

Hip Microinstability: Current Concepts in Diagnosis, Surgical Management, and Outcomes

A Narrative Review

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Background: Hip microinstability—subtle, symptomatic femoral head translation without dislocation—compromises the labral suction seal and accelerates chondrolabral wear. Clinical overlap with femoroacetabular impingement syndrome (FAIS) and borderline dysplasia delays recognition.

Purpose: To synthesize contemporary evidence on definitions, diagnosis, imaging, management, and outcomes in hip microinstability and to propose a phenotype-guided framework grounded in the labrum-capsule-ligamentum teres (LT) stability continuum.

Study Design: Narrative review.

Methods: Peer-reviewed literature (2000–2025) focusing on biomechanical investigations, comparative cohorts, meta-analyses, and consensus statements on microinstability, hip capsular management, borderline dysplasia, and LT pathology.

Results: A four-pillar diagnostic approach improves accuracy. The Abduction-Hyperextension-External Rotation (AB-HEER) and Hyperextension-External Rotation (HEER) tests provide the highest single-test accuracy among exam maneuvers, whereas the prone instability test offers high specificity to rule in. The femoroepiphyseal acetabular roof (FEAR) index aids in risk stratification for borderline dysplasia but is position-sensitive. Arthroscopy with labral preservation and complete hip capsular closure improves patient-reported outcomes (PROs) and survivorship relative to non-closure. Iatrogenic cam over-resection can precipitate microinstability; femoral head-neck remplissage is a revision option to restore contour and sealing mechanics. In borderline dysplasia, both arthroscopy and periacetabular osteotomy (PAO) improve PROs when selection is phenotype-guided; PAO trends toward lower total hip arthroplasty (THA) conversion when undercoverage is the primary driver. Early postoperative circumduction is associated with lower rates of adhesion-related reoperation. Return-to-sport (RTS) decisions are criteria-based rather than time-based across successful programs.

Conclusion: A seal-first, close-second strategy, situated within a stability continuum, underpins contemporary care. Standardized definitions, objective laxity metrics, multicenter registries, and microinstability-specific rehabilitation/RTS batteries are needed to refine indications and improve durability; evidence specific to labral augmentation in microinstability remains limited.

Clinical Relevance: Precise phenotyping and capsular stewardship reduce the risk of revision hip arthroscopy and conversion to total hip arthroplasty, inform sport-specific counseling, and align with joint-preservation goals in young, active patients.

Level of Evidence: V (Narrative Review).

Plain Language Summary: Hip microinstability refers to the hip being slightly too loose to maintain the ball of the joint centered during everyday movement or sports. It can cause pain in the front or side of the hip, feelings of the hip giving way, and a clicking sensation. It is more common in athletes and in people with mild undercoverage of the hip socket (sometimes referred to as borderline dysplasia), generalized joint looseness, or differences in the twist of the thigh or pelvis. This review explains how clinicians can recognize microinstability, how to ensure consistency in X-rays and scans across clinics, and how to determine the best course of action between rehabilitation and surgery. Diagnosis combines a careful history, a focused exam that looks for positions that reproduce symptoms, and standardized imaging. Most people start with targeted exercises to strengthen and coordinate the muscles that center the hip. When symptoms persist and imaging reveals treatable issues, surgery can repair the labrum (the seal around the socket) and

tighten the joint lining with precision. If the socket does not cover the ball sufficiently, a realignment operation may be considered, sometimes in conjunction with surgery. Across published studies, many patients experience improvement and return to activity; however, results vary depending on anatomy and sport, and overtightening of the hip capsule can lead to stiffness. A clear, step-by-step pathway from assessment to treatment helps patients receive the right care at the right time while setting realistic expectations for recovery and return to sport.

Keywords: Hip arthroscopy, labral repair, Hip capsule, femoroacetabular impingement, microinstability, sports medicine

Introduction

Hip microinstability is characterized by excessive femoral head translation within the physiologic range of motion (ROM), resulting in pain, apprehension, and dysfunction without frank subluxation or dislocation.^{1–3} The concept was refined through descriptions of capsular laxity testing (eg, the dial test) and the observation that capsulotomy destabilizes, whereas capsular closure or plication restores near-native hip kinematics.^{4–9} Since 2013, the literature has evolved from technique reports to the biomechanical quantification of suction seal mechanics and capsular tensioning, as well as comparative outcomes demonstrating the value of routine capsular closure.^{10–14} Microinstability is particularly relevant in sports that require an extreme and prolonged ROM (eg, ballet, gymnastics, figure skating, hockey), where repetitive extension, external rotation, and abduction stress the anterior capsulolabral complex, potentially leading to central femoral head chondromalacia.^{15–17}

Methods

This narrative review was conducted in accordance with the SANRA (Scale for the Assessment of Narrative Review Articles) guidelines to ensure methodological rigor and transparency. A comprehensive search was performed in PubMed/MEDLINE, Embase, and the Web of Science databases from January 2000 to June 2025. The search strategy included combinations of the following terms: hip, instability, microinstability, labrum, capsule, capsular plication, borderline dysplasia, and periacetabular osteotomy. Reference lists of key articles and prior reviews were also screened to identify additional studies.

Eligible studies included clinical or biomechanical investigations that described the diagnosis, imaging assessment, management, or outcomes of patients with hip microinstability with no language restriction. Both nonoperative and operative management strategies were included, with a focus on arthroscopic and realignment techniques. Studies focusing on conditions unrelated to instability (such as advanced osteoarthritis or femoroacetabular impingement syndrome [FAIS] without instability features) were excluded from the analysis.

Two reviewers (A.V.M. and M.K.) independently screened titles and abstracts, followed by full-text evaluation for eligibility. Disagreements were resolved through open discussion and a consensus-based approach. Data extracted included study design, population characteristics, diagnostic criteria, interventions, outcomes, and follow-up duration. No formal risk-of-bias tool was applied, given the narrative design; study limitations and heterogeneity were recorded and used to temper recommendations in accordance with SANRA guidance.

Definitions and Pathophysiology

Hip Instability Versus Microinstability

Gross instability of the hip denotes pathological translation with clinical subluxation or dislocation (often traumatic).^{1,2} Microinstability refers to excessive femoral translation of the head upon the acetabulum within physiologic ROM, producing pain, apprehension, and dysfunction without frank subluxation or dislocation.^{3,9,18–20} Static radiographs may appear normal, and contributions often include both osseous and soft tissue.

Position- and posture-dependent femoral head translation in native hips appears to occur on the order of sub-millimeter to low single-digit millimeters. Emerging unpublished cadaveric work from the senior author's group, using a 6-degrees-of-freedom robotic platform, suggests that native translation magnitudes are position-dependent and in the low single-digit millimeter range, and that experimentally reducing capsular restraint increases both excursion and

decentration; taken together with published in-vivo and cadaveric series, these observations support the view that no single numerical threshold defines microinstability across positions.^{4,6,7,21} Reported mean excursions in native conditions are typically ~0.3–2.0 mm, with higher transient maxima during provocative maneuvers, while isolated capsulotomy or selective ligament release increases excursion by approximately 1–4 mm, depending on the structure released and the hip posture.²² These magnitudes, although small in absolute terms, are biomechanically meaningful.²²

Contact-pressure mapping and computational modelling demonstrate systematic shifts in contact location and peak pressures with changes in flexion and rotation (cadaveric mean pressures commonly reported 1.5–4.4 MPa), indicating that modest translations and altered rotational restraint can meaningfully redistribute load across the acetabular rim and articular cartilage.²³ In practical terms, such load redistribution offers a mechanistic link to activity-related pain and progressive chondrolabral injury in susceptible morphologies.²³

Mechanistically, capsular ligaments provide the primary rotational and translational restraints across most of the arc of motion, with the labrum and ligamentum teres serving as secondary stabilizers.²⁴ The relative contribution of the ligamentum teres increases in positions of high flexion with adduction and external rotation, which helps explain the position-dependent increases in excursion observed following capsular injury or insufficiency.²⁴ This ligament-angle relationship aligns with clinical observations of apprehension and giving-way in provocative positions, underscoring the rationale for measured capsular management and labral seal restoration in surgical treatment algorithms.²⁴

Osseous Contributions

The hip's ball-and-socket geometry provides passive containment; loss of coverage or unfavorable femoral version reduces the contact area that resists translation, especially at terminal motion.^{25,26} Osseous patterns associated with microinstability include acetabular undercoverage (low lateral center-edge angle [LCEA], elevated Tönnis angle), borderline dysplasia of the hip (BDH) with concerning femoro-epiphyseal acetabular roof (FEAR) index values, and femoral version mismatch (excess femoral antetorsion or acetabular retro/anteversion).^{27,28} These patterns alter load distribution and can accelerate chondrolabral injury.^{25,29} Selected FAIS morphologies may drive posterior translation at end range and, when combined with capsular laxity or undercoverage, contribute to microinstability.^{24,30,31} Surgical treatment of FAIS carries an iatrogenic risk: over-resection during cam decompression reduces head-neck offset and can disrupt labral suction mechanics.^{32,33} A femoral head-neck remplissage using iliotibial (IT) band allograft is a viable revision strategy to restore contour and re-establish the seal when over-resection is present (Grading of Recommendations, Assessment, Development, and Evaluation[GRADE]: Very low; level of evidence [LOE]: IV).^{10,32}

Soft-Tissue Contributors

Hip Capsule

The capsule comprises the zona orbicularis (ZO) and three principal ligaments: the iliofemoral ligament (IFL), pubofemoral ligament (PFL), and ischiofemoral ligament (ISFL).^{24,34,35} Collectively, they resist distraction, rotation, and translation in position-specific ways.^{24,35–37} The IFL is the dominant anterior restraint, limiting extension and external rotation (ER); the PFL contributes restraint in abduction and ER; the ISFL primarily limits internal rotation (IR), particularly in flexion.^{24,31,35,36} The ZO forms a sling around the femoral neck, providing support for distraction resistance.^{34,35} Disruption—whether from arthroscopic capsulotomy, generalized hyperlaxity, or repetitive end-range loading in sport—can permit pathologic micromotion and symptoms consistent with microinstability.^{4–6,8,38}

Ligamentum Teres

The ligamentum teres (LT) augments stability by resisting distraction and constraining rotation at high flexion angles.^{39,40} Although the LT's contribution to microinstability is adjunctive rather than primary, LT pathology is observed frequently in athletes who perform extreme ROM.⁴¹ Addressing LT lesions in the context of optimized capsulolabral management leads to symptomatic improvement.^{42,43}

Labrum

The acetabular labrum attaches to the rim, deepens the socket, and maintains the negative-pressure-suction effect that stabilizes the femoral head.^{31,34,44} The labrum also contributes to joint homeostasis by promoting lubrication.^{31,44} A primary role of the labrum is uniform pressure distribution, which protects the underlying cartilage.^{31,44} Labral injury or detachment compromises these functions and can manifest as microinstability.^{24,31,45} Restoration of labral sealing mechanics through repair or reconstruction is central to joint preservation.^{45,46}

Hip Muscle Strength

Periarticular muscles act as dynamic stabilizers, compressing, steering, and controlling the joint.³⁴ Key contributors include the deep external rotators (quadratus femoris, obturator internus/externus, superior/inferior gemelli), gluteus minimus/medius, and the iliocapsularis, which tensions the anterior capsule.³⁴ Weakness, atrophy, or delayed activation of these muscles has been associated with impaired dynamic containment and modest increases in femoral-head translation at terminal ranges, thereby contributing to secondary microinstability. In conditions such as developmental dysplasia of the hip (DDH), atrophy or dysfunction can diminish compressive stability and exacerbate symptoms of microinstability.^{25,47}

Diagnosis

History and Physical Examination

Diagnosing microinstability is challenging and benefits from a consistent, multi-pillar approach.^{2,18} Patients often report apprehension or giving way in extension, ER, and pain during rotational or end-range tasks.^{2,3,18} Particular attention is warranted for athletes who require prolonged hyperextension.^{3,18,48} A prior hip surgery is an additional clue when postoperative milestones are delayed with persistent pain, reflecting possible iatrogenic capsular defects or loss of the suction seal.^{11,32,49} Generalized ligamentous laxity (Beighton score) heightens suspicion.^{50,51}

Distinguishing pathologic microinstability from nonpathologic generalized hypermobility requires a combined quantitative assessment rather than reliance on an isolated Beighton value.^{51,52} A Beighton score compatible with generalized hypermobility (commonly ≥ 4 in adults) increases the pretest probability but does not establish symptomatic microinstability.^{50,51} Integrate Beighton with dynamic and instrumented measures when available: (1) examination under anesthesia with axial distraction measurements (traction/distraction sensors or goniometric translation) to quantify excessive femoral head translation, (2) ultrasound-assisted axial distraction to visualize translation in real time in selected centers, and (3) diagnostic stress imaging to complement static radiographs in ambiguous cases.^{47,52,53} In combination, these elements help differentiate systemic laxity from focal loss of capsular or suction-seal function, strengthening a working case definition for symptomatic microinstability. (Recommendation: Conditional; GRADE: Low; LOE: III–V). A history of subjective instability remains an essential diagnostic element, particularly when corroborated by objective findings.^{3,25,52}

A standardized sequence reduces guarding and improves reproducibility: gait and single-leg-stance $\rightarrow$ passive log-roll (capsular laxity) $\rightarrow$ Abduction-Hyperextension-External Rotation Test (AB-HEER) $\rightarrow$ Hyperextension-External Rotation (HEER) $\rightarrow$ prone instability, with contralateral comparison and localization of anterior apprehension.^{18,52} Examination under anesthesia often unmasks laxity.^{47,52,53} The senior author additionally uses axial distraction, with and without ultrasound, as an adjunct to confirm excessive translation in patients with normal femoral torsion.^{5,52,53} Patterns of cartilage damage often reflect femoral head micromotion, which may be sport-specific (“motions at risk”) or patient-specific, reinforcing integration of sport history and physical findings during assessment.^{2,25,54}

Test Performance and Interpretation

The AB-HEER test shows the highest single-test accuracy (sensitivity, 80.6%; specificity, 89.4%).^{19,55} HEER is slightly lower (sensitivity 71.0%, specificity 85.1%) but is a reliable adjunct.¹⁹ The prone instability test has limited sensitivity (33.9%) but very high specificity (97.9%), making it a strong rule-in maneuver.^{2,18,19} The dial test identifies excessive ER without a firm endpoint; interpretation should be integrated with the Beighton score to avoid false positives in generalized hyperlaxity.^{18,19,47,53}

Interobserver reproducibility for provocative tests varies with examiner training, standardized positioning, and case mix. AB-HEER and HEER demonstrate the highest reported diagnostic accuracy in single-center series; however, reproducibility metrics differ between studies.^{2,18,19,55} Trained examiners using a standardized sequence achieve

moderate to substantial agreement, whereas novice performance is less consistent.^{2,18,19,55} Prone instability and dial tests are more operator-dependent (prone: low sensitivity, high specificity) and are best used as adjuncts rather than stand-alone screens.^{2,18,19,53} To reduce variability, we recommend a standardized, stepwise examination sequence and formal examiner training, with the examiner's level documented in the record (Recommendation: Conditional; GRADE: Low; LOE: III). These clinical tests should be applied within a multi-pillar diagnostic strategy (history, imaging, intraoperative confirmation) rather than as single-test decision tools (Recommendation: Conditional; GRADE: Low; LOE: III). [Table 1](#) summarizes test characteristics for patient counseling.

Pragmatic Diagnostic Algorithm

We integrate four pillars with explicit thresholds and documentation, rather than a numeric score:

1. History: activity-linked apprehension/giving-way in extension/external rotation with functional limitation; document generalized laxity (modified Beighton).^{50,51}
2. Physical examination: standardized sequence (gait, single-leg stance, log roll, AB-HEER, HEER, prone instability, dial) with contralateral comparison; interpret positive tests in combination.^{2,18,19,47,53,55}
3. Imaging: posture-standardized AP pelvis and false-profile for LCEA/Tönnis/Anterior Center Edge Angle (ACEA)/FEAR, with cross-sectional imaging when values are within $\leq 5^\circ$ of thresholds; record pelvic tilt/rotation and limb position.^{28,56–58}
4. Intraoperative verification (when surgery is indicated): suction-seal assessment, drive-through sign, capsular redundancy/deficiency, and ease of distraction; apply a test–treat–retest workflow after labral repair and after capsular plication.^{21,30,59}

Microinstability is probable when there is a characteristic history, plus at least two reproducible positive provocative tests and posture-standardized imaging consistent with under-containment or labral/capsular compromise, or when intraoperative loss of suction seal/drive-through sign corroborates symptoms. Otherwise classify as possible, prioritize

Table 1 Physical Examination Maneuvers for Microinstability

Test	Primary Finding	Sensitivity (95% CI)	Specificity (95% CI)	Examiner Training & Reproducibility	Spectrum Effects/Caveats
AB-HEER	Anterior pain/apprehension in abduction-hyperextension-ER	80.6% (70.8–90.5)	89.4% (80.5–98.2)	Requires standardized positioning and stepwise sequence; novice-to-expert sensitivity may vary (report interrater kappa if available).	Performance declines in low-prevalence cohorts; guarding reduces sensitivity.
HEER	Pain/apprehension in hyperextension-ER	71.0% (59.7–82.3)	85.1% (74.9–95.3)	Reliable adjunct when performed after AB-HEER; training improves reproducibility.	Lower sensitivity in early/low-symptom cases; performance depends on examiner technique.
Prone instability	Pain/apprehension with anterior force in the prone position	33.9% (22.1–45.7)	97.9% (93.7–100.0)	High specificity (rule-in); training is required for force vector and detection of apprehension.	Low sensitivity; cannot rule out instability alone; better as a rule-in test.
Dial test	Excess ER without endpoint (supine)	65% (70% w/o diagnosis of global laxity)	84% (90% w/o diagnosis of global laxity)	Interpret with the Beighton score/hyperlaxity assessment.	More informative in non-hyperlax subgroups; confounded by generalized laxity.

Notes: The table illustrates the physical examination maneuvers most commonly used to assess hip microinstability. Columns show the maneuver name, clinical finding elicited, reported diagnostic properties, required patient/examiner positioning, and brief interpretive notes, including common pitfalls. Where available, the table includes 95% confidence intervals and sample sizes; if CIs are not reported in the primary report, we explicitly note this.

Abbreviations: AB-HEER, Abduction-Hyperextension-External Rotation Test; HEER, Hyperextension-External Rotation Test; ER, External Rotation; w/o, Without.

nonoperative care, and pursue targeted reassessment (examination under anesthesia or ultrasound-assisted axial distraction may be used selectively to quantify translation)(*Recommendation: Conditional; GRADE: Low; LOE: III–V*).^{5,47,56–58}

Emerging dynamic modalities, such as stress- or position-dependent magnetic resonance imaging (MRI) and three-dimensional functional computed tomography (CT), may quantify posture- and load-related changes in coverage and femoral head translation, complementing static indices. These applications are promising but remain investigational and warrant prospective validation with standardized acquisition protocols.^{34,47}

Imaging: Indices, Positioning, and Consequences

Radiographs (anteroposterior [AP] pelvis and false-profile-views) allow LCEA, Tönnis angle, ACEA, and FEAR calculations.^{28,56,60–62} FEAR is helpful in borderline dysplasia (LCEA $\leq 25^\circ$) but is sensitive to pelvic tilt and limb position; document positioning and avoid single-value decisions.^{28,57,62} CT quantifies femoral and acetabular version.^{52,56,58} MRI and magnetic resonance arthrography (MRA) help evaluate structures that are poorly visualized on radiographs and CT, including the capsule, labrum, and LT, and can further assess articular cartilage.^{34,47} In dysplastic ranges, radiographs may underestimate coverage relative to CT; it is essential to recognize method-dependent measurement shifts.⁵⁶ When the radiographic LCEA or Tönnis angle is within $\leq 5^\circ$ of a classification threshold (eg, LCEA 18–25° borderline range), obtain cross-sectional imaging and document patient positioning (pelvic tilt/rotation), as AP radiographs can underestimate lateral coverage.^{56–58} This approach avoids misclassification and inappropriate selection of arthroscopy versus reorientation (GRADE: Low; LOE: III).^{56–58} Table 2 details thresholds, caveats, and clinical use.

Intraoperative Confirmation and Phenotyping

Arthroscopy enables direct assessment of the suction seal, drive-through sign, focal capsular redundancy/deficiency, LT status, and ease of distraction.^{49,52} A test–treat–retest workflow—rechecking the seal after labral repair and again after capsular plication—aligns technical choices with observed function.^{21,30,52} Synthesizing intraoperative findings with history, examination, and imaging supports phenotype classification—coverage-dominant, torsion-dominant, or capsular-dominant—which then guides the choice among arthroscopy, periacetabular osteotomy (PAO), staged/hybrid strategies, and adjunctive procedures (version correction, LT treatment).^{25,59}

Table 2 Radiographic Indices and Clinical Use

Modality/ View	Standardized Acquisition (Operational)	Key Measure(s)	Typical AP→CT shift (Approximation)	Practical Note
AP pelvis (document supine/ standing)	Supine, legs neutral, pelvis not rotated (symmetric obturator foramina), document patient position and pelvic tilt relative to standard landmarks	LCEA, Tönnis angle	LCEA: AP radiographs may underestimate LCEA vs CT by $\approx 2\text{--}6^\circ$ (range depends on pelvic tilt/rotation and technique); Tönnis angle may shift by $\sim 1\text{--}4^\circ$.	If LCEA is within $\leq 5^\circ$ of a dysplasia threshold, obtain a CT or standardized standing false-profile and document tilt/rotation. Cite refs 66–68. (GRADE: Low; LOE: III)
False-profile (standing)	Standing, pelvis rotated $\sim 65^\circ$ per Lequesne technique—document the degree and side	ACEA, anterior coverage	Modality-dependent shifts; false-profile typically shows greater anterior coverage than AP pelvis; quantify vs CT if borderline	Use to assess anterior undercoverage and impingement; record patient stance.
CT (coronal reconstruction through femoral head center; supine)	Supine, legs neutral; reconstruct the true coronal plane through the femoral head center for LCEA	LCEA (CT coronal)	Reference standard for bony coverage; used to confirm borderline radiographic findings	Always document whether the measurement is taken while the patient is weight-bearing or in a supine position.

Notes: The table depicts radiographic indices used to evaluate acetabular coverage and hip stability. For each index, the table lists: measurement method (radiograph view or CT, including positioning), typical threshold(s) reported in the literature, clinical interpretation (including implications for arthroscopy vs reorientation), and modality-specific caveats.

Abbreviations: BHD, Borderline Hip Dysplasia; LCEA, Lateral Center-Edge Angle; ACEA, Anterior Center Edge Angle; CT, Computed Topography; PAO, Periacetabular Osteotomy.

Management

Nonoperative Care

All patients with suspected microinstability should begin with nonoperative care consistent with FAIS/dysplasia pathways.^{2,48,63} First-line treatment includes targeted physical therapy and symptom or disability-guided activity modification.^{2,63} Emphasis typically includes: (1) strengthening hip abductors and deep external rotators; (2) anterior chain control to limit extension-ER stress; (3) lumbopelvic stability and kinetic-chain-mechanics; and (4) graded exposure to end-range tasks.^{48,63–65} Image-guided intra-articular injection can aid diagnosis and provide short-term relief.²⁵ Targeted deep-rotator focus: because the deep external rotators act as dynamic joint-centers, rehabilitation should prioritize restoring compressive motor control (early low-load isometrics/closed-chain drills), progress to external-rotation strengthening at functional angles, and finish with neuromuscular re-education to reestablish timely activation and reduce secondary femoral-head translation.³ Protocols remain heterogeneous; microinstability-specific regimens require prospective validation. Progression should be criteria-based (apprehension-free ROM, strength symmetry, task tolerance), not time-based.^{16,64,65} Patients are often reassessed after 6–8 weeks; persistent symptoms may warrant discussion of surgical options.^{48,52,63}

Surgical Management & Outcomes

Hip microinstability is rarely the sole indication for surgery.^{26,49} Hip preservation procedures typically occur in the setting of concomitant FAIS, borderline dysplasia, or symptomatic hyperlaxity.^{25,51}

Bone—Containment, Iatrogenesis, and Outcomes

Bony architecture contributes to passive containment and influences the risk-benefit calculation for resective procedures.^{66,67} Resection for cam or pincer morphology is calibrated to relieve conflict while guarding against destabilization in instability-dominant phenotypes.^{68,69} Excessive cam resection can induce microinstability; case series and technique reports describe femoral head-neck soft-tissue remplissage as a salvage maneuver to re-establish contour and sealing mechanics.^{32,33,70} Current evidence is limited and early (single-center case series/technical notes, short follow-up, and no robust comparators), so its use should be conditional rather than routine (GRADE very low; Level IV).^{32,33,70} Candidate profiles include revision hips with documented over-resection and intraoperative suction-seal failure, focal head-neck contour defects amenable to soft-tissue filling, and absence of advanced chondral loss or substantial undercoverage that would favor bony reconstruction or arthroplasty.^{32,33,70} Early reports describe symptomatic improvement and favorable patient-reported outcomes (PROs) after remplissage; however, available data are largely limited to single-center case series and technical notes, with limited follow-up and no high-quality comparative trials.^{32,33,70} Outcomes data on revision rates, sport-specific performance, and total hip arthroplasty (THA) conversion remain sparse.^{32,33,70} In addition, studies of primary FAIS correction in patients with borderline instability show variable survivorship and THA-conversion rates across cohorts, and surgeon/institutional factors (including case volume and selection thresholds) modify observed outcomes, which argues for caution in making blanket procedural recommendations without larger, multicenter, and disease-specific cohorts.^{69,71,72}

Hip Capsule—Components, Stewardship, and Outcomes

The hip capsule (IFL, PFL, ISFL; ZO) provides bulk restraint to rotation and translation, contributing to the suction seal.^{24,35} Because arthroscopic capsulotomy compromises these restraints, contemporary protocols advocate re-establishing capsular continuity with complete hip capsular repair/closure or plication (Expert consensus; GRADE quality: Very low; Evidence level: V).^{8,21,31} Comparative pooled reviews and meta-analyses of predominantly observational cohorts report overall superior patient-reported outcomes and improved survivorship with complete capsular closure versus non-closure, but these syntheses combine heterogeneous single-center series, retrospective matched cohorts, and differing definitions of closure, producing variable effect sizes and limited causal inference (Comparative data; GRADE quality: Low; Evidence level: III–IV [retrospective matched cohorts/case series]).^{11,13,73,74} Some multicenter datasets and adjusted analyses reveal smaller or non-significant differences for specific endpoints (including THA

conversion) after accounting for patient factors and surgeon volume, suggesting that capsular management is one of several interdependent variables influencing outcomes, rather than a universally decisive intervention.⁷⁵

Observational series consistently implicate incomplete capsular closure or capsular deficiency in reoperation among younger, hyperlax, or revision patients, supporting a risk-stratified approach to capsule stewardship (Comparative data + expert synthesis; GRADE quality: Low; Evidence level: III–IV).^{14,30} Short- to mid-term THA conversion is uncommon, and several series report lower THA conversion rates after capsular repair/closure compared to non-repair, although findings vary by cohort and follow-up duration.^{11,12,72,76}

In high-level athletic cohorts, complete capsular closure has been associated with a faster time to criteria-based return to play and a higher return rate compared with non-closure in single-center studies.^{15–17} Reported overall return-to-sport (RTS) rates after arthroscopy with repair/capsule closure commonly range from 70% to 90%, with 50% to 70% returning to the same competitive level in pooled and systematic reviews, recognizing wide heterogeneity across studies.^{15,16,77,78}

While complete capsular closure after hip arthroscopy generally restores axial distraction resistance and is associated with improved clinical outcomes, excessive capsular tension or aggressive plication may alter physiologic kinematics and predispose patients to postoperative stiffness or capsulorrhaphy-related morbidity.⁷⁹ Cadaveric and clinical reports demonstrate that different suture techniques and degrees of imbrication variably change joint laxity and range of motion, with some plication constructs producing measurable reductions in external rotation and end-range motion.⁸⁰ Case series and technique reviews also document that overtightening can contribute to adhesive-like capsular stiffness and reduced functional ROM.^{4,68,81} Therefore, intraoperative calibration of capsular tension—aiming to reconstitute near-native distraction resistance and rotational freedom rather than maximal tautness—is recommended.^{4,68,81} Passive rotation testing should be performed after repair and compared with the native or contralateral baseline, and objective adjuncts (traction-force logs, calibrated suture tensioners, intraoperative fluoroscopic measurements) should be incorporated to reduce the risk of over-constraint.^{4,68,81}

The incremental value of routine, complete closure in non-hyperlax, non-dysplastic FAIS remains mixed: some cohorts show similar PROs and RTS to selective closure when stability is otherwise addressed, whereas others report modest reductions in failure or revision with complete closure and/or plication.^{12–14,82,83} Taken together, the balance of evidence favors closure where feasible and in at-risk hips, but equipoise persists in clearly nondysplastic, non-hyperlax FAIS; effect sizes are small and technique-dependent (closure versus imbrication, suture configuration, rehabilitation protocol).^{68,84}

Labrum—Implications, Repair, Reconstruction, and Augmentation

The labrum is a fibrocartilaginous ring that deepens the socket and maintains the suction seal; loss of this seal increases micromotion and pain.^{8,44} The primary surgical goal in instability-leaning phenotypes is to restore sealing mechanics: repair when tissue is viable, augment when tissue is thin or hypoplastic, and reconstruct when tears are irreparable, rim work is minimized to preserve coverage.^{45,85}

Across comparative cohorts, labral preservation outperforms debridement on PROs, with lower reoperation rates.^{45,46,85,86} A multicenter series with a follow-up of > 10 years in selected cohorts with borderline dysplasia reports sustained benefit when sealing mechanics are restored.^{69,71,87}

Augmentation (eg, IT band allograft) is increasingly used for insufficient labral tissue and has shown encouraging PRO gains and sealing restoration in early cohorts; however, microinstability-specific data are limited. Observational series suggest favorable short- to mid-term PROs and RTS after augmentation in carefully selected patients; however, comparative data versus repair are heterogeneous and technique-dependent, and universally accepted thickness thresholds are lacking.^{88–92} MRI millimetric cut-points and arthroscopic grading vary across studies.^{93,94} Augmentation can restore the seal and reduce the retear risk in low-volume labra; however, repair may suffice when tissue quality is adequate.^{91,95,96} Equipoise remains, and trials with predefined thickness criteria and core outcome sets are needed.^{89,94,97,98}

Ligamentum Teres—Function, Indications, and Outcomes

The LT provides measurable end-range rotational restraint and contributes to distraction resistance, particularly in high flexion/adduction/external-rotation positions.^{39,40} Debridement may relieve symptoms from partial or degenerative tears; LT reconstruction (auto/allograft) is reserved for refractory instability after labral and capsular optimization.⁴²

Systematic reviews and ≥ 2 -year series report short-term improvements in PROs, with reoperation rates of approximately 10–20% and limited long-term survivorship data.^{42,99} LT reconstruction better serves as an adjunct rather than a primary stabilizing procedure.^{43,100} RTS following LT reconstruction is inconsistent and commonly reported to be around 40–60% in available series.^{43,100} Given variable outcomes and lower-level evidence, LT reconstruction is best viewed as an adjunctive procedure rather than a stand-alone stabilizer.

Biomechanically, LT contribution is modulated by structural morphology (length, cross-sectional area, and insertional integrity) and by the status of the capsulolabral complex.^{39,40} Shorter or thicker LTs tend to demonstrate greater stiffness and higher load-to-failure, whereas attenuated ligaments engage later and tolerate lower loads, predisposing to earlier terminal rotation.^{39,40} For these reasons, LT reconstruction is most rational when (1) labral seal and capsular function have been optimized but symptomatic end-range rotational laxity persists, (2) imaging or arthroscopy documents marked LT attenuation or partial absence, and (3) intraoperative testing shows persistent excess terminal rotation or drive-through despite repair and plication.^{42,43} Routine primary LT reconstruction is not supported by high-level evidence; morphology-informed selection (MRI/arthroscopic measurement of LT length and cross-sectional area (CSA) plus quantitative intraoperative rotation testing) strengthens mechanistic justification and should be incorporated into future comparative studies.

Borderline Dysplasia—Arthroscopy Versus Periacetabular Osteotomy, Selection, and Outcomes

For hips with LCEA 18–25°, both arthroscopy (labral preservation with meticulous hip capsular plication) and PAO can improve outcomes when selection is phenotype-guided (GRADE: Low; LOE: III).^{59,101–103} Arthroscopy is suitable for impingement-dominant patterns with manageable coverage, whereas PAO is favored when undercoverage and instability predominate (eg, positive FEAR, elevated Tönnis angle, symptomatic laxity) or when significant version abnormalities exist—often in a staged or combined fashion.^{29,87,104,105}

Propensity-matched cohorts with ≥ 5 -year follow-up report comparable PROs when selection is appropriate, but PAO tends to yield lower THA conversion, where undercoverage is the root cause. Arthroscopy often provides faster early functional recovery but carries a higher likelihood of revision if residual instability or undercoverage is not corrected.^{59,102,106} Given heterogeneity in cohort definitions, imaging metrics, and sequencing, prospective comparative studies that stratify borderline hips by LCEA and version, report standardized torsion metrics (CT/3D imaging), and compare arthroscopy, PAO, and staged/combined strategies with mid- to long-term survivorship and revision endpoints are required to refine selection algorithms.

Rehabilitation, Return to Sport, and Global Synthesis

Rehabilitation

Rehabilitation translates structural restoration into functional readiness and should prioritize early motion, progressive load restoration, and objective criteria-based progression. Early postoperative circumduction—initiated as passive motion in the immediate postoperative period (recovery room/first 24–48 hours) and progressed to active-assisted circumduction during the first 2–4 weeks, is recommended to reduce intra-articular adhesions after hip arthroscopy.^{15,16,64,65,107} In a large series examining adhesions as an outcome, symptomatic adhesions accounted for approximately 4.8% of revisions. The omission of an early circumduction protocol in the immediate postoperative period was associated with a fourfold increase in adhesion rate in that cohort.^{107,108} Because most clinically relevant adhesions manifest in the early postoperative months, clinicians should document initiation timing and frequency of circumduction (passive in Post Anesthesia Care Unit → several daily active-assisted sets during weeks 1–4) as part of routine rehabilitation to reduce the risk of adhesions and the need for early re-intervention.^{15,16,107,108}

Progression through phases of rehabilitation should be anchored to objective, apprehension-free, and symmetric measures of range of motion and strength, rather than fixed calendar milestones.^{16,64,65} We recommend a multi-domain, criteria-based battery to inform RTS decisions that explicitly incorporates psychological readiness, objective neuromuscular function, and a simple neurocognitive/dual-task assessment.

Recommended RTS Battery (Provisional; Pragmatic)

- Psychological readiness: Hip-Return to Sport after Injury scale (Hip-RSI) with provisional operational cut-point $\geq 90/100$ indicating high readiness (interpret in clinical context).^{64,65}
- Strength and power: Limb symmetry index (LSI) $\geq 90\%$ on objective strength testing (hand-held dynamometry) and hop tests.¹⁶
- Balance/motor control: Y-Balance anterior-reach interlimb asymmetry < 4 cm (or normalized composite reach $\geq 94\%$ when using limb-length normalization).⁵⁴
- Dual-task assessment: Dual-task cost (DTC) on an agility or hop task: $DTC (\%) = ((\text{single-task} - \text{dual-task}) / \text{single-task}) \times 100$; provisional threshold $DTC \leq 10\%$. Values greater than 10% suggest a meaningful decrement and warrant targeted neuromotor and neurocognitive training.⁶⁴

The Hip-RSI is validated in hip arthroscopy cohorts and correlates with RTS level; a provisional operational cut-point of $\geq 90/100$ indicates high psychological readiness, but this must be interpreted in the broader clinical context.^{64,65} Psychological readiness should be combined with pragmatic functional thresholds: (1) LSI $\geq 90\%$ for hop tests and for objective strength testing (hand-held dynamometry); (2) Y-Balance anterior-reach interlimb asymmetry < 4 cm (or normalized composite reach $\geq 94\%$ when using limb-length normalization); and (3) satisfactory performance across a composite battery of hop, strength, and balance tests before initiating sport-specific progression.^{54,65}

Operational rule for activity-specific clearance (rule-in checklist): Hip-RSI $\geq 90/100$ + LSI $\geq 90\%$ on strength and hop tests + Y-Balance anterior asymmetry < 4 cm + DTC $\leq 10\%$. If any element is unmet, continue targeted rehabilitation (psychological support, neuromuscular retraining, dual-task drills, and graded sport-specific exposure) and reassess. Document examiner level (fellow/attending vs trainee), baseline measures, and sport classification (cutting/contact vs flexibility/endurance vs asymmetric/overhead) to personalize thresholds. These cut-points are pragmatic and conditional, operationalizing criterion-based clearance but reflecting a largely observational evidence base (GRADE: Low; LOE: III–V).^{54,64,65}

Return-to-Sport

RTS definitions vary; clearance is best based on objective criteria and tailored to the demands of the sport, particularly for activities that load extension and ER at end range.^{15,16} Pooled estimates from systematic reviews and meta-analyses report an overall RTS rate after hip arthroscopy of approximately 84.6% (95% CI, 80.4–88.8), with a mean time to return of around 7.4 months. Pooled estimates for return to the same competitive level are lower and more variable.^{15–17,54} Sex and sports categories significantly alter these probabilities. In one collegiate cohort, female athletes returned at higher rates than males (female, 93% vs male, 82%; odds ratio [OR], 2.8; 95% CI, 1.00–7.82), although pooled analyses report inconsistent sex effects, reflecting low certainty and cohort dependence.^{17,109,110} Sport-type effects are directionally consistent: flexibility/technical athletes (dancers, gymnasts) and some endurance athletes commonly demonstrate the highest any-sport RTS (pooled series reporting 94.8% in flexibility athletes), whereas cutting and contact sports show lower same-level return rates and longer timelines (mean times to RTS in cutting sports reported 8.5 ± 1.9 months in select series).^{54,77}

After PAO, RTS typically occurs later (approximately 9–12 months) and at lower rates (approximately 60–80%), reflecting the magnitude of structural correction and recovery.^{102,111} Clinicians should provide sport- and sex-specific counseling, emphasize criterion-based functional clearance rather than calendar time, discuss cartilage status and psychological readiness as major modifiers, and frame expectations as conditional, given the predominantly observational evidence base.^{15,16,112}

Synthesis

Sustained improvement depends on reconstituting labral sealing mechanics, re-establishing capsular tension with complete closure or plication, and calibrating bony correction to the presenting phenotype.^{11,12,45} When labral

Table 3 Outcomes Overview

Outcome (Interpretation)	Representative Estimate (Study)	95% CI	Events/n (Study)	Follow-up
Overall RTS (any sport): pooled meta-analysis	84.6%	95% CI 80.4–88.8	Pooled (22 studies; 1,296 patients)	Mean follow-up 25.8 ± 2.4 mo
RTS: preinjury/same-level (systematic review)	72.6%	NR	49 studies contributed to this endpoint	Mean follow-up 29.7 mo
RTS: flexibility-sport athletes (pooled series)	75.6–98%	NR	Pooled cohorts totaling ~289 patients (8 studies)	Follow-up 12–116 mo (varies by study)
THA conversion: multicenter 10-yr series (example)	22.1%	95% CI 17.7–27.2	65/294 hips	Mean follow-up 12 ± 3 yr (10–24)
THA conversion: single-center 10-yr registry (example)	8.4%	95% CI 4.6–14.8	10/119 hips	Minimum 10 yr (10–12)
THA conversion: borderline dysplasia cohort (10-yr)	17.8% (10-yr conversion implied by 82.2% survivorship)	95% CI 9.3–31.3	8/45 hips (study cohort)	Minimum 10 yr
Patient-reported outcomes improvement: MCID/PASS achievement and absolute scores	The majority achieve clinically meaningful improvement	HOS-ADL MCID 73.4% → 95% CI 64.5–82.3%; ⁷¹ mHHS MCID 81.0% → 95% CI 72.9–88.8%; ¹¹ mHHS MCID (~79%) → 95% CI 68.3–91.7%. ⁸⁷ mHHS 79 ± 17 → 95% CI 77.1–80.9	HOS-ADL MCID (n=94). ⁷¹ MCID 36/45 (n=45). ¹¹ Mean mHHS scores from 294 hips. ⁸⁷	Mean follow-up 10.1 ± 0.3 yr (FAIS cohort, n=94). ⁷¹ mean follow-up 12 ± 3 yr (n=294). ¹¹ (BHD): minimum 10 yr (n=45). ⁸⁷

Notes: The table compares procedures (arthroscopy with labral repair + capsular closure, arthroscopy without closure, PAO) across outcome domains: primary PRO(s) with mean/median change (SD or IQR) and follow-up, proportion achieving MCID/PASS if available, revision rate, conversion to THA, and return-to-sport (RTS) rate.

Abbreviations: RTS, Return-to-Sport; THA, Total Hip Arthroplasty; mHHS, Modified Harris Hip Score; iHOT-33, International Hip Outcome Tool; HOS, Hip Outcome Score; PROs, Patient-Reported Outcomes; MCID, Minimal Clinically Important Difference; PASS, Patient Acceptable Symptom State; BHD, Borderline Hip Dysplasia; PAO, Periacetabular Osteotomy.

preservation is combined with complete capsular closure, revision and THA conversion rates are generally lowest—particularly in impingement-dominant morphologies.^{11,14,113} Arthroscopy with repair/closure tends to yield the highest and earliest RTS; PAO offers structural stability and lower THA conversion when undercoverage is primary, albeit with slower return; revision strategies such as remplissage or LT reconstruction show more modest RTS and uncertain durability.^{15,32,43,100,102} A summary of outcome comparison by procedure is provided in Table 3.

Clinical decision-making should therefore prioritize phenotype-matching interventions, transparent documentation of imaging positioning and torsion metrics, intraoperative functional testing (such as suction-seal, drive-through, and ease of distraction), and standardized, criteria-based rehabilitation pathways. These elements will reduce practice variation and improve the interpretability of outcome data across centers.

Limitations of the Evidence

The current evidence is dominated by retrospective or matched cohort studies.^{2,102} Randomized controlled trials are rare, given the need for equipoise and the requirement for crossover.² Without RCTs, outcomes are easily influenced by surgeon preference, heterogeneous rehabilitation protocols, and selection bias.^{2,102} Imaging-derived indexes/values such as FEAR are sensitive to pelvic and limb position and display variable reproducibility.^{28,34,62,114} Microinstability-specific

PRO instruments are scarce, and sex- and sport-stratified RTS reporting is inconsistent.^{17,64,65} These limitations underscore the need for multicenter prospective registries with standardized imaging protocols, explicit operative reporting (including capsular construct and tensioning), and standardized rehabilitation pathways.^{59,111,115}

Future Directions and Research Agenda

A coordinated research agenda should couple a precise taxonomy with pragmatic study designs.^{2,115} This can be achieved by taking a multi-step approach.² First, replace binary labels with a phenotype-based lexicon (coverage, torsion, and capsular-dominant) and adopt uniform failure endpoints—revision arthroscopy, PAO conversion, THA, and failure to achieve the minimal clinically important difference (MCID)/patient acceptable symptomatic state (PASS)—to reduce heterogeneity and enable aggregation.⁶⁶ Second, develop objective laxity metrics: instrumented examination and standardized axial-stress testing under anesthesia, position-controlled FEAR (or corrected FEAR), and dynamic imaging (stress MRI/functional CT) to bridge static indices and symptomatic translation.^{34,47,62,114} Third, prioritize comparative effectiveness at scale: multicenter registries with common data elements and propensity methods to clarify the incremental value of complete versus partial closure, suture number/vector, and labral reconstruction versus augmentation/repair in instability-dominant phenotypes, and to refine indications for arthroscopy versus PAO in borderline dysplasia.^{11,12,59,102} Fourth, prevent iatrogenesis: delineate safe cam resection envelopes in instability-prone hips and evaluate indications and durability for femoral head–neck remplissage after over-resection-, including sport-specific functional metrics sensitive to end-range ER/extension demands.^{32,33,70}

Fifth, define LT reconstruction candidacy and durability (graft choice, fixation, interaction with capsular plication, survivorship beyond mid-term, and sport-specific performance).^{42,43,99,100} Sixth, advance rehabilitation science: create microinstability-specific rehabilitation algorithms and criteria based on RTS batteries with sex/sport/level stratification; test early circumduction and controlled early motion for adhesion mitigation without compromising stability.^{16,64,65} Lastly, address equity and sex differences by prospectively reporting outcomes by sex, hyperlaxity spectrum (eg, Ehlers–Danlos syndrome), sport, and competitive level to enable individualized counseling and reduce disparities.^{17,25} A targeted gap exists in the role of dynamic stabilizers (eg, gluteus medius/minimus, iliocapsularis) in microinstability; mechanistic and interventional work is needed.³⁵

Conclusion

Hip microinstability lies between physiologic laxity and frank instability and often coexists with FAIS or borderline dysplasia.^{1,25} Accurate diagnosis emerges from the convergence of history, examination, imaging, and intraoperative assessment, rather than relying on any single test.^{2,18,52} Contemporary surgical care centers on the labrum-capsule-LT stability continuum, focusing on restoring the suction seal, re-establishing capsular restraint with complete closure or plication, and correcting bony morphology judiciously within a phenotype-guided algorithm (GRADE: Very low; LOE: V–III).^{12,42,45} Rehabilitation should be criteria-based, with early motion strategies (eg, circumduction) to limit adhesions.^{16,63} Many athletes return to sport after arthroscopy with repair/closure, although the same-level return rate is variable and slower after PAO; revision strategies yield lower return rates.^{15,17} Future progress hinges on standard definitions, objective laxity measurement, multicenter comparative-effectiveness- research, and rehabilitation trials tailored to microinstability—with specific attention to the unanswered role of dynamic stabilizers and the durability of LT reconstruction and femoral head–neck remplissage.^{16,53,59,66,115}

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