Leunig M, Leunig-Ganz K, Harris WH. The etiology of osteoarthritis of the hip: an integrated mechanical concept. *Clin Orthop Relat Res*. 2008;466:264-272. http://dx.doi.org/10.1007/s11999-007-0060-z

60. Ganz R, Parvizi J, Beck M, Leunig M, Nötzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res*. 2003:112-120. http://dx.doi.org/10.1097/01.blo.0000096804.78689.c2

61. Gosvig KK, Jacobsen S, Sonne-Holm S, Palm H, Troelsen A. Prevalence of malformations of the hip joint and their relationship to sex, groin pain, and risk of osteoarthritis: a population-based survey. *J Bone Joint Surg Am*. 2010;92:1162-1169. http://dx.doi.org/10.2106/JBJS.H.01674

62. Griffin KM, Henry CO, Byrd JWT. Rehabilitation after hip arthroscopy. *J Sport Rehabil*. 2000;9:77-88.

63. Groh MM, Herrera J. A comprehensive review of hip labral tears. *Curr Rev Musculoskelet Med*. 2009;2:105-117. http://dx.doi.org/10.1007/s12178-009-9052-9

64. Guanche CA, Sikka RS. Acetabular labral tears with underlying chondromalacia: a possible association with high-level running. *Arthroscopy*. 2005;21:580-585. http://dx.doi.org/10.1016/j.arthro.2005.02.016

65. Guevara CJ, Pietrobon R, Carothers JT, Olson SA, Vail TP. Comprehensive morphologic evaluation of the hip in patients with symptomatic labral tear. *Clin Orthop Relat Res*. 2006;453:277-285. http://dx.doi.org/10.1097/01.blo.0000246536.90371.12

66. Guyatt GH, Sackett DL, Sinclair JC, Hayward R, Cook DJ, Cook RJ. Users' guides to the medical literature. IX. A method for grading health care recommendations. Evidence-Based Medicine Working Group. *JAMA*. 1995;274:1800-1804.

67. Hack K, Di Primio G, Rakhra K, Beaulé PE. Prevalence of cam-type femoroacetabular impingement morphology in asymptomatic volunteers. *J Bone Joint Surg Am.* 2010;92:2436-2444. http://dx.doi.org/10.2106/JBJS.J.01280

68. Hardcastle P, Nade S. The significance of the Trendelenburg test. *J Bone Joint Surg Br.* 1985;67:741-746.

69. Harris WH. Etiology of osteoarthritis of the hip. *Clin Orthop Relat Res*. 1986:20-33.

70. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am*. 1969;51:737-755.

71. Harris-Hayes M, McDonough CM, Leunig M, Lee CB, Callaghan JJ, Roos EM. Clinical outcomes assessment in clinical trials to assess treatment of femoroacetabular impingement: use of patient-reported outcome measures. *J Am Acad Orthop Surg*. 2013;21 suppl 1:S39-S46. http://dx.doi.org/10.5435/JAAOS-21-07-S39

72. Harris-Hayes M, Sahrmann SA, Norton BJ, Salsich GB. Diagnosis and management of a patient with knee pain using the movement

system impairment classification system. *J Orthop Sports Phys Ther*. 2008;38:203-213. http://dx.doi.org/10.2519/jospt.2008.2584

73. Harris-Hayes M, Wendl PM, Sahrmann SA, Van Dillen LR. Does stabilization of the tibiofemoral joint affect passive prone hip rotation range of motion measures in unimpaired individuals? A preliminary report. *Physiother Theory Pract*. 2007;23:315-323. http://dx.doi.org/10.1080/09593980701378108

74. Hewett TE, Paterno MV, Myer GD. Strategies for enhancing proprioception and neuromuscular control of the knee. *Clin Orthop Relat Res*. 2002:76-94.

75. Hong RJ, Hughes TH, Gentili A, Chung CB. Magnetic resonance imaging of the hip. *J Magn Reson Imaging*. 2008;27:435-445. http://dx.doi.org/10.1002/jmri.21124

76. Hunt D, Clohisy J, Prather H. Acetabular labral tears of the hip in women. *Phys Med Rehabil Clin N Am*. 2007;18:497-520. http://dx.doi.org/10.1016/j.pmr.2007.05.007

77. Ikeda T, Awaya G, Suzuki S, Okada Y, Tada H. Torn acetabular labrum in young patients. Arthroscopic diagnosis and management. *J Bone Joint Surg Br*. 1988;70:13-16.

78. Ito K, Leunig M, Ganz R. Histopathologic features of the acetabular labrum in femoroacetabular impingement. *Clin Orthop Relat Res*. 2004:262-271.

79. Ito K, Minka MA, 2nd, Leunig M, Werlen S, Ganz R. Femoroacetabular impingement and the cam-effect. A MRI-based quantitative anatomical study of the femoral head-neck offset. *J Bone Joint Surg Br*. 2001;83:171-176.

80. Jacobsen S, Sonne-Holm S. Hip dysplasia: a significant risk factor for the development of hip osteoarthritis. A cross-sectional survey. *Rheumatology (Oxford)*. 2005;44:211-218. http://dx.doi.org/10.1093/rheumtology/keh436

81. Jäger M, Wild A, Westhoff B, Krauspe R. Femoroacetabular impingement caused by a femoral osseous head-neck bump deformity: clinical, radiological, and experimental results. *J Orthop Sci*. 2004;9:256-263. http://dx.doi.org/10.1007/s00776-004-0770-y

82. James SL, Ali K, Malara F, Young D, O'Donnell J, Connell DA. MRI findings of femoroacetabular impingement. *AJR Am J Roentgenol*. 2006;187:1412-1419. http://dx.doi.org/10.2214/AJR.05.1415

83. Johnston TL, Schenker ML, Briggs KK, Philippon MJ. Relationship between offset angle alpha and hip chondral injury in femoroacetabular impingement. *Arthroscopy*. 2008;24:669-675. http://dx.doi.org/10.1016/j.arthro.2008.01.010

84. Jung KA, Restrepo C, Hellman M, AbdelSalam H, Morrison W, Parvizi J. The prevalence of cam-type femoroacetabular deformity in asymptomatic adults. *J Bone Joint Surg Br*. 2011;93:1303-1307. http://dx.doi.org/10.1302/0301-620X.93B10.26433

85. Kalberer F, Sierra RJ, Madan SS, Ganz R, Leunig M. Ischial spine projection into the pelvis: a new sign for acetabular retroversion. *Clin Orthop Relat Res*. 2008;466:677-683. http://dx.doi.org/10.1007/s11999-007-0058-6

86. Kassarjian A, Brisson M, Palmer WE. Femoroacetabular impingement. *Eur J Radiol*. 2007;63:29-35. http://dx.doi.org/10.1016/j.ejrad.2007.03.020

87. Keeney JA, Peelle MW, Jackson J, Rubin D, Maloney WJ, Clohisy JC. Magnetic resonance arthrography versus arthroscopy in the evaluation of articular hip pathology. *Clin Orthop Relat Res*. 2004:163-169.

88. Kelly BT, Williams RJ, 3rd, Philippon MJ. Hip arthroscopy: current indications, treatment options, and management issues. *Am J Sports Med*. 2003;31:1020-1037.

89. Kendall FP, McCreary EK, Provance PG, Rodgers MM, Romani WA. *Muscles: Testing and Function With Posture and Pain*. 5th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2005.

90. Kim WY, Hutchinson CE, Andrew JG, Allen PD. The relationship between acetabular retroversion and osteoarthritis of the hip. *J Bone Joint Surg Br*. 2006;88:727-729. http://dx.doi.org/10.1302/0301-620X.88B6.17430

91. Kim YJ, Jaramillo D, Millis MB, Gray ML, Burstein D. Assessment of early osteoarthritis in hip dysplasia with delayed gadolinium-enhanced magnetic resonance imaging of cartilage. *J Bone Joint Surg Am*. 2003;85-A:1987-1992.

92. Kim YT, Azuma H. The nerve endings of the acetabular labrum. *Clin Orthop Relat Res*. 1995:176-181.

93. Kivlan BR, Clemente FR, Martin RL, Martin HD. Function of the ligamentum teres during multi-planar movement of the hip joint. *Knee Surg Sports Traumatol Arthrosc*. 2013;21:1664-1668. http://dx.doi.org/10.1007/s00167-012-2168-2

94. Kivlan BR, Martin RL, Sekiya JK. Response to diagnostic injection in patients with femoroacetabular impingement, labral tears, chondral lesions, and extra-articular pathology. *Arthroscopy*. 2011;27:619-627. http://dx.doi.org/10.1016/j.arthro.2010.12.009

95. Klässbo M, Larsson G, Harms-Ringdahl K. Promising outcome of a hip school for patients with hip dysfunction. *Arthritis Rheum*. 2003;49:321-327. http://dx.doi.org/10.1002/art.11110

96. Klaue K, Durnin CW, Ganz R. The acetabular rim syndrome. A clinical presentation of dysplasia of the hip. *J Bone Joint Surg Br*. 1991;73:423-429.

97. Kohnlein W, Ganz R, Impellizzeri FM, Leunig M. Acetabular morphology: implications for joint-preserving surgery. *Clin Orthop Relat Res*. 2009;467:682-691. http://dx.doi.org/10.1007/s11999-008-0682-9

98. Krause DA, Schlagel SJ, Stember BM, Zoetewey JE, Hollman JH. Influence of lever arm and stabilization on measures of hip abduction and adduction torque obtained by hand-held dynamometry. *Arch Phys Med Rehabil*. 2007;88:37-42. http://dx.doi.org/10.1016/j.apmr.2006.09.011

99. Kubiak-Langer M, Tannast M, Murphy SB, Siebenrock KA, Langlotz F. Range of motion in anterior femoroacetabular impingement. *Clin Orthop Relat Res*. 2007;458:117-124. http://dx.doi.org/10.1097/BLO.0b013e318031c595

100. Lage LA, Patel JV, Villar RN. The acetabular labral tear: an arthroscopic classification. *Arthroscopy*. 1996;12:269-272.

101. Landis JR, Koch GG. An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. *Biometrics*. 1977;33:363-374.

102. Lavigne M, Parvizi J, Beck M, Siebenrock KA, Ganz R, Leunig M. Anterior femoroacetabular impingement: part I. Techniques of joint preserving surgery. *Clin Orthop Relat Res*. 2004:61-66.

103. Lequesne M, de Seze S. [False profile of the pelvis. A new radiographic incidence for the study of the hip. Its use in dysplasias and different coxopathies]. *Rev Rhum Mal Osteoartic*. 1961;28:643-652.

104. Leunig M, Beaulé PE, Ganz R. The concept of femoroacetabular impingement: current status and future perspectives. *Clin Orthop Relat Res*. 2009;467:616-622. http://dx.doi.org/10.1007/s11999-008-0646-0

105. Leunig M, Beck M, Woo A, Dora C, Kerboull M, Ganz R. Acetabular rim degeneration: a constant finding in the aged hip. *Clin Orthop Relat Res*. 2003:201-207. http://dx.doi.org/10.1097/01.blo.0000073341.50837.91

106. Leunig M, Casillas MM, Hamlet M, et al. Slipped capital femoral epiphysis: early mechanical damage to the acetabular cartilage by a prominent femoral metaphysis. *Acta Orthop Scand*. 2000;71:370-375. http://dx.doi.org/10.1080/000164700317393367

107. Lewis CL, Ferris DP. Walking with increased ankle pushoff decreases hip muscle moments. *J Biomech*. 2008;41:2082-2089. http://dx.doi.org/10.1016/j.jbiomech.2008.05.013

108. Lewis CL, Sahrmann SA. Acetabular labral tears. *Phys Ther*. 2006;86:110-121.

109. MacDermid JC, Walton DM, Law M. Critical appraisal of research evidence for its validity and usefulness. *Hand Clin*. 2009;25:29-42. http://dx.doi.org/10.1016/j.hcl.2008.11.003

110. MacDonald SJ, Garbuz D, Ganz R. Clinical evaluation of the symptomatic young adult hip. *Semin Arthroplasty*. 1997;8:3-9.

111. Maeyama A, Naito M, Moriyama S, Yoshimura I. Periacetabular osteotomy reduces the dynamic instability of dysplastic hips. *J Bone Joint Surg Br*. 2009;91:1438-1442. http://dx.doi.org/10.1302/0301-620X.91B11.21796

112. Martin HD, Savage A, Braly BA, Palmer IJ, Beall DP, Kelly B. The function of the hip capsular ligaments: a quantitative report. *Arthroscopy*. 2008;24:188-195. http://dx.doi.org/10.1016/j.arthro.2007.08.024

113. Martin RL, Enseki KR, Draovitch P, Trapuzzano T, Philippon MJ. Acetabular labral tears of the hip: examination and diagnostic challenges. *J Orthop Sports Phys Ther*. 2006;36:503-515. http://dx.doi.org/10.2519/jospt.2006.2135

114. Martin RL, Irrgang JJ, Sekiya JK. The diagnostic accuracy of a clinical examination in determining intra-articular hip pain for potential hip arthroscopy candidates. *Arthroscopy*. 2008;24:1013-1018. http://dx.doi.org/10.1016/j.arthro.2008.04.075

115. Martin RL, Kelly BT, Leunig M, et al. Reliability of clinical diagnosis in intraarticular hip diseases. *Knee Surg Sports Traumatol Arthrosc*. 2010;18:685-690. http://dx.doi.org/10.1007/s00167-009-1024-5

116. Martin RL, Kelly BT, Philippon MJ. Evidence of validity for the Hip Outcome Score. *Arthroscopy*. 2006;22:1304-1311. http://dx.doi.org/10.1016/j.arthro.2006.07.027

117. Martin RL, Palmer I, Martin HD. Ligamentum teres: a functional description and potential clinical relevance. *Knee Surg Sports Traumatol Arthrosc*. 2012;20:1209-1214. http://dx.doi.org/10.1007/s00167-011-1663-1

118. Martin RL, Philippon MJ. Evidence of reliability and responsiveness for the Hip Outcome Score. *Arthroscopy*. 2008;24:676-682. http://dx.doi.org/10.1016/j.arthro.2007.12.011

119. Martin RL, Philippon MJ. Evidence of validity for the Hip Outcome Score in hip arthroscopy. *Arthroscopy*. 2007;23:822-826. http://dx.doi.org/10.1016/j.arthro.2007.02.004

120. Martin RL, Sekiya JK. The interrater reliability of 4 clinical tests used to assess individuals with musculoskeletal hip pain. *J Orthop Sports Phys Ther*. 2008;38:71-77. http://dx.doi.org/10.2519/jospt.2008.2677

121. Maslowski E, Sullivan W, Forster Harwood J, et al. The diagnostic validity of hip provocation maneuvers to detect intra-articular hip pathology. *PM R*. 2010;2:174-181. http://dx.doi.org/10.1016/j.pmrj.2010.01.014

122. Mason JB. Acetabular labral tears in the athlete. *Clin Sports Med*. 2001;20:779-790.

123. McCarthy J, Noble P, Aluisio FV, Schuck M, Wright J, Lee JA. Anatomy, pathologic features, and treatment of acetabular labral tears. *Clin Orthop Relat Res*. 2003:38-47. http://dx.doi.org/10.1097/01.blo.0000043042.84315.17

124. McCarthy JC, Busconi B. The role of hip arthroscopy in the diagnosis and treatment of hip disease. *Orthopedics*. 1995;18:753-756.

125. McCarthy JC, Lee J. Hip arthroscopy: indications and technical pearls. *Clin Orthop Relat Res*. 2005;441:180-187.

126. McCarthy JC, Noble PC, Schuck MR, Wright J, Lee J. The Otto E. Aufranc Award: the role of labral lesions to development of early degenerative hip disease. *Clin Orthop Relat Res*. 2001:25-37.

127. McCarthy JC, Noble PC, Schuck MR, Wright J, Lee J. The watershed labral lesion: its relationship to early arthritis of the hip. *J Arthroplasty*. 2001;16:81-87.

128. Meyer DC, Beck M, Ellis T, Ganz R, Leunig M. Comparison of six radiographic projections to assess femoral head/neck asphericity. *Clin Orthop Relat Res*. 2006;445:181-185. http://dx.doi.org/10.1097/01.blo.0000201168.72388.24

129. Minardi JJ, Lander OM. Septic hip arthritis: diagnosis and arthrocentesis using bedside ultrasound. *J Emerg Med*. 2012;43:316-318. http://dx.doi.org/10.1016/j.jemermed.2011.09.029

130. Mintz DN, Hooper T, Connell D, Buly R, Padgett DE, Potter HG. Magnetic resonance imaging of the hip: detection of labral and chondral abnormalities using noncontrast imaging. *Arthroscopy*. 2005;21:385-393. http://dx.doi.org/10.1016/j.arthro.2004.12.011

131. Mitchell B, McCrory P, Brukner P, O'Donnell J, Colson E, Howells R. Hip joint pathology: clinical presentation and correlation between magnetic resonance arthrography, ultrasound, and arthroscopic findings in 25 consecutive cases. *Clin J Sport Med*. 2003;13:152-156.

132. Mohtadi NG, Griffin DR, Pedersen ME, et al. The development and validation of a self-administered quality-of-life outcome measure for young, active patients with symptomatic hip disease: the International Hip Outcome Tool (iHOT-33). *Arthroscopy*. 2012;28:595-610.e1. http://dx.doi.org/10.1016/j.arthro.2012.03.013

133. Murphy SB, Kijewski PK, Millis MB, Harless A. Acetabular dysplasia in the adolescent and young adult. *Clin Orthop Relat Res*. 1990:214-223.

134. Murphy SL, Lyden AK, Phillips K, Clauw DJ, Williams DA. Subgroups of older adults with osteoarthritis based upon differing comorbid symptom presentations and potential underlying pain mechanisms. *Arthritis Res Ther*. 2011;13:R135. http://dx.doi.org/10.1186/ar3449

135. Murray RO, Duncan C. Athletic activity in adolescence as an etiological factor in degenerative hip disease. *J Bone Joint Surg Br*. 1971;53:406-419.

136. Nakanishi K, Tanaka H, Sugano N, et al. MR-based three-dimensional presentation of cartilage thickness in the femoral head. *Eur Radiol*. 2001;11:2178-2183. http://dx.doi.org/10.1007/s003300100842

137. Narvani AA, Tsiridis E, Kendall S, Chaudhuri R, Thomas P. A preliminary report on prevalence of acetabular labrum tears in sports patients with groin pain. *Knee Surg Sports Traumatol Arthrosc*. 2003;11:403-408. http://dx.doi.org/10.1007/s00167-003-0390-7

138. Nepple JJ, Carlisle JC, Nunley RM, Clohisy JC. Clinical and radiographic predictors of intra-articular hip disease in arthroscopy. *Am J Sports Med*. 2011;39:296-303. http://dx.doi.org/10.1177/0363546510384787

139. Neumann DA. Kinesiology of the hip: a focus on muscular actions. *J Orthop Sports Phys Ther*. 2010;40:82-94. http://dx.doi.org/10.2519/jospt.2010.3025

140. Neumann G, Mendicuti AD, Zou KH, et al. Prevalence of labral tears and cartilage loss in patients with mechanical symptoms of the hip: evaluation using MR arthrography. *Osteoarthritis Cartilage*. 2007;15:909-917. http://dx.doi.org/10.1016/j.joca.2007.02.002

141. Ng VY, Arora N, Best TM, Pan X, Ellis TJ. Efficacy of surgery for femoroacetabular impingement: a systematic review. *Am J Sports Med*. 2010;38:2337-2345. http://dx.doi.org/10.1177/0363546510365530

142. Nilsdotter AK, Lohmander LS, Klässbo M, Roos EM. Hip disability and osteoarthritis outcome score (HOOS) – validity and responsiveness in total hip replacement. *BMC Musculoskelet Disord*. 2003;4:10. http://dx.doi.org/10.1186/1471-2474-4-10

143. Nogier A, Bonin N, May O, et al. Descriptive epidemiology of mechanical hip pathology in adults under 50 years of age. Prospective series of 292 cases: clinical and radiological aspects and physiopathological review. *Orthop Traumatol Surg Res*. 2010;96:S53-S58. http://dx.doi.org/10.1016/j.otsr.2010.09.005

144. Noguchi Y, Miura H, Takasugi S, Iwamoto Y. Cartilage and labrum degeneration in the dysplastic hip generally originates in the anterosuperior weight-bearing area: an arthroscopic observation. *Arthroscopy*. 1999;15:496-506.

145. Nötzli HP, Wyss TF, Stoecklin CH, Schmid MR, Treiber K, Hodler J. The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. *J Bone Joint Surg Br*. 2002;84:556-560.

146. Ochoa LM, Dawson L, Patzkowski JC, Hsu JR. Radiographic prevalence of femoroacetabular impingement in a young population with hip complaints is high. *Clin Orthop Relat Res*. 2010;468:2710-2714. http://dx.doi.org/10.1007/s11999-010-1233-8

147. Palastanga N, Field D, Soames R. *Anatomy and Human Movement: Structure and Function*. 5th ed. Edinburgh, UK: Butterworth-Heinemann; 2006.

148. Parvizi J, Leunig M, Ganz R. Femoroacetabular impingement. *J Am Acad Orthop Surg*. 2007;15:561-570.

149. Peelle MW, Della Rocca GJ, Maloney WJ, Curry MC, Clohisy JC. Acetabular and femoral radiographic abnormalities associated with labral tears. *Clin Orthop Relat Res*. 2005;441:327-333.

150. Philippon M, Schenker M, Briggs K, Kuppersmith D. Femoroacetabular impingement in 45 professional athletes: associated pathologies and return to sport following arthroscopic decompression. *Knee Surg Sports Traumatol Arthrosc*. 2007;15:908-914. http://dx.doi.org/10.1007/s00167-007-0332-x

151. Philippon MJ. The role of arthroscopic thermal capsulorrhaphy in the hip. *Clin Sports Med*. 2001;20:817-829.

152. Philippon MJ, Kuppersmith DA, Wolff AB, Briggs KK. Arthroscopic findings following traumatic hip dislocation in 14 professional athletes. *Arthroscopy*. 2009;25:169-174. http://dx.doi.org/10.1016/j.arthro.2008.09.013

153. Philippon MJ, Maxwell RB, Johnston TL, Schenker M, Briggs KK. Clinical presentation of femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc*. 2007;15:1041-1047. http://dx.doi.org/10.1007/s00167-007-0348-2

154. Phillips B, Ball C, Sackett D, et al. Oxford Centre for Evidence-based Medicine - Levels of Evidence (March 2009). Available at: http://www.cebm.net/index.aspx?o=1025. Accessed May 6, 2014.

155. Plötz GM, Brossmann J, Schünke M, Heller M, Kurz B, Hassenpflug J. Magnetic resonance arthrography of the acetabular labrum. Macroscopic and histological correlation in 20 cadavers. *J Bone Joint Surg Br*. 2000;82:426-432.

156. Pollard TC, Villar RN, Norton MR, et al. Genetic influences in the aetiology of femoroacetabular impingement: a sibling study. *J Bone Joint Surg Br*. 2010;92:209-216. http://dx.doi.org/10.1302/0301-620X.92B2.22850

157. Pollard TC, Villar RN, Norton MR, et al. Femoroacetabular impingement and classification of the cam deformity: the reference interval in normal hips. *Acta Orthop*. 2010;81:134-141. http://dx.doi.org/10.3109/17453671003619011

158. Potter BK, Freedman BA, Andersen RC, Bojescul JA, Kuklo TR, Murphy KP. Correlation of Short Form-36 and disability status with outcomes of arthroscopic acetabular labral debridement. *Am J Sports Med*. 2005;33:864-870. http://dx.doi.org/10.1177/0363546504270567

159. Pua YH, Wrigley TV, Cowan SM, Bennell KL. Intrarater test-retest reliability of hip range of motion and hip muscle strength measurements in persons with hip osteoarthritis. *Arch Phys Med Rehabil*. 2008;89:1146-1154. http://dx.doi.org/10.1016/j.apmr.2007.10.028

160. Rab GT. The geometry of slipped capital femoral epiphysis: implications for movement, impingement, and corrective osteotomy. *J Pediatr Orthop*. 1999;19:419-424.

161. Rakhra KS, Sheikh AM, Allen D, Beaulé PE. Comparison of MRI alpha angle measurement planes in femoroacetabular impingement. *Clin Orthop Relat Res*. 2009;467:660-665. http://dx.doi.org/10.1007/s11999-008-0627-3

162. Rao J, Zhou YX, Villar RN. Injury to the ligamentum teres. Mechanism, findings, and results of treatment. *Clin Sports Med*. 2001;20:791-799.

163. Rennie AM. Familial slipped upper femoral epiphysis. *J Bone Joint Surg Br*. 1967;49:535-539.

164. Reynolds D, Lucas J, Klaue K. Retroversion of the acetabulum. A cause of hip pain. *J Bone Joint Surg Br*. 1999;81:281-288.

165. Risberg MA, Holm I, Myklebust G, Engebretsen L. Neuromuscular training versus strength training during first 6 months after anterior cruciate ligament reconstruction: a randomized clinical trial. *Phys Ther*. 2007;87:737-750. http://dx.doi.org/10.2522/ptj.20060041

166. Robertson WJ, Kadrmas WR, Kelly BT. Arthroscopic management of labral tears in the hip: a systematic review of the literature. *Clin Orthop Relat Res*. 2007;455:88-92. http://dx.doi.org/10.1097/BLO.0b013e31802c7e0f

167. Rothenfluh DA, Reedwisch D, Müller U, Ganz R, Tennant A, Leunig M. Construct validity of a 12-item WOMAC for assessment of femoro-acetabular impingement and osteoarthritis of the hip. *Osteoarthritis Cartilage*. 2008;16:1032-1038. http://dx.doi.org/10.1016/j.joca.2008.02.006

168. Safran MR, Giordano G, Lindsey DP, et al. Strains across the acetabular labrum during hip motion: a cadaveric model. *Am J Sports Med*. 2011;39 suppl:92S-102S. http://dx.doi.org/10.1177/0363546511414017

169. Sampson TG. Arthroscopic treatment for chondral lesions of the hip. *Clin Sports Med*. 2011;30:331-348. http://dx.doi.org/10.1016/j.csm.2010.12.012

170. Schenker ML, Martin RL, Weiland DE, Philippon MJ. Current trends in hip arthroscopy: a review of injury diagnosis, techniques and outcome scoring. *Curr Opin Orthop*. 2005;16:89-94.

171. Schmerl M, Pollard H, Hoskins W. Labral injuries of the hip: a review of diagnosis and management. *J Manipulative Physiol Ther*. 2005;28:632. http://dx.doi.org/10.1016/j.jmpt.2005.08.018

172. Seldes RM, Tan V, Hunt J, Katz M, Winiarsky R, Fitzgerald RH, Jr. Anatomy, histologic features, and vascularity of the adult acetabular labrum. *Clin Orthop Relat Res*. 2001:232-240.

173. Shindle MK, Ranawat AS, Kelly BT. Diagnosis and management of traumatic and atraumatic hip instability in the athletic patient. *Clin Sports Med*. 2006;25:309-326. http://dx.doi.org/10.1016/j.csm.2005.12.003

174. Shu B, Safran MR. Hip instability: anatomic and clinical considerations of traumatic and atraumatic instability. *Clin Sports Med*. 2011;30:349-367. http://dx.doi.org/10.1016/j.csm.2010.12.008

175. Simoneau GG, Hoenig KJ, Lepley JE, Papanek PE. Influence of hip position and gender on active hip internal and external rotation. *J Orthop Sports Phys Ther*. 1998;28:158-164. http://dx.doi.org/10.2519/jospt.1998.28.3.158

176. Singleton MC, LeVeau BF. The hip joint: structure, stability, and stress; a review. *Phys Ther*. 1975;55:957-973.

177. Sink EL, Gralla J, Ryba A, Dayton M. Clinical presentation of femoroacetabular impingement in adolescents. *J Pediatr Orthop*. 2008;28:806-

811. http://dx.doi.org/10.1097/BPO.0b013e31818e194f

178. Sink EL, Zaltz I, Heare T, Dayton M. Acetabular cartilage and labral damage observed during surgical hip dislocation for stable slipped capital femoral epiphysis. *J Pediatr Orthop*. 2010;30:26-30. http://dx.doi.org/10.1097/BPO.0b013e3181c6b37a

179. Smith J, Hurdle MF, Weingarten TN. Accuracy of sonographically guided intra-articular injections in the native adult hip. *J Ultrasound Med*. 2009;28:329-335.

180. Stratford PW, Balsor BE. A comparison of make and break tests using a hand-held dynamometer and the Kin-Com. *J Orthop Sports Phys Ther*. 1994;19:28-32. http://dx.doi.org/10.2519/jospt.1994.19.1.28

181. Stull JD, Philippon MJ, LaPrade RF. "At-risk" positioning and hip biomechanics of the Peewee ice hockey sprint start. *Am J Sports Med*. 2011;39 suppl:29S-35S. http://dx.doi.org/10.1177/0363546511414012

182. Suzuki S, Awaya G, Okada Y, Maekawa M, Ikeda T, Tada H. Arthroscopic diagnosis of ruptured acetabular labrum. *Acta Orthop Scand*. 1986;57:513-515.

183. Takechi H, Nagashima H, Ito S. Intra-articular pressure of the hip joint outside and inside the limbus. *Nihon Seikeigeka Gakkai Zasshi*. 1982;56:529-536.

184. Tan V, Seldes RM, Katz MA, Freedhand AM, Klimkiewicz JJ, Fitzgerald RH, Jr. Contribution of acetabular labrum to articulating surface area and femoral head coverage in adult hip joints: an anatomic study in cadavera. *Am J Orthop (Belle Mead NJ)*. 2001;30:809-812.

185. Tannast M, Goricki D, Beck M, Murphy SB, Siebenrock KA. Hip damage occurs at the zone of femoroacetabular impingement. *Clin Orthop Relat Res*. 2008;466:273-280. http://dx.doi.org/10.1007/s11999-007-0061-y

186. Tannast M, Kubiak-Langer M, Langlotz F, Puls M, Murphy SB, Siebenrock KA. Noninvasive three-dimensional assessment of femoroacetabular impingement. *J Orthop Res*. 2007;25:122-131. http://dx.doi.org/10.1002/jor.20309

187. Telleria JJ, Lindsey DP, Giori NJ, Safran MR. An anatomic arthroscopic description of the hip capsular ligaments for the hip arthroscopist. *Arthroscopy*. 2011;27:628-636. http://dx.doi.org/10.1016/j.arthro.2011.01.007

188. Thorborg K, Holmich P, Christensen R, Petersen J, Roos EM. The Copenhagen Hip and Groin Outcome Score (HAGOS): development and validation according to the COSMIN checklist. *Br J Sports Med*. 2011;45:478-491. http://dx.doi.org/10.1136/bjsm.2010.080937

189. Tibor LM, Liebert G, Sutter R, Impellizzeri FM, Leunig M. Two or more impingement and/or instability deformities are often present in patients with hip pain. *Clin Orthop Relat Res*. 2013;471:3762-3773. http://dx.doi.org/10.1007/s11999-013-2918-6

190. Tönnis D. *Congenital Dysplasia and Dislocation of the Hip in Children and Adults*. Berlin, Germany: Springer; 1987.

191. Tönnis D. General radiography of the hip joint. In: *Congenital Dysplasia and Dislocation of the Hip in Children and Adults*. Berlin, Germany: Springer; 1987:100-142.

192. Tönnis D, Heinecke A. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. *J Bone Joint Surg Am*. 1999;81:1747-1770.

193. Toomayan GA, Holman WR, Major NM, Kozlowicz SM, Vail TP. Sensitivity of MR arthrography in the evaluation of acetabular labral tears. *AJR Am J Roentgenol*. 2006;186:449-453. http://dx.doi.org/10.2214/AJR.04.1809

194. Troelsen A. Surgical advances in periacetabular osteotomy for treatment of hip dysplasia in adults. *Acta Orthop Suppl*. 2009;80:1-33.

195. Van De Velde S, Fillman R, Yandow S. The aetiology of protrusio acetabuli. Literature review from 1824 to 2006. *Acta Orthop Belg*. 2006;72:524-529.

196. Ward SR, Winters TM, Blemker SS. The architectural design of the gluteal muscle group: implications for movement and rehabilitation. *J Orthop Sports Phys Ther*. 2010;40:95-102. http://dx.doi.org/10.2519/jospt.2010.3302

197. Wiberg G. The anatomy and roentgenographic appearance of a normal hip joint. *Acta Chir Scand*. 1939;83:7-38.

198. Widler KS, Glatthorn JF, Bizzini M, et al. Assessment of hip abductor muscle strength. A validity and reliability study. *J Bone Joint Surg Am*. 2009;91:2666-2672. http://dx.doi.org/10.2106/JBJS.H.01119

199. World Health Organization. *ICD-10: International Statistical Classification of Diseases and Related Health Problems: Tenth Revision*. Geneva, Switzerland: World Health Organization; 2005.

200. World Health Organization. *International Classification of Functioning, Disability and Health: ICF*. Geneva, Switzerland: World Health Organization; 2009.

201. Wynne-Davies R. Acetabular dysplasia and familial joint laxity: two etiological factors in congenital dislocation of the hip. A review of 589 patients and their families. *J Bone Joint Surg Br*. 1970;52:704-716.

202. Wyss TF, Clark JM, Weishaupt D, Nötzli HP. Correlation between internal rotation and bony anatomy in the hip. *Clin Orthop Relat Res*. 2007;460:152-158. http://dx.doi.org/10.1097/BLO.0b013e3180399430

203. Youdas JW, Mraz ST, Norstad BJ, Schinke JJ, Hollman JH. Determining meaningful changes in hip abductor muscle strength obtained by handheld dynamometry. *Physiother Theory Pract*. 2008;24:215-220. http://dx.doi.org/10.1080/03639040701429374

204. Youdas JW, Mraz ST, Norstad BJ, Schinke JJ, Hollman JH. Determining meaningful changes in pelvic-on-femoral position during the Trendelenburg test. *J Sport Rehabil*. 2007;16:326-335.

205. Yuan BJ, Bartelt RB, Levy BA, Bond JR, Trousdale RT, Sierra RJ. Decreased range of motion is associated with structural hip deformity in asymptomatic adolescent athletes. *Am J Sports Med*. 2013;41:1519-1525. http://dx.doi.org/10.1177/0363546513488748

206. Zaragoza E, Lattanzio PJ, Beaulé PE. Magnetic resonance imaging with gadolinium arthrography to assess acetabular cartilage delamination. *Hip Int*. 2009;19:18-23.

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