

Microinstability of the hip: a previously unrecognized pathology

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Summary

Background: Hip microinstability is an established diagnosis; however, its occurrence is still debated by many physicians. Diagnosis of hip microinstability is often challenging, due to a lack of specific signs or symptoms, and patients may remain undiagnosed for long periods. This may lead to early manifestation of degenerative joint disease. Consequently, careful patient and family history must be obtained and diagnostic imaging should follow. After a thorough clinical evaluation of the patient with suspected hip microinstability, the physician should focus on how to improve symptoms and functionality in daily and sports activities.

Purpose: The purpose of this review article was to give a current update regarding this diagnosis and to provide a complete diagnostic approach in order to effectively treat hip microinstability.

Methods: We reviewed the literature on the diagnosis, the non-operative and operative indications for the treatment of this complex and often misdiagnosed pathology.

Conclusion: Conservative treatment is considered the best initial approach, though, surgical intervention should be considered if symptoms persist or other hip pathology exists. Successful surgical intervention, such as hip arthroscopy, should focus on restoring the normal anatomy of the hip joint in order to regain its functionality.

The role of the hip joint capsule has gained particular research interest during the last years, and its repair or reconstruction during hip arthroscopy is considered necessary in order to avoid iatrogenic hip microinstability. Various capsular closure/plication techniques have been developed towards this direction with encouraging results.

Level of evidence: V.

KEY WORDS: hip arthroscopy, hip microinstability, hip dysplasia.

Introduction

The native hip is a particularly constrained joint with a powerful suction seal that is imperative for optimal function of the joint^{1,2}. The hip capsule is one of the most important static stabilizers of the hip joint³ and disruption or debridement of the capsule during hip arthroscopy is a potential contributor to postoperative iatrogenic hip instability. Therefore, hip surgeons must be thoughtful of hip capsule management as hip arthroscopic procedures are increasing exponentially⁴. Unlike other joints in the anatomy, hip instability is generally defined as extra-physiologic hip motion that causes pain with or without symptoms of hip joint instability⁵. This entity is not well defined, as no objective criteria has been proposed to characterize hip microinstability⁶.

The source of pain and symptoms are subtle anatomic abnormalities and in most cases are associated with a repetitive movement generally involving rotations and axial load⁶. Alternatively, ligamentous laxity or muscle weakness can also mimic hip microinstability⁷. As a result of the altered biomechanics between the femoral head and the acetabulum, the surrounding structures such as the labrum, the capsule and the cartilage may be at risk. Symptoms related to this pathology are persistent groin pain, tendinitis from dynamic stabilizer overload or pistoning of the femoroacetabular joint.

Iatrogenic microinstability is a significant cause for failure of hip arthroscopy and a growing cause of revision hip arthroscopy. Therefore, awareness of this pathology is vital for the surgeon in order to avoid unnecessary insult to the capsule or the labrum during hip arthroscopy and thus impede future iatrogenic pathology. The purpose of this article was to review the most relevant data from anatomy and biomechan-

ics for diagnosis and treatment of this pathology. This article submits to the ethical standards of the journal⁸.

Anatomy and Biomechanics

The bony part of the hip joint consists of the acetabulum and the femoral head that are placed together to create a “ball and socket” mechanism in order to serve the mobility and stability properties of the hip joint. As a result, the femoral head receives 170° coverage from the acetabular surface that creates a quasi-hemisphere⁷. More specifically, its posterior coverage is greater than the anterior, due to the acetabular tilt in the coronal plane (48°) as well as in the sagittal plane (21°)⁹. The femoral neck is inclined superiorly 130° relative to the femoral shaft and is also 10° anteverted relative to the femoral transcondylar axis⁷.

In order to standardize the anatomical approach to the acetabulum during the hip arthroscopy procedure, Philippon et al. established a reproducible method to arthroscopically localize the anatomical landmarks on the acetabulum¹⁰. According to their model, the 3:00 position on the clock face corresponds to the superior margin of the psoas U that can be easily located as well as the stellate crease at 12 o'clock.

Apart from the bones, the stability of this joint is based on the soft tissue components that mainly include the labrum, the capsule, the static hip stabilizers (ligamentum teres and capsular ligaments) as well as the dynamic hip stabilizers (muscles).

The Acetabular Labrum

The labrum is an avascular structure made of fibrocartilage, which runs along the acetabular rim, being continuous with the transverse acetabular ligament at the site of the acetabular fossa¹¹. In addition, a transitional zone of calcified cartilage (1-2 mm) connects the labrum with the acetabular articular cartilage¹². The labrum provides stability to the hip joint by increasing the acetabular volume by 20% and the acetabular surface area by 25% approximately¹².

The presence of the labrum increases the intra-articular negative hydrostatic fluid pressure contributing to the “suction cup”, preventing the leak of fluid from the central compartment⁵. In a study of eight cadaveric hips, Philippon et al.² underlined the role of the acetabular labrum in the hip fluid seal by measuring the intra-articular fluid pressurization in six different hip joint states including the intact state, labral tear, labral repair (looped vs through the tissue sutures), partial and complete resection as well as the reconstruction with iliotibial band state. They reported that partial labral tears decrease the pressurization effect of the hip fluid seal and that the through-the-tissue type labral repair can achieve superior results in the restoration of fluid pressure compared with the looped type. Moreover, the same researchers studied the contribution of the labrum as well as the hip cap-

sule to the distractive stability of the hip in the aforementioned six labral states¹. They found that a distraction level of 1-2 mm labrum was the most important hip stabilizer, whereas in greater distraction states, the contribution of the capsule to hip stability started to increase. In addition, the partial labral tear decreased the distractive stability of the joint while the labral reconstruction procedure significantly improved it. Consequently, a relationship between labral pathology and hip microinstability seems to exist and the contribution of the capsule to the hip joint stability cannot be ignored. When loading forces are applied to the hip joint, the labrum is considered to have a protecting role by distributing those stresses¹³. The presence of nociceptors and proprioceptors¹⁴ in the labrum are responsible for the sensory information transferred from the hip joint to the CNS, supporting the coordination of movements that may affect the joint stability.

The Hip Capsule

The hip capsule is composed of both longitudinal and circular fibers. The longitudinal component is 60% reinforced⁵ owing to the existence of the three stabilization ligaments externally; the iliofemoral, the pubofemoral and the ischiofemoral ligaments. At the inner side of the capsule the circular fibers define the zona orbicularis, which encircles mainly the femoral neck, and its thickness increases while moving from the anteroinferior (1.3 mm) to the posterosuperior part (4 mm)¹⁵.

A pericapsular recess of the proximal hip capsule (5 mm proximal and medial to the acetabular rim)¹⁵ may be an useful anatomical pearl in MRI assessment of the capsular elasticity¹⁶. Biomechanically, the capsule seems to offer in the distractive stability of the hip joint at 3-5 mm of distraction as reported by Nepple et al. 2014¹.

Static Hip Stabilizers

Iliofemoral, Pubofemoral, Ischiofemoral Ligament

The iliofemoral ligament, the strongest ligament of the body⁵, has its acetabular origin at the 1:26 position using the clock face system¹⁷. Its lateral arm follows a horizontal route along the neck of the femur to insert at the anterior greater trochanteric crest, whereas the medial arm inserts distally at the intertrochanteric line¹⁸. The ischiofemoral ligament originates at 10:15 clock position on the acetabulum¹⁷ and follows a spiral route to insert at the base of the greater trochanter¹⁹. The pubofemoral ligament arises at the 4:44 clock position on the acetabular rim¹⁷ and blends with the medial arm of iliofemoral ligament, lacking a femoral attachment site⁵.

According to the contribution of the aforementioned ligaments to hip joint stability, Martin et al. hypothesized that the grade of restriction of the rotational hip movements that each of those ligaments offered, was

alternating with the range of motion¹⁸. On a cadaveric study, they measured the contribution of the removal of each of the above hip joint ligaments to the rotational movements both in flexion and extension. For internal rotation (flexion and extension), about 60% contribution came from the ischiofemoral ligament whereas the lateral arm of the iliofemoral ligament added another 12-30%. For external rotation, the greatest contribution, 50%, was from the iliofemoral ligament with the pubofemoral ligament adding another 5%. Importantly, the pubofemoral ligament increased its contribution to the external rotation when moving from flexion to extension where it reached its maximum contribution of 34%. When all of the 3 ligaments were removed, the greatest increase in rotational (both internal and external) range of motion was seen in extension rather than the flexion. Consequently, it is assumed that the hip joint is relaxed when it is flexed, and therefore this position increases its susceptibility to injury.

The Ligamentum Teres

The ligamentum teres has a pyramidal shape with the wider part originating from the acetabular notch whereas its insertion lies into the fovea capitis of the femur (posterior and inferior to its center)⁵. It's length approaches 30-35 mm but there exists great variability²⁰ and furthermore it may not be present in 10% of individuals²¹.

In order to reach its maximum tightness, the hip must be flexed, adducted and externally rotated^{22,23}, but according to others this occurs in flexion and abduction^{24,25}. Philippon et al.²⁶ studied the structural characteristics of the ligamentum teres on 12 human cadaveric models with mean age of 53.6 years and found that the mean ultimate failure load of this ligament is 204 N, showing similar results to another study²⁷. During surgery, in order to achieve 10 mm hip joint distraction, a traction force of 110-225 N²⁸ must be applied and therefore failure should not occur. The stabilizing role of this mesodermal structure has gained specific research interest. In a recent study²⁹, when the ligamentum teres was resected arthroscopically, both internal and external rotation of the hip was observed but other studies suggest that it is not contributing to hip stability³⁰. Therefore, it might play a role, especially when microinstability exists in

the absence of other hip joint pathology. Finally, hypertrophy of the ligamentum teres may be present in dysplastic hips or in cases of hip osteonecrosis³⁰.

Dynamic Stabilizers of the Hip Joint

Dynamic stabilizers of the hip joint are muscles that support the hip capsule and consequently they may have an impact on hip function and stability. More specifically, the iliocapsularis muscles, the indirect head of the rectus femoris as well as the gluteus minimus, are the main representatives of this category. The iliocapsularis reinforces the anterior hip capsule especially in dysplastic hips where it is usually hypertrophied³¹. Relative to their contribution to the hip capsule support, the iliocapsularis is the greatest contributor and adheres at the 2:30 position of the clock face, whereas the indirect head of rectus femoris attaches between 11:30 and 14:00¹⁰. Finally Walters et al.¹⁵ described the "stability arc" in the peripheral hip compartment which consists of the gluteus medius, the iliocapsularis and the superomedial head of the rectus femoris.

Physical Examination

Hip microinstability is often difficult to diagnose. The orthopedic surgeon must be relatively suspicious when assessing the patient with hip disturbances in order to come to a reliable conclusion regarding this pathology. Prior trauma to the hip joint and its mechanism of occurrence should be described in detail. Thorough personal and family history must be taken, accompanied by a comprehensive physical examination, in order to rule out non-hip joint pathology that may manifest with groin or hip pain. Such conditions include gastrointestinal, vascular, genitourinary as well as lumbosacral region issues³².

Assessment of generalized ligamentous laxity, using the Beighton's Physical Examination Criteria (Table I)³³, is a component of the clinical examination that must not be neglected when looking for hip microinstability. When considering a hyperelastic patient, microinstability can only be addressed if pain or other symptoms are still present without taking into consideration

Table I. The Beighton Score.

Joint/ Finding	Negative	Unilateral	Bilateral
Passive dorsiflexion of the fifth finger > 90°	0	1	2
Passive flexion of thumbs to the forearm	0	1	2
Hyperextension of the elbows beyond 10°	0	1	2
Hyperextension of the knees beyond 10°	0	1	2
Forward flexion of the trunk with knees fully extended and palms resting on the floor	0	1	1

Beighton Criteria: A total score of at least 5 defines hypermobility.

the increased range of motion present on that patient⁷. In addition, connective tissue disorders that can result in hyperextensible and/or unstable joints include Ehrlers-Danlos syndrome, Marfan syndrome, Down syndrome and arthrochalis multiplex congenita. Finally, sports like football, dancing, skiing and others may contribute to hip hyperextensibility and microinstability could be the result of repetitive microtrauma⁷.

Pain is not always present and some patients may complain of the “hip giving away” without other symptoms^{6,34}. Snapping, clicking, catching and popping are mechanical symptoms that may be referred from patients of that category, with or without hip impingement symptoms⁵. Finally, hip dysplasia issues should be carefully assessed, since, even a mild dysplasia, without additional joint pathology, can result in microinstability⁵.

Physical examination should start by inspecting the patient’s posture and gait as well as the overall physical condition. Muscle atrophy or hypertrophy may alter the stabilization forces acting on the hip joint and affect its motion and stability. Active and passive range of motion of the hip joint should be evaluated and compared against the unaffected side. Finally, neurovascular examination should take place in both legs³⁵. Specific tests might help the physician disclose a microinstability issue of the hip. A positive hip dial test indicates increased capsular laxity. With the patient in supine position and starting from a neutral extended position, the physician internally rotates the involved limb and then releases the force. External rotation greater than 45° on the axial plain in the absence of an end point defines a positive test result. While performing the dial test³⁶ one must take into account the degree of the femoral neck anteversion of the patient, since a decreased femoral neck anteversion will increase the external rotation and give a false positive result³⁷. In addition, a positive relocation test can be seen³⁵. Apprehension signs during certain hip joint movements, especially external rotation, could indicate a stability problem³⁸. Finally, when traction forces are applied, easy distraction of the hip joint shows microinstability and this test can be performed with the patient under anesthesia to confirm the diagnosis.

Relative to the evaluation of the soft tissue around the hip joint, Thomas and Ober’s test should be performed to evaluate the tightness of hip flexors and iliobtibial band, respectively³⁸. An useful clinical sign that could raise a physician’s suspicion for microinstability existence is a reactive spasm of the secondary stabilizing muscles around the hip joint that may be tender on palpation. This occurs in order to better stabilize the affected leg. Weakness can also be seen in those muscles due to the overwork³⁸.

Imaging

Imaging studies contribute significantly in the diagnostic process of hip microinstability, especially in pa-

tients presenting with subtle symptoms and a non-contributory physical exam that did not yield a specific conclusion.

In order to evaluate multiple joint morphological parameters³⁹ radiographic studies should include an AP pelvic view as well as additional views of the affected hip such as the AP view, the cross-table lateral, the false-profile view of Lequesne³⁸ and sometimes the split view. *Coxa profunda* (Figure 1) or *protrusio acetabuli* are both associated with a deep socket. A positive cross sign (Figure 2) indicates a retroverted acetabulum similarly to the posterior wall and/or ischial spine signs. In addition, acetabular dysplasia can be



Figure 1. Anteroposterior radiographic image of a left hip demonstrating the *coxa profunda* sign, in which the floor of the *fossa acetabuli* (white dotted line) exceeds the ilioischial line medially (green dotted line).



Figure 2. Anteroposterior left hip radiography showing a crossover sign. Note that the anterior rim line (yellow dotted line) lies lateral to the posterior rim (green dotted line) in the cranial aspect of the acetabulum and crossing the latter in the distal aspect of the acetabulum.

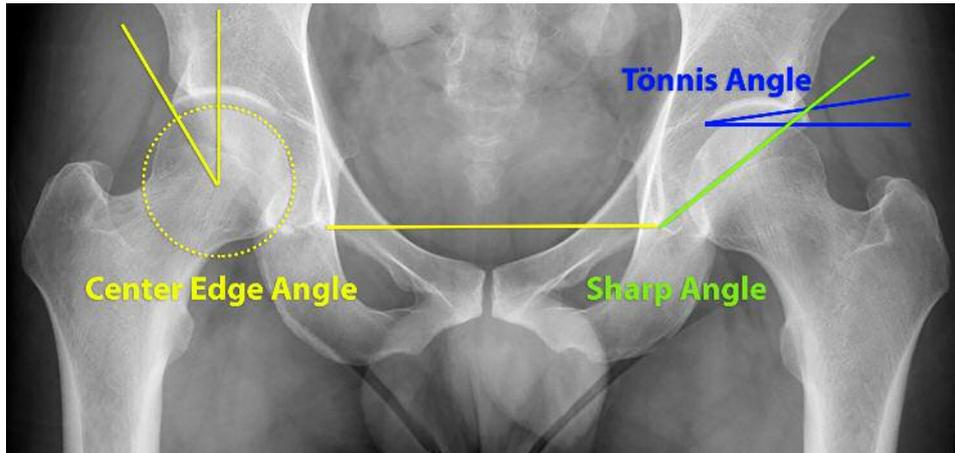


Figure 3. Anteroposterior radiographic image of both hips demonstrating the most important radiographic measurements. The lateral CEA angle is formed by a vertical line through the center of the femoral head and a line connecting the femoral head center with the most lateral edge of the acetabulum. A normal lateral center edge angle ranges between 25 to 40°. The Sharp angle can be measured by drawing a line that connects both tear drop signs on the right and left side of the ischial bones and measuring from this line to the most lateral aspect (most sclerotic portion) of the lateral acetabulum or the pincer deformity. Finally, the Tönnis angle that can be calculated by drawing a horizontal line connecting the base of the acetabular teardrops; next a parallel horizontal line running through the most distal point of the sclerotic acetabular sourcil; the angle is measured between this line and the lateral margin of the acetabular sourcil.

detected by measuring the lateral center-edge angle of Wiberg (less than 20-25° indicates dysplasia) as well as the angle of acetabular inclination (Tönnis angle) with measurements greater than 10° proving dysplastic changes (Figure 3). Split radiographs have gained specific interest during the last years regarding its diagnostic value in patients with hip microinstability, especially in ballet dancers^{40,41}. Mitchell et al.⁴⁰ in a study of 47 professional dancers of both genders measured the change in hip center position (HCP) on AP pelvis and AP pelvis split radiographs. They found that hip subluxation occurred at the split stance, being more prominent in women than men⁴⁰. In addition, the grade of subluxation was influenced by any existent dysplastic changes, the alpha angle and the femoral neck-shaft angle. In addition, Harris et al.⁴¹ underlined the role of the split view as giving the chance to assess the hip joint when the tip of greater trochanter points at 12 o'clock of the acetabulum (internal rotation-toes forward) or at 9 o'clock (external rotation-toes up).

MRI is most useful for the detection of soft tissue abnormalities such as labral pathology, cartilage defects or capsuloligamentous deficiencies^{42,43}. MRI arthrography, besides a more detailed view of the cartilage, offers the ability to assess the hip capsule in terms of laxity or iatrogenic injury that may result in microinstability symptoms. According to a retrospective study from Magerkurth et al.⁴⁴ patients with obvious articular laxity during hip arthroscopy had a thin adjacent joint capsule (<3 mm) and wide anterior hip joint recess measured (>5 mm) on MRI arthrography.

Other diagnostic modalities that can be used are CT, ultrasonography, classic arthrography or bone scans, which can be useful for addressing other pathologies when assessing patients for hip microinstability.

Treatment

In order to effectively treat hip microinstability, multiple factors should be taken into account. Although clinical and diagnostic tests are of outmost importance, the clinical presentation should rule the therapeutic algorithm where symptom relief and improvement of patient's overall functionality is the ultimate goal.

Non-surgical treatment is considered the first line approach to patients with hip microinstability symptoms. Patients should be enrolled in an activity modification module and physical therapy program. Anti-inflammatory medication should also be considered in order to alleviate pain and help any existing inflammatory process to subside quickly. Physical therapy should concentrate on strengthening the core abdominal muscles as well as the rest of the hip stabilizers, mainly the hip external rotators and the abductors. Low back muscle strengthening is also important⁴⁵. In patients who followed the aforementioned conservative protocol for 6-8 weeks but failed to improve, an intra-articular injection of anesthetic to the hip joint usually follows. If significant pain improvement is seen, then surgical management may follow^{30,46}. Also, candidates for a surgical procedure are patients with persisting instability³⁰.

Severe hip dysplasia is an indication of an open procedure such as the acetabular and proximal femur osteotomies^{47,48}. Hip arthroscopy has a dual role regarding the treatment of hip microinstability. The correction of borderline dysplastic characteristics, that may contribute to microinstability, in combination with the manipulation of soft tissues in and around the hip joint are responsible for the encouraging results that has already been reported in literature^{49,50}.

Intra-articular pathology, such as labral tears, cartilage defects and/or ligamentum teres abnormalities are often present in patients with hip microinstability. Capsular laxity and/or capsular defects also play an important role. Arthroscopic thermal capsuloraphy has been described by Philippon et al. and the subsequent shrinkage of the joint space enhanced hip stability⁴⁶. A modern approach is the arthroscopic capsular plication^{45,51}, where absorbable sutures are placed on the iliofemoral ligament in order to correct the capsular defect and increase its tightness, bringing together the two capsular edges. Tightness could be monitored by placing more sutures based on the degree of the desired stabilization³⁸. Relative to the post-operative management of these patients, partial weight bearing for 4 weeks and hip brace for 6 weeks is applied. The brace should prevent external rotation, abduction and hip extension movements in order to preserve capsular integrity after repair or reconstruction³⁸.

Consequently, a successful surgical approach should be holistic, meaning that both the intra-articular and extra-articular hip pathology should be corrected. Thus, apart from capsular manipulation procedures, labral repair or reconstruction, microfracture and ligamentum teres preservation should be considered when treating hip microinstability.

Conclusion

In addition to the bony structure, the anatomical integrity of the soft tissues together with their elastic properties, contribute significantly to the stabilization properties of the hip joint. Gymnastics and other related sports can potentially result in significant (acquired) increase in the elasticity of the hip joint capsule and ligaments, and therefore microinstability may become a long-term consequence in those athletes. While the hip joint is a stable joint and does not dislocate with minor forces, microinstability does exist. The alteration of the anatomical relationships of its components, for any reason, such as trauma, systemic disease, dysplastic changes and others may predispose to instability problems and long-term osteoarthritis. Especially, the proximal femoral anatomical abnormalities are thought to contribute significantly to the above concept. Diagnosis of this entity is challenging since symptoms are usually not clear and therefore a high level of suspicion is necessary. When microinstability of the hip has been confirmed, a trial of conservative treatment is preferred at first, leaving the surgical approach for refractory cases. A comprehensive and mindful rehabilitation is vital to achieve satisfactory results.

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