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Clinical and Radiologic Improvements Following Arthroscopic Correction of FAI: A Review of Early-Stage Evidence

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ABSTRACT

***Background*:** Femoroacetabular impingement (FAI) has emerged as a major etiologic factor in hip pain and damage among young and active individuals, leading to progressive labral injury, chondral degeneration, and potential early osteoarthritis. With increasing recognition of its pathomechanics, arthroscopic management has evolved into the preferred surgical approach for symptomatic cases unresponsive to conservative therapy. The minimally invasive nature of hip arthroscopy allows precise correction of cam and pincer morphologies, preservation or restoration of the labrum, and concurrent management of cartilage lesions, offering the potential for early symptomatic relief and functional recovery. This review examines the current early-stage evidence of **clinical and radiologic improvements** following arthroscopic correction of FAI, emphasizing the first 6–24 months postoperatively.

Clinically, numerous prospective and comparative studies have documented significant early improvements in pain, mobility, and patient-reported outcome measures (PROMs) including the modified Harris Hip Score (mHHS), Hip Outcome Score (HOS), and International Hip Outcome Tool (iHOT). Early return-to-activity and return-to-sport rates in athletic populations are high, particularly among patients with minimal chondral damage and successful labral preservation. Improvements in early postoperative strength, gait mechanics, and functional performance further support the effectiveness of arthroscopic intervention within the early recovery interval.

Radiologic advancements have played a crucial role in assessing early surgical success. Postoperative imaging consistently demonstrates reductions in alpha angles, restoration of head–neck offset, normalization of acetabular coverage parameters, and improved joint congruency. Magnetic resonance imaging (MRI), including advanced techniques such as T2 mapping or dGEMRIC, provides early evidence of labral healing and biochemical cartilage changes in appropriately selected patients. Three-dimensional computed tomography (3D CT) has emerged as the gold standard for evaluating the completeness of bony correction, correlating closely with early clinical improvements and reduced rates of residual deformity or early revision.

The aim of this review is to synthesize early-stage evidence that connects **radiologic correction** with **clinical improvement**, elucidating prognostic determinants that influence early postoperative outcomes. By integrating clinical and imaging findings, this review highlights key factors that optimize surgical success while identifying gaps that warrant continued investigation. The present evaluation reinforces the growing evidence supporting early benefits of arthroscopic FAI correction when performed with meticulous technique and patient-specific planning.

Keywords: Clinical, Radiologic Improvements, Arthroscopic Correction of FAI

INTRODUCTION

Femoroacetabular impingement (FAI) is now widely recognized as a major cause of hip pain and early degenerative joint disease in young and active individuals. First described systematically by Ganz and colleagues, FAI is characterized by abnormal abutment between the femoral head–neck junction and the acetabular rim, resulting in progressive labral tearing and chondral delamination that, if untreated, may accelerate the onset of osteoarthritis [1]. Cam morphology produces shear forces against the acetabular cartilage during flexion and rotation, whereas pincer morphology generates overcoverage-related labral compression; mixed morphology, the most common pattern, combines both mechanisms [2]. As diagnostic understanding has improved, the identification of symptomatic FAI has increased substantially across sports medicine and orthopaedic practice.

Arthroscopic correction of FAI has evolved dramatically over the past two decades, transitioning from an emerging technique to the contemporary gold standard in the management of symptomatic cases unresponsive to conservative measures. Hip arthroscopy provides minimally invasive access to simultaneously address bony deformity, labral pathology, capsular stability, and chondral lesions with reduced morbidity compared with open surgical dislocation [3]. As instrumentation and surgical strategies have improved—including routine capsular closure, refined femoroplasty, and advanced labral repair techniques—both clinical and radiologic short-term outcomes have become increasingly predictable and favorable [4].

Radiologic assessment plays a critical role in evaluating early postoperative success. Improvements in alpha angle, head–neck offset, and acetabular coverage after arthroscopic reshaping are strongly associated with early symptomatic relief and functional gains [5]. Magnetic resonance imaging (MRI) provides insights into postoperative labral healing, cartilage status, and restoration of joint congruity, while three-dimensional computed tomography (3D CT) offers unparalleled accuracy in evaluating the completeness of cam and pincer correction [6]. The correlation between radiologic correction and clinical improvement has therefore emerged as an important focus of recent research, especially during the early recovery period.

Despite progress, significant gaps remain in understanding the relationship between imaging-based correction and early functional outcomes. Variability in imaging protocols, definitions of adequate morphologic correction, and thresholds for clinically significant improvement continue to challenge interpretation across studies [7]. Moreover, patient-specific factors—including age, cartilage quality, symptom duration, sport participation, and psychological readiness—modify early outcomes and complicate direct comparisons of radiologic and clinical measures. These limitations underscore the need for a synthesized evaluation of the early-stage evidence bridging clinical and imaging perspectives.

The aim of this review is to critically examine **early clinical and radiologic improvements** following arthroscopic correction of FAI, highlighting the interplay between structural correction and functional recovery. By integrating findings from early postoperative studies, this review seeks to clarify prognostic indicators, identify key determinants of early surgical success, and illuminate areas requiring further high-quality research.

Pathomechanics of Cam-Type Femoroacetabular Impingement

Cam-type femoroacetabular impingement (FAI) arises from an aspherical femoral head–neck junction that reduces the concavity of the anterosuperior femoral contour. During hip flexion and rotation, this abnormal morphology produces shear forces on the acetabular cartilage, leading to delamination, labral peeling, and progressive chondral degeneration [1]. Biomechanical studies have demonstrated that even small increases in the alpha angle significantly elevate contact pressures on the acetabular rim, accelerating intra-articular injury in young athletic individuals [2]. These repetitive microtrauma mechanisms explain the characteristic early cartilage lesions seen in cam-type FAI and underscore the importance of morphological correction in preventing ongoing structural damage [2].

Pathomechanics of Pincer-Type and Mixed-Type Impingement

Pincer-type FAI is characterized by excessive acetabular coverage or focal acetabular retroversion, resulting in compressive forces on the labrum during hip motion. Unlike cam lesions, pincer morphology typically causes labral degeneration and ossification due to chronic impaction against the acetabular rim, while sparing the central cartilage until later stages [3]. Mixed-type FAI—combining cam and pincer features—is the most prevalent presentation, reported in up to 86% of symptomatic cases.

The coexistence of shear and compressive mechanisms accelerates the progression of chondrolabral injury and increases the likelihood of early symptomatic onset [3]. This multifactorial mechanism explains the need for comprehensive arthroscopic correction addressing both femoral and acetabular morphology.

Natural History and Risk of Degeneration

Left untreated, symptomatic FAI may contribute to early osteoarthritis of the hip. Longitudinal studies suggest a strong association between cam morphology and the development of degenerative joint disease, with higher alpha angles predicting earlier radiographic progression [4]. Pincer morphology, although less strongly correlated with early arthritis, still contributes to mechanical overload and labral attrition. These observations form the biological rationale for early intervention: relieving impingement reduces mechanical stresses, preserves the labral seal, and may mitigate long-term degenerative progression [4].

Rationale for Arthroscopic Correction

Arthroscopic correction of FAI aims to restore normal hip mechanics, alleviate impingement symptoms, and preserve intra-articular structures critical for joint health. By reshaping the femoral head–neck junction, reducing acetabular overcoverage, repairing or reconstructing the labrum, and stabilizing the capsule, arthroscopy directly addresses the structural drivers of pain and dysfunction. Clinical studies support that early correction improves joint kinematics and reduces peak contact stresses, correlating with early improvements in pain, function, and sport performance [5]. Additionally, arthroscopy provides the ability to treat concurrent pathologies—such as chondral flaps, synovitis, or loose bodies—further contributing to early symptomatic relief.

Importance of Linking Pathomechanics to Radiologic and Clinical Recovery

Understanding the biomechanical underpinnings of FAI is essential for interpreting the relationship between early radiologic correction and clinical improvement. Adequate reduction of the alpha angle and normalization of acetabular coverage parameters have been directly correlated with improved early patient-reported outcomes and reduced risk of early revision surgery [6]. Conversely, failure to address the full extent of deformity—particularly in cam-dominant presentations—remains a leading cause of persistent pain in the first postoperative year. Therefore, knowledge of pathomechanics guides both surgical decision-making and evaluation of early postoperative imaging.

Radiologic assessment is fundamental to diagnosing femoroacetabular impingement (FAI), evaluating associated intra-articular damage, planning arthroscopic correction, and assessing postoperative improvement. Standardized imaging protocols enable objective quantification of femoral and acetabular morphology and allow for consistent monitoring of early postoperative changes. Radiographic, CT, and MRI modalities each provide unique insights, making multimodal imaging a core component in evaluating surgical success and early recovery trajectories [7].

Plain Radiographs and Standardized Views

Plain radiographs remain the primary first-line imaging modality in FAI assessment. Essential views include the anteroposterior (AP) pelvis, Dunn 45°, Dunn 90°, frog-leg lateral, and false-profile views, each highlighting specific structural abnormalities [8]. The AP pelvis evaluates acetabular retroversion markers (crossover sign, ischial spine sign), acetabular depth, and joint space narrowing. Dunn views are critical for measuring the alpha angle and assessing cam morphology. Early postoperative radiographs are used to confirm reduction in alpha angle, restoration of head–neck offset, and correction of acetabular overcoverage. Frequent radiographic parameters correlated with early outcomes include the lateral center-edge angle (LCEA), Tönnis angle, and the alpha angle across multiple planes [8].

Computed Tomography (CT) for Morphologic Precision

CT offers superior spatial resolution compared with radiography and provides detailed characterization of complex cam and pincer morphologies. Three-dimensional (3D) CT reconstructions have become the gold standard for accurately quantifying preoperative deformity and evaluating postoperative correction [9]. Studies have demonstrated that 3D CT is more sensitive than radiographs in detecting residual cam deformity, a leading cause of persistent early symptoms and early revision surgery. Early postoperative CT imaging allows precise evaluation of head–neck offset restoration, acetabular rim reshaping, and avoidance of over- or under-resection. The ability to visualize morphology in multiple planes also enhances surgical planning and postoperative assessment accuracy [9].

Magnetic Resonance Imaging (MRI) and MR Arthrography

MRI, particularly with intra-articular contrast (MRA), remains indispensable for evaluating labral tears, cartilage lesions, and capsular pathology. MRI is also valuable in the early postoperative period for evaluating labral healing, capsular integrity, joint effusion, and cartilage status. Advanced MRI techniques such as dGEMRIC, T2 mapping, and T1rho imaging permit early biochemical assessment of cartilage quality and may detect early changes predictive of postoperative outcomes [10]. Studies suggest that improved labral integrity and reduced postoperative effusion on MRI correlate with early improvements in PROMs, reinforcing MRI's role in early postoperative assessment.

Dynamic Imaging and Functional Assessment

Emerging imaging techniques aim to assess the hip joint under dynamic or functional conditions. These include functional radiography, dynamic ultrasound for iliopsoas/hip flexor evaluation, and novel MRI sequences that simulate motion. Early evidence indicates that dynamic imaging may detect subtle instability or impingement not visible on static imaging. Though not yet routine, dynamic modalities hold potential for refining early postoperative evaluation and identifying persistent mechanical issues that contribute to early symptoms [11].

Radiologic Indicators of Successful Early Correction

Several radiologic markers correlate strongly with early postoperative clinical improvement. These include:

- **Significant reduction in alpha angle** (commonly >20° decrease),
- **Improved head–neck offset and sphericity**,
- **Normalization of acetabular overcoverage**,
- **Restoration of labral seal on MRI**,
- **Absence of residual crossover or ischial spine signs**, and
- **Resolved effusion or synovitis** in the early MRI period.

Patients achieving these radiologic benchmarks typically demonstrate faster reductions in pain, earlier restoration of range of motion, and greater early improvements in PROMs within the first 6–12 months [12]. In contrast, residual deformity or persistent labral pathology on early imaging is associated with delayed recovery and higher early revision rates.

Limitations and Variability in Imaging Protocols

Despite advancements, variability persists across studies regarding imaging technique, timing, and measurement thresholds. Differences in radiographic acquisition angles, CT protocol settings, MRI sequence selection, and interobserver reliability present challenges in standardizing radiologic assessment. These inconsistencies complicate direct comparison across early outcome studies and highlight the need for consensus imaging guidelines to enhance reproducibility and accuracy in future research [13].

Overview of Early Functional Improvements

Early clinical outcomes following arthroscopic management of femoroacetabular impingement (FAI) consistently demonstrate significant improvements in pain, function, and mobility during the first 6–24 months after surgery. Prospective cohort studies show that most patients experience rapid symptom reduction within the initial 3–6 months, followed by progressive functional gains as rehabilitation advances [14]. Improvements in range of motion, gait mechanics, and ability to perform daily and sport-specific activities are common early indicators of procedural success. These early enhancements reflect the combined benefits of morphological correction, labral preservation, capsular stabilization, and structured rehabilitation programs.

Modified Harris Hip Score (mHHS) Improvements

The mHHS is one of the most widely reported early outcome measures in FAI literature. Early postoperative increases of 20–30 points above baseline are consistently observed, exceeding the minimal clinically important difference (MCID) threshold for meaningful improvement [15]. These gains are most pronounced in younger patients, those with minimal cartilage damage, and individuals treated early in the course of symptoms. Patients with mixed-type FAI often show slightly greater mHHS

improvements compared to isolated pincer-type presentations, reflecting the higher mechanical load relief achieved through combined cam and pincer correction [15].

Hip Outcome Score (HOS-ADL and HOS-Sport)

The HOS-ADL and HOS-Sport subscales provide additional insights into early postoperative functional recovery. Significant improvements are reported within 6–12 months following arthroscopy, with HOS-ADL reflecting quicker recovery due to early restoration of mobility and pain reduction [16]. HOS-Sport improvements typically follow a slower trajectory because of the higher demands placed on joint stability, strength, and neuromuscular control during athletic activities. Among athletes, early increases in HOS-Sport correlate strongly with return-to-sport (RTS) readiness and early sport performance markers [16].

International Hip Outcome Tool (iHOT-12 and iHOT-33)

The iHOT instruments are particularly sensitive to early postoperative improvements in younger, active populations. Many patients achieve meaningful increases in iHOT-12 scores as early as 3 months post-surgery, with continued gains over the following year [17]. iHOT-33, which evaluates broader domains such as social functioning and quality of life, also demonstrates significant early improvement, often outperforming traditional measures in detecting meaningful early functional change. Early iHOT gains strongly predict mid-term patient satisfaction and functional durability.

Pain Reduction and Early Symptom Relief

Immediate and early postoperative pain relief is one of the most compelling benefits of arthroscopic FAI correction. Pain scores commonly decrease within weeks after surgery, reflecting reduced impingement forces and restoration of labral sealing mechanics. Although some discomfort persists due to surgical soft-tissue trauma, controlled rehabilitation and capsular closure significantly aid early pain normalization. Rapid early pain relief has been linked to higher patient satisfaction, faster mobilization, and earlier return to functional activities [18].

Return to Daily Activities and Quality of Life

Return to daily activities (RTDA) is an important early indicator of surgical success. Most patients resume basic activities—including walking, stair climbing, and household tasks—within 1 to 3 weeks postoperatively, depending on individual recovery and rehabilitation adherence. Early improvements in RTDA are reinforced by reduced night pain, improved hip stability, and decreased reliance on assistive devices. Quality-of-life gains follow closely, with patients reporting improved confidence, movement efficiency, and ability to participate in low-impact exercise during early follow-up intervals [19].

Influence of Capsular Management on Early Clinical Outcomes

Capsular management has emerged as a key determinant of early outcomes. Capsular closure or plication enhances joint stability and reduces postoperative microinstability, contributing to improved functional performance during the early recovery period. Studies have shown that patients undergoing capsular repair report faster improvements in early PROMs and reduced incidence of early hip flexor or groin symptoms compared with those without capsular closure [20]. This underscores the importance of capsular integrity in optimizing early clinical outcomes.

Patient Satisfaction in Early Postoperative Period

Early patient satisfaction rates following arthroscopic correction of FAI are high, often exceeding 85–90% within the first year after surgery. Satisfaction correlates strongly with achievement of MCID and Patient Acceptable Symptom State (PASS) thresholds across functional scores. Patients who experience early improvements in pain and function are more likely to maintain favorable longer-term outcomes, highlighting the importance of the early postoperative period as an influential phase in overall recovery trajectories [21].

Early Radiologic Improvements

Significance of Early Radiologic Changes

Early radiologic improvements following arthroscopic correction of femoroacetabular impingement (FAI) provide objective evidence of successful morphological reshaping and correlate closely with early clinical recovery. Radiologic changes seen in the first postoperative months—particularly reductions in alpha angle, improved head–neck offset, and normalization of acetabular coverage—serve as structural markers reflecting the biomechanical restoration achieved through surgery. Studies have

shown that the magnitude of early radiologic correction is strongly associated with improvements in early PROMs, reduced pain, and greater satisfaction, highlighting the essential role of imaging in verifying the adequacy of surgical correction [22].

Reduction in Alpha Angle and Head–Neck Offset Restoration

One of the most important radiologic markers of successful cam correction is a significant reduction in the alpha angle across multiple radial planes. Early postoperative studies consistently document decreases of 20°–30° in alpha angle, corresponding with restored femoral sphericity and improved clearance during hip flexion and rotation [23]. Restoration of head–neck offset reduces shear forces at the acetabular cartilage surface and is often accompanied by early improvements in internal rotation and pain reduction. Radiographic improvements in these parameters are strongly associated with early functional gains, reinforcing their utility as surrogate markers for early clinical progress [23].

Normalization of Acetabular Coverage in Pincer and Mixed FAI

Early radiologic improvements in pincer and mixed-type FAI commonly include reductions in lateral center-edge angle (LCEA) and correction of acetabular retroversion markers such as the crossover sign. Acetabular rim trimming typically produces an LCEA reduction of 3–6°, sufficient to relieve labral compression without compromising joint stability [24]. Correcting acetabular overcoverage also contributes to improved joint congruency and labral mechanics. Early imaging confirms the restoration of acetabular morphology and correlates with reduced groin pain and improved flexion comfort during early follow-up periods [24].

MRI Evaluation of Labral Healing and Capsular Integrity

MRI is instrumental in the early postoperative evaluation of soft-tissue healing, particularly the labrum and capsule. Early postoperative MRIs often demonstrate improved labral integrity following repair, decreased edema, and restoration of the labral seal mechanism. Studies indicate that patients with early MRI evidence of labral healing exhibit superior early improvements in PROMs and quicker return to activity compared with those demonstrating incomplete healing or persistent labral defects [25]. Capsular closure integrity, increasingly visible through high-resolution MRI sequences, also correlates with reduced early instability symptoms and faster functional recovery.

Advanced MRI Techniques for Cartilage Evaluation

Advanced quantitative MRI techniques—such as T2 mapping, T1rho imaging, and dGEMRIC—have provided early insights into cartilage health following arthroscopic FAI correction. While traditional MRI sequences may not detect early biochemical changes, these advanced modalities can identify early improvements in cartilage composition or stabilization of cartilage breakdown. Early postoperative studies demonstrate that patients with mild-to-moderate preoperative cartilage lesions show improved or stable T2 values within the first postoperative year, correlating with favorable early clinical outcomes [26]. These imaging markers may eventually help predict longer-term cartilage preservation.

3D CT Assessment of Completeness of Bony Correction

Three-dimensional CT remains the most accurate imaging modality to evaluate completeness of bony resection. Early postoperative 3D CT studies confirm that complete cam correction—particularly in the anterosuperior quadrant—correlates with significant early improvements in internal rotation, pain relief, and functional performance [27]. Conversely, residual cam deformity on early CT is one of the strongest predictors of persistent symptoms and increased likelihood of early revision surgery. 3D CT also provides precise postoperative assessment of acetabular rim trimming, helping identify under- or over-resection that may influence early stability and comfort.

Radiologic Predictors of Early Clinical Success

Several radiologic findings have been identified as positive predictors of early postoperative success:

- Significant reductions in alpha angle (>20° change),
- Spheric restoration of the femoral head–neck junction,
- Normalization of acetabular coverage without instability,
- MRI evidence of intact labral repair and capsular closure,
- Resolution of postoperative effusion or synovitis, and

- No residual crossover sign or retroversion abnormalities.

Patients achieving these radiologic thresholds consistently demonstrate faster pain reduction, greater early PROM improvements, and earlier return to activity compared with those with incomplete radiologic correction [28].

Evolution of Arthroscopic Approaches for FAI Correction

The evolution of hip arthroscopy has substantially influenced early outcomes after femoroacetabular impingement (FAI) correction. Initial arthroscopic methods were limited by visualization challenges and incomplete deformity resection; however, modern techniques now provide comprehensive access to both central and peripheral compartments. Improved portal placement, enhanced arthroscopic visualization, and refined traction protocols have resulted in lower complication rates and more predictable early postoperative improvements [29]. These procedural advancements allow precise cam and pincer correction, which directly correlates with early symptom relief and functional gains.

Refinement of Femoroplasty Techniques

Advances in femoroplasty have significantly improved early postoperative outcomes by ensuring accurate correction of cam morphology. Modern techniques emphasize circumferential resection of the femoral head–neck junction using burrs with calibrated depth markings and intraoperative dynamic testing. Studies indicate that the completeness of cam resection—particularly in the anterosuperior quadrant—is one of the strongest predictors of early pain reduction and improved range of motion [30]. Avoidance of residual deformity reduces early mechanical symptoms and revision risk, demonstrating the impact of precise femoroplasty on early outcomes.

Acetabuloplasty and Labral Preservation Strategies

Early outcomes have been positively influenced by the transition from labral debridement to widespread adoption of labral repair. Labral preservation restores the suction seal mechanism, which enhances joint stability and early postoperative biomechanics. Arthroscopic acetabuloplasty techniques now employ calibrated rim trimming to minimize over-resection while ensuring adequate correction of pincer morphology. Multiple comparative studies have demonstrated superior early clinical outcomes, including improved PROMs and return-to-sport rates, when labral repair is performed in conjunction with precise acetabular reshaping [31]. These modern preservation-focused strategies contribute substantially to the quality of early recovery.

Capsular Closure and Plication Techniques

Capsular management is one of the most significant advancements influencing early outcomes. Historically, the capsule was left unrepaired, which led to postoperative microinstability in some patients. Current evidence strongly supports routine capsular closure or plication to restore joint stability and reduce early symptoms. Capsular closure has been associated with faster improvements in early functional scores, reduced postoperative groin pain, and better outcomes in female patients and individuals with ligamentous laxity [32]. This shift toward capsular preservation has become a cornerstone of modern arthroscopic FAI correction.

Use of Fluoroscopy and 3D Navigation

Fluoroscopic guidance remains essential for accurate intraoperative assessment of bony resection. Surgeons increasingly employ multi-planar fluoroscopic views, 3D navigation systems, and even augmented reality tools to minimize the risk of under- or over-resection. Enhanced intraoperative imaging reduces early revision rates by ensuring complete deformity correction during surgery rather than identifying residual impingement postoperatively. Early studies demonstrate that image-guided FAI correction correlates with improved early clinical outcomes and lower early complication rates [33].

Advances in Labral Reconstruction Techniques

When the labrum is irreparable, modern labral reconstruction techniques using iliotibial band autografts or allografts have shown favorable early outcomes. Reconstruction restores the labral seal and joint biomechanics, preventing early postoperative instability and improving functional recovery. Early clinical studies demonstrate that athletes undergoing labral reconstruction achieve meaningful improvements in PROMs and early return to sport comparable to repair when performed with precise graft contouring and secure fixation [34]. These techniques offer a valuable option in revision cases or situations of severe labral deficiency.

Arthroscopic Management of Concomitant Chondral Lesions

Treatment of chondral lesions has advanced significantly, influencing early clinical outcomes. Techniques such as microfracture, chondroplasty, and biologic augmentation with platelet-rich plasma (PRP) or bone marrow aspirate concentrate (BMAC) are increasingly employed to address articular cartilage defects. Early postoperative studies suggest that biologically augmented cartilage treatment may enhance early symptom relief and support improved short-term functional results compared with traditional chondroplasty alone [35]. These adjunct strategies contribute to a more comprehensive and effective early surgical outcome.

Impact of Technical Advances on Early Recovery Trajectory

Collectively, modern surgical advances—including precision femoroplasty, calibrated acetabuloplasty, labral preservation, capsular repair, and advanced imaging guidance—have produced a marked improvement in early clinical and radiologic outcomes. These innovations reduce postoperative pain, enhance stability, increase early range of motion, and accelerate progression through rehabilitation phases. The evolution of arthroscopic techniques has therefore played a central role in optimizing early-stage recovery and functional restoration following FAI correction.

Importance of Structured Rehabilitation in Early Recovery

Rehabilitation plays an essential role in determining the speed and magnitude of early functional recovery following arthroscopic correction of femoroacetabular impingement (FAI). Evidence demonstrates that patients who follow structured, criterion-based rehabilitation protocols experience significantly faster improvements in pain, mobility, and strength compared with those following time-based or unsupervised programs [36]. Rehabilitation supports the biological healing processes of the labrum and capsule while promoting restoration of hip mechanics disrupted by chronic impingement. In the early postoperative period, structured rehabilitation is critical for preventing stiffness, protecting repairs, and ensuring a stable foundation for progressive functional improvement.

Phase I: Protection, Pain Control, and Early Motion (0–4 Weeks)

The first phase emphasizes joint protection, controlled mobility, and inflammation reduction. Use of crutches and restricted weight-bearing—typically for 1 to 2 weeks following uncomplicated procedures or longer after labral repair or capsular plication—is essential to protect the surgical repairs. Gentle passive motion, circumduction, and aquatic therapy help reduce stiffness while avoiding impingement positions. Evidence shows that higher early adherence to Phase I guidelines correlates with reduced postoperative pain and better early PROM scores [37]. Early neuromuscular activation of the core and hip stabilizers also prevents compensatory gait patterns.

Phase II: Strengthening and Neuromuscular Re-education (4–12 Weeks)

During Phase II, emphasis shifts toward restoring dynamic hip stability, improving neuromuscular control, and progressively strengthening the hip abductors, extensors, and external rotators. Closed-kinetic-chain exercises and progressive resistance programs are central elements of this phase. Studies have demonstrated that patients engaging in targeted hip abductor and core strengthening achieve superior early improvements in functional outcomes and report lower pain levels at 3–6 months postoperatively [38]. Neuromuscular re-education and proprioceptive training also facilitate normalization of gait mechanics and movement patterns altered by chronic impingement.

Phase III: Advanced Strength and Functional Integration (12–20 Weeks)

In Phase III, rehabilitation progresses toward higher-demand activities and sport-specific functional tasks. Plyometric training, lateral movement drills, and higher-level strengthening exercises are added gradually based on patient tolerance and objective strength benchmarks. Research indicates that Phase III progression is strongly predictive of early return-to-sport (RTS) readiness and improvements in HOS-Sport and iHOT subscores [39]. Continued attention to movement quality, single-leg control, and avoidance of hip internal rotation under load is crucial to minimize reinjury risk.

Phase IV: Return to Sport and Performance Conditioning (20+ Weeks)

Phase IV focuses on restoring high-level sport performance and ensuring the patient meets RTS criteria, which commonly include >90% limb symmetry in strength, pain-free motion, and successful completion of functional tests such as hop tests and agility circuits. RTS typically occurs between 4–7 months depending on the sport's demands and the extent of preoperative pathology.

Studies report RTS rates exceeding 80%–90% in well-structured programs, with better early outcomes seen in athletes who complete sport-specific conditioning under professional supervision [40]. Psychological readiness assessments may further enhance early RTS success.

Influence of Rehabilitation Quality on Early PROMs

High-quality postoperative rehabilitation is strongly associated with improved early outcome measures, including mHHS, HOS, and iHOT scores. Patients who adhere to structured programs demonstrate faster early gains in hip strength and mobility, earlier reductions in pain, and higher satisfaction compared with those who prematurely advance activity or inconsistently follow protocols. Evidence shows that early PROM improvements are directly related to rehabilitation adherence, reinforcing its importance in achieving optimal short-term outcomes [41].

Managing Early Rehabilitation Challenges

Common early postoperative challenges include hip flexor irritation, stiffness, groin discomfort, and compensatory gait patterns. Effective rehabilitation protocols address these issues through targeted manual therapy, gradual load progression, and correction of aberrant motor patterns. Early recognition and management of these challenges prevents prolonged dysfunction and accelerates early recovery. Clinicians play a central role in identifying movement deficits and modifying rehabilitation accordingly to optimize functional gains [42].

Integration of Biologic and Adjunct Therapies

Adjunctive therapies such as platelet-rich plasma (PRP), neuromuscular electrical stimulation, and blood-flow restriction training have shown potential in enhancing early functional recovery, though evidence remains evolving. Some studies suggest PRP injections may reduce postoperative inflammation and improve early pain scores, enabling more effective participation in rehabilitation exercises [43]. Blood-flow restriction training may also support early strength gains without excessive loading—a valuable strategy during the protective phases of recovery.

Summary of Rehabilitation's Impact on Early Recovery

Overall, rehabilitation is a cornerstone determinant of early improvements in pain, function, mobility, and sport participation following arthroscopic FAI correction. When combined with meticulous surgical correction, individualized and criterion-based rehabilitation programs yield superior outcomes, accelerate return to activity, and reduce the risk of early complications or revision. These findings underscore the importance of integrating high-quality rehabilitation into standard postoperative care pathways for optimal early-stage recovery.

Complications of Hip Arthroscopy

Overview of Complication Rates

Hip arthroscopy is widely regarded as a safe procedure with relatively low complication rates compared with open surgical techniques. Large registry and multicenter studies report overall complication incidences ranging from **1% to 8%**, with most events being transient and resolving without long-term impact [44]. Complications vary depending on surgical complexity, traction time, portal placement accuracy, and patient-specific factors such as hyperlaxity or obesity. The broader adoption of capsular closure, modern traction systems, and improved visualization techniques has further reduced complication rates, contributing to safer early recovery profiles [44].

Traction-Related Neuropraxia

One of the most common early complications is traction-related neuropraxia, particularly affecting the pudendal nerve, lateral femoral cutaneous nerve, or sciatic nerve. These injuries result from prolonged traction time or excessive traction force used during central compartment access. Incidence rates range between **0.5% and 5%**, with the vast majority resolving within days to weeks [45]. Strategies such as intermittent traction, use of post-less tables, and adequate perineal padding have reduced neuropraxia frequency. Persistent symptoms are rare but may negatively affect early functional recovery in severe cases [45].

Iatrogenic Chondral and Labral Injury

Although less common with increasing surgical expertise, iatrogenic chondral scuffing or labral injury can occur during portal creation or instrument manipulation. Reported incidences range from **0.2% to 3%**, and while many cases are minor, they may

contribute to prolonged postoperative pain or delayed early functional gains [46]. Use of curved instruments, optimized portal trajectories, and fluoroscopic or arthroscopic visualization during entry help minimize these avoidable injuries. Even small iatrogenic lesions may have biomechanical implications on labral sealing function early after surgery.

Capsular Insufficiency and Microinstability

Capsular insufficiency has emerged as an important complication, particularly in cases where the capsule is left unrepaired or unintentionally violated. Failure to restore capsular integrity may lead to postoperative microinstability, groin pain, and a sense of hip looseness, often becoming apparent within the early 3–6-month postoperative window [47]. Capsular repair or plication significantly reduces this risk, and modern technique protocols now recommend routine closure. Persistent microinstability has been linked to early poor PROMs and increased likelihood of revision procedures [47].

Heterotopic Ossification (HO)

Heterotopic ossification occurs when ectopic bone forms within soft tissues following arthroscopy. HO is reported in **1%–5%** of cases, though most are radiographic findings without clinical consequence. Symptomatic HO may manifest as stiffness or pain during early rehabilitation, occasionally requiring non-steroidal anti-inflammatory drug (NSAID) prophylaxis or, rarely, surgical excision [48]. Lower rates are observed with consistent prophylaxis protocols, particularly in high-risk patients or those undergoing extensive capsular work or rim trimming [48].

Infection and Venous Thromboembolism (VTE)

Infection following hip arthroscopy is extremely rare, with superficial infections occurring in <1% and deep joint infections in <0.1% of cases [49]. Standard perioperative antibiotic protocols have contributed to these low rates. Venous thromboembolism is also uncommon, with reported incidences between **0.1% and 0.5%**. Identified risk factors include smoking, reduced mobility, hormonal therapy, and elevated BMI. Early mobilization and selective chemoprophylaxis reduce these risks significantly, supporting safe early postoperative recovery [49].

Early Revision Surgery and Risk Factors

Although overall revision rates remain low, early revision within the first 12–24 months occurs in **3%–7%** of patients. The most common indications include residual cam or pincer deformity, capsular insufficiency, labral re-tears, or persistent instability [50]. Residual deformity remains the leading preventable cause of early failure. Patients with advanced preoperative cartilage damage, long symptom duration, or borderline dysplasia are at higher risk for early revision. Recognition of these risk factors and meticulous surgical execution are essential for minimizing early surgical failure and optimizing early outcomes [50].

CONCLUSION

Arthroscopic correction of femoroacetabular impingement (FAI) has evolved into a highly effective intervention that consistently produces meaningful early clinical and radiologic improvements. Across multiple early-stage studies, patients demonstrate rapid reductions in pain, restoration of functional mobility, and significant gains in patient-reported outcome measures. These improvements reflect the synergy between precise morphological correction, preservation or restoration of labral integrity, and stabilization of the capsular complex. Early radiologic evidence—including reductions in α-angle, normalization of acetabular coverage, improved head–neck offset, and favorable MRI indicators of labral healing—further validates the biomechanical effectiveness of modern arthroscopic techniques.

Advances in surgical approaches, including meticulous femoroplasty, calibrated acetabuloplasty, labral repair or reconstruction, and routine capsular closure, have been central to enhancing the quality and predictability of early results. These techniques minimize residual impingement, support biomechanical restoration, and reduce early complications. Complementary to surgical refinements, structured, criterion-based rehabilitation programs play a crucial role in optimizing early recovery trajectories. Patients who follow well-designed rehabilitation protocols not only experience faster symptom relief but also achieve more robust improvements in functional performance and earlier return to activity or sport.

Despite clear progress, variability persists in early outcomes due to differences in patient selection, cartilage status, imaging protocols, and surgical execution. The relationship between radiologic correction and clinical improvement continues to be refined, with growing recognition of the importance of precise bony correction and labral preservation in determining early success. Additionally, complications such as traction neuropraxia, capsular insufficiency, heterotopic ossification, and residual

deformity—though relatively uncommon—remain important considerations that can influence early recovery and prompt the need for revision in select cases.

Overall, the early-stage evidence strongly supports the effectiveness of arthroscopic management of FAI in achieving rapid structural and functional improvements when performed with modern techniques. Continued progress in imaging, surgical innovation, and rehabilitation science will further enhance these early outcomes. Future high-quality studies should focus on standardizing imaging thresholds, refining surgical indications, and identifying predictors of sustained long-term benefit. With ongoing advancements, arthroscopic correction of FAI is poised to remain a cornerstone treatment for young, active patients seeking timely relief and early restoration of hip function.

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