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Current Concept Review

Rehabilitation and return to play following hip arthroscopy in young athletes

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ABSTRACT

Hip arthroscopy is a hip preservation surgery used to manage acute pain and injury while attempting to preserve the hip joint and prevent or delay the progression of degenerative changes by restoring stability, reducing pathologic stress and instability, and preventing continued joint incongruity and impingement [1–4]. Research supports a high likelihood of return to a prior level of athletic participation in athletes of all ages after hip arthroscopy with especially favorable results in athletes under the age of 18 [3–5]. The postoperative rehabilitation process is vital to correct impairments and compensatory strategies. Unfortunately, there is great variability in current rehabilitation protocols.

Adolescent athletes returning to activity after hip arthroscopy may be at an increased risk of reinjury and continued pain if return to sport occurs too early [6]. Inconsistencies exist with current protocols and return to sport testing. For instance, assessing readiness for return to sport is often based upon tests and measures utilized for anterior cruciate ligament reconstruction. These tests and measures may not effectively isolate or address hip function and readiness to return to play after hip arthroscopy. This current concept review presents existing literature and a standardized rehabilitation process to restore normal function and maximize a safe return to athletics after hip arthroscopy in the young athlete.

Key Concepts:

(1) There are few evidence-based postoperative rehabilitation programs for the young athletic population to effectively guide progress toward return to play readiness.
(2) Continued hip and core strengthening exercises should be implemented after the return to play to maintain hip and core strength, improve neuromuscular control, and address additional functional impairments that may lead to repeat injury and dysfunction.
(3) Patient-reported outcome (PRO) measures are correlated with higher postoperative improvement and should be utilized to assess psychological and physical readiness for return to play.

Introduction

High-impact sports with repetitive loading and pivoting place significant stress through the hip and may increase the risk for the development of hip pathology [3–5,7–10]. Over the past 2 decades, there has been a rise in the arthroscopic management of hip pathologies in adolescent athletes, specifically femoroacetabular impingement (FAI) and acetabular labral tears [7]. Arthroscopic hip procedures allow for dynamic intraoperative assessment and correction of mechanical pathology via minimally invasive methods and allow for a more rapid recovery [1]. Despite surgical advances, standardized rehabilitation processes and return-to-play testing for young athletes with hip pathology are lacking. A variety of different rehabilitation protocols exist with limited consensus on timeline for progression and return to sport, patient-reported outcome (PRO) measure selection, and return to sport testing. To improve the likelihood of a successful return to sport after hip arthroscopy, this review will summarize existing data and propose a postoperative protocol for young athletes who have undergone hip arthroscopy for FAI and labral pathology.

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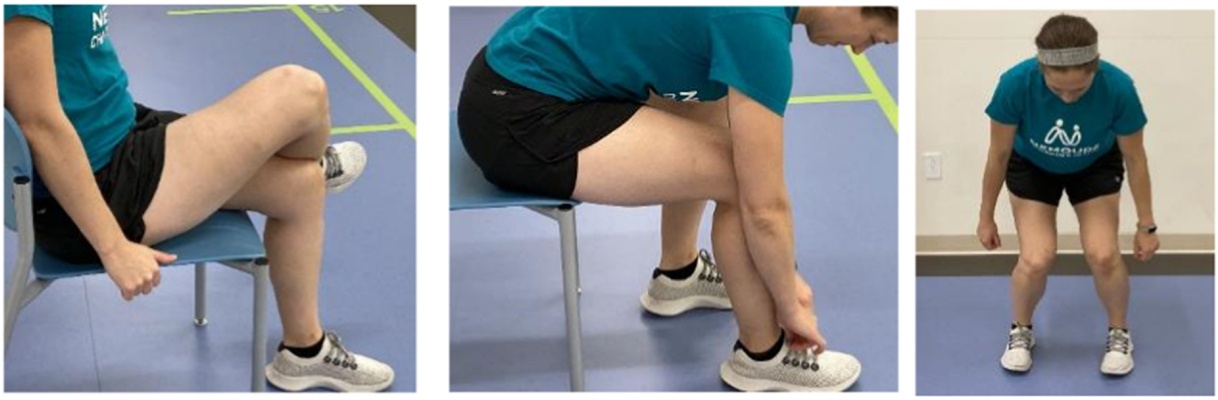

Figure 1. Positions to avoid both pre and post hip arthroscopy including sitting cross-legged, movements requiring high degrees of hip flexion, and completing functional movements with femoral internal rotation, valgus collapse, and excessive trunk flexion.

Preoperative considerations

Most patients with hip pain due to FAI or labral pathology will have been treated with physical therapy and occasionally steroid injection before operative interventions are considered [11]. This includes education about lifestyle modifications such as avoidance of repetitive or extreme hip flexion and femoroacetabular rotation under load (Fig. 1), as well as strategies to balance strength and flexibility of anterior and posterior structures of the lower extremity (Fig. 2) [11]. Understanding correct core activation and stabilization patterns are important to effectively stabilize the hip and spine. If the athlete participates in a weight-lifting program, modification of exercises such as squats, lunges, cleans, and deadlifts is warranted [12].

Nonoperative rehabilitation is based on several generalized rehabilitation principles with early activity modification to reduce symptoms and promote long-term achievement of successful outcomes. Hip and lumbar spine range of motion (ROM), joint mobility, and muscle flexibility should be normalized via manual therapy, joint gapping, and neuromuscular re-education [9–11,13]. Flexibility and soft tissue mobilization of the iliopsoas, adductors (Fig. 3), gluteal muscles, and thoracolumbar spine, as well as promoting increased gluteal and core activation, muscle coordination, and generalized lower quarter strength, help to decrease anteriorly directed forces on the hip [11]. As a result, improvements in posterior femoral gliding and resting position of the femoral head assist in decreasing abnormal forces on the hip [11]. Improved lumbopelvic stability can be achieved by focusing on the activation of the gluteal muscles, transversus abdominis, and multifidii with the correction of abnormal compensations of the rectus abdominis, adductors, and iliopsoas [11]. During nonoperative rehabilitation, asymmetrical movement patterns should be addressed to facilitate normal lower quarter mechanics with daily movements and return to sport activities (Fig. 4) [11]. Correcting weight shift or trunk lean with squatting should be addressed to limit compensatory pattern development. Maintaining and improving cardiovascular conditioning is important [11]. During this phase, the need for additional referrals should be determined. If conservative measures fail and hip arthroscopy is warranted, the above preoperative rehabilitation likely maximizes postoperative results.

During the preoperative discussion, the planned procedure, relevant anatomy and biomechanics, rehabilitation timeline, and expectations for the postoperative phase should be reviewed with the patient and family. Weight-bearing restrictions, crutch use, brace wear, and other postoperative restrictions should be discussed. Expectations for postoperative rehabilitation should be reviewed to promote patient and family compliance with recommendations. A preoperative assessment of pain, range of motion, joint mobility, soft tissue mobility, flexibility, strength, function, and quality of life is helpful in maximizing patient success [14]. A review of strategies to reduce hip pain both pre and postoperatively and to promote active patient and family participation in rehabilitation is imperative.

Postoperative considerations

Role of postoperative bracing

Bracing after hip arthroscopy has been utilized with varying degrees of frequency and duration with a goal to limit hip flexion and hip abduction ROM [15]. There is limited evidence on postoperative bracing with no demonstrated benefit. A systematic review on postoperative rehabilitation after hip arthroscopy included 18 studies and found only 4 studies discussed the use of a brace and only 3 studies utilizing a brace postoperatively [16]. Recommended brace duration varied from 10 days to 6 weeks [16]. In a survey of expert hip surgeons, 40% recommended utilizing a hip brace after hip arthroscopy [17] while another survey found 59% of surgeons utilized hip bracing after hip arthroscopy for some or most of their patients [18]. Since brace use varies by protocol and surgeon preferences, more research is needed to assess the effectiveness of postoperative bracing.

Figure 2. A series of self-soft tissue mobilization to address hip tightness using a lacrosse ball targeting the adductor, psoas, and tensor fascia latae.

Figure 3. Soft tissue release to adductor group.

Postoperative rehabilitation

There is little evidence guiding the standardization of postoperative rehabilitation protocols for hip arthroscopy which are frequently based on level IV evidence and informal expert opinion with less evidence existing for young athletes [19]. This leads to inconsistencies, variability, and lack of standardization throughout the rehabilitation process and return to play testing. Postoperative rehabilitation typically lasts between 12 and 28 weeks with temporal and criterion-based progressions and procedure-specific considerations [2,11]. An evidence-based postoperative rehabilitation protocol is available in Appendix 1.

Maximum protection phase

The maximum protection phase is initiated in the early postoperative period [2–4,11]. The priority of the first phase of postoperative rehabilitation is to maintain balance between joint and tissue protection and restoration of sufficient motion [2,11]. Pain is managed with manual therapy and ice. Physical therapy examination during the early postoperative phase is limited by postoperative restrictions and pain. Addressing compensatory patterns and fear avoidance behaviors early is helpful to maximize function. Postoperative assessment of posture, alignment, ROM, joint mobility, lower extremity muscle flexibility, soft tissue mobility, and gait is important to understanding overall patient status [2,11]. Hip-specific special test completion in the early postoperative phase is not recommended due to abnormal stress placed on healing tissue. Limited active and forced hip flexion, end range hip extension, anterior hip translation, and acetabular rotation on the femur (trunk rotation with foot planted) are recommended with limitations dictated by surgical procedure [9]. Care should be taken to avoid the development of hip instability. Research suggests earlier inclusion of hip circumduction to reduce the risk of capsulolabral adhesions, which can contribute to persistent symptoms and the possible need for additional arthroscopic management [3]. The ideal timeline for incorporation of hip circumduction exercises to minimize this risk is unknown [4].

During the immediate postoperative phase, partial weight-bearing or weight-bearing as tolerated patterns are typically prescribed. It is recommended to utilize “foot flat” as opposed to “toe touch” or nonweight-bearing pattern, as toe touch weight-bearing (TTWB) and nonweight-bearing patterns increase compressive forces across the hip and activation of anterior hip muscles [20]. Altered weight-bearing typically ranges from 1 to 8 weeks with 2 weeks being the most frequently cited duration [19]. The goals of this phase include pain management, ambulation with the appropriate gait pattern within weight-bearing restrictions, improvement in ROM of the hip and lumbar spine, and mobilization of neural tissue [2]. Prone lying is helpful to gradually improve anterior hip flexibility and assist with postural correction (Fig. 5) [2].

It is important to avoid irritation of the iliopsoas and proximal rectus tendon as the development of tendinopathy may contribute to continued functional deficits for up to 1 year postoperatively [2]. During this phase, manual therapy and light isometric strengthening is initiated [6,9]. The focus is on teaching correct activation of the transversus abdominis and other postural stabilizers (Fig. 6) [6,9]. Manual therapy should be directed toward areas of impaired soft tissue mobility and pain drivers such as the psoas, rectus femoris, tensor fascia lata, adductors, and gluteal muscles, using graded joint mobilizations as tolerated (Fig. 3 and 7). The athlete should avoid hip flexion beyond 90° (Fig. 8), such as while donning shoes and socks or sitting in low chairs, prolonged standing, and activities causing excessive hip rotation such as twisting or pivoting. Additional information and progression criteria for this phase are listed in Appendix 1.

Early impairment phase

The goal of the second phase (early impairment phase) is to restore ROM and prepare for full weight-bearing [2,11]. During this phase,

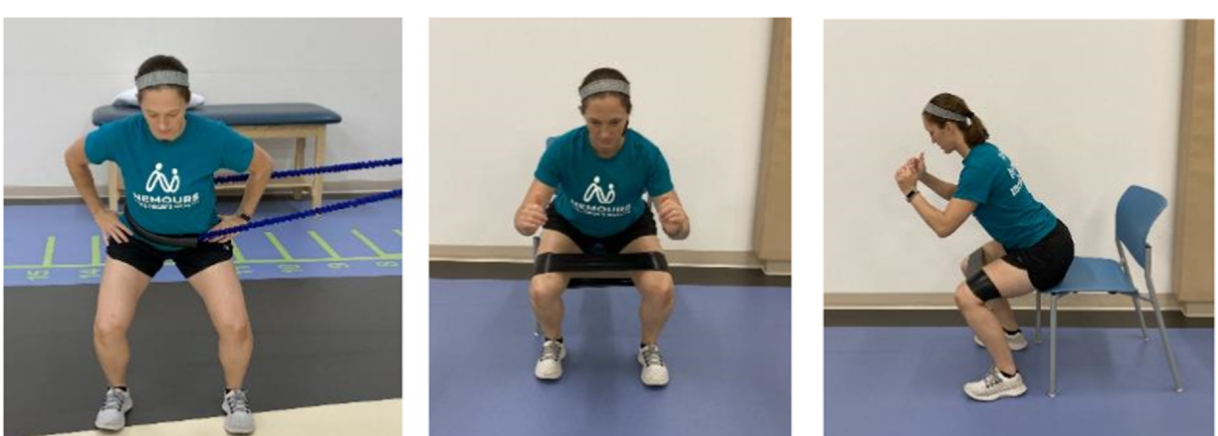

Figure 4. Strategies to improve muscle activation and lower quarter alignment such as squat with band pull at the hips (*left*) to reduce asymmetrical weight shift and banded squat (*middle and right*) to improve use of hip abductors.

Figure 5. Prone positioning to gradually stretch anterior core and hip musculature.

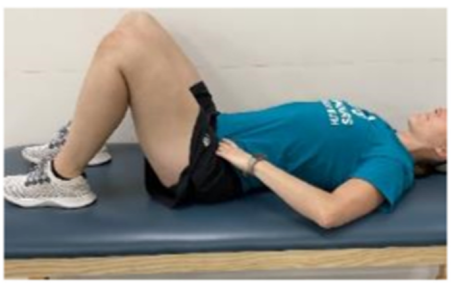

Figure 6. Phase 1 core activation including transversus abdominis activation, posterior pelvic tilt, and submaximal pelvic clocks.

ROM is progressed based on the surgical procedures completed. Lower quarter flexibility and joint mobility should be progressed with exercises such as stool internal and external rotation and quadruped rocking (Fig. 9), and with mobility banded progressions (Fig. 10) in addition to strategies utilized for pain and ROM from the first phase [11,21]. Gait mechanics typically return to within normal limits [21]. If needed, aquatic therapy may be utilized [2,6].

As postoperative restrictions are lifted, assessment of muscle activation patterns, lower extremity and core strength, biomechanics, gait, balance, and movement strategies should be examined [2,11]. Handheld dynamometry can provide objective information about lower extremity strength with a focus on hip flexion, abduction, and extension strength testing (Fig. 11) [2,9,11,57]. Despite improvements in strength, deficits in strength often persist compared to age-matched controls [22]. Patients with FAI who were treated arthroscopically demonstrated significant deficits in postoperative hip flexion and extension strength compared to those treated nonoperatively [22]. Achieving symptom-free sagittal plane hip kinematics should be a focus [11]. Upright biking is completed with less than 90° of hip flexion [2]. Strengthening is progressed with an emphasis on strength and endurance of gluteal muscles, quadriceps, hamstrings, transversus abdominis, and external obliques (Fig. 12 and 13) [2,6,9](Fig. 14).

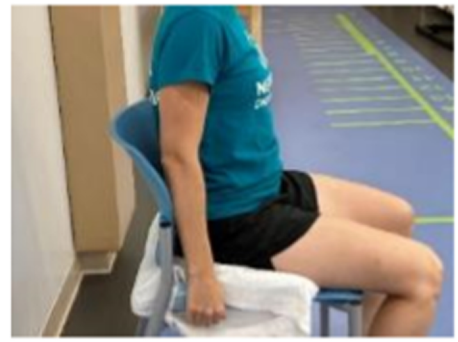

Figure 8. Modification of sitting posture to avoid hip flexion beyond 90°.

The athlete should gradually progress dynamic stabilization, sensory training, and correction of compensatory patterns (Fig. 15) [2,6,9]. The focus should be on the management of hypertonicity of the adductor group, trunk lean, and abnormal lower extremity control [2,6,9]. It remains imperative to avoid repetitive hip flexion to avoid both inflammation and tendinopathy development of the iliopsoas. Additional information and progression criteria for this phase are listed in Appendix 1.

Late impairment phase

During the third phase (late impairment phase), ROM progresses to symmetrical levels [2,11]. Return to full activities of daily living and nonlabor occupational activities should occur [2,11]. Pain management and manual therapy techniques are utilized based on patient presentation. Single leg and dynamic balance are progressed with focus on correct muscle activation patterns (Fig. 16). Improved gluteal strength limits abnormal anterior translation of the femoral head during functional activities, especially during hip extension, and may help to decrease abnormal forces on the hip in the long-term (Fig. 17) [2,11]. Emphasize psoas activation by resolving psoas inhibition without excessive hip flexor loading. If fatigue, tissue overload, or compensations are present, correct mechanics prior to progressing. Lingering aberrant movement patterns may reflect hyperlaxity of surrounding tissues or inadequate muscle activation, indicating the need for additional neuromuscular re-education [23]. Encourage proper mechanics with functional movements and return to sport testing.

Limitations in hip flexion ROM are correlated with poor deep squat tolerance and mechanics as well as increased variance with the star excursion balance test [24]. Cardiovascular fitness is progressed including spinning, elliptical, and aqua jogging [2,11]. Additional information and progression criteria including hip flexion strength greater than 75% of the uninvolved side, strength greater than 80% in all remaining planes of motion, and functional testing scores are listed in Appendix 1 [2,11] (Fig. 18).

Figure 7. Gentle hip mobilizations (long axis traction, *left*, and lateral distraction, *right*) with mobilization belt.

Figure 9. Early hip range of motion exercises targeting hip rotation (*left, middle)* and hip flexion via quadruped rocking *(right)*.

Functional restoration and return to sport specific activity phase

The fourth phase of rehabilitation begins between 12 and 16 weeks postoperatively and lasts between 2 and 8 weeks [2,11]. The goal is to return to light recreational activities with progression of strength, dynamic balance, and initiation of plyometrics as tolerated (Fig. 19) [2,11].

Cardiovascular fitness is progressed and running is initiated [2,11]. The primary goal is to promote hip stability and skill execution with cocontraction of gluteus medius and minimus in varying degrees of hip flexion [2,11]. Motion analysis should be considered to refine movement patterns. Injury-prevention exercises should be progressed. Progression criteria include strength greater than 90% of the contralateral hip in all planes [2,11]. Improvements in PRO scores are also recommended including a Hip Outcome Score (HOS) > 85% for the Activities of Daily Living subscale [2,11]. Additional information and progression criteria for this phase are listed in Appendix 1.

Functional assessment and return to play

Success after hip arthroscopy is traditionally measured by improvements in pain, ROM, strength, and radiographic findings which are poor indicators of function and tolerance of return to sport in isolation [25]. To determine success after arthroscopy, a combination of PRO measures, objective measures, and functional measures are needed [25]. Return to play decisions should be based on temporal and functional criteria. The return to sport process begins once all previous progression criteria are achieved including normalization of ROM, flexibility, strength, gait, cardiovascular fitness, neuromuscular control, and functional performance. The primary goal is the achievement of normal, symmetrical pelvic-femoral mechanics including single leg hop, double-leg drop jump, and straight-ahead jogging without complaints of pain or instability [2]. Sport-specific testing should be completed with scores ≥90% limb symmetry index prior to progressing with the return to play [2,11]. Additional information for functional assessment is in the functional assessment section and criteria for return to sport are listed in Appendix 1.

Sport-specific skill acquisition

Once an adolescent athlete after hip arthroscopy has met all previously outlined criteria, then they are ready to initiate a gradual progression of sport-specific skills. This phase requires a thorough understanding of the unique demands of the sport or activity the athlete is returning to. This progression should be gradual and guided, focusing on maximizing muscle activation, neuromuscular control, power, and endurance with sport-specific skills while addressing motor learning and control.

Functional assessment

Successful outcomes after hip arthroscopy for athletes require the ability to meet the demands of sport without pain or dysfunctional movement patterns. In a survey of the literature, high variability exists

Figure 10. Mobility banded progressions to improve lateral distraction in half kneeling (*far left*) and pigeon (*left middle)*, posterior positioning of femoral head in half kneeling (*right middle)*, and long axis distraction in sidelying (*far right*).

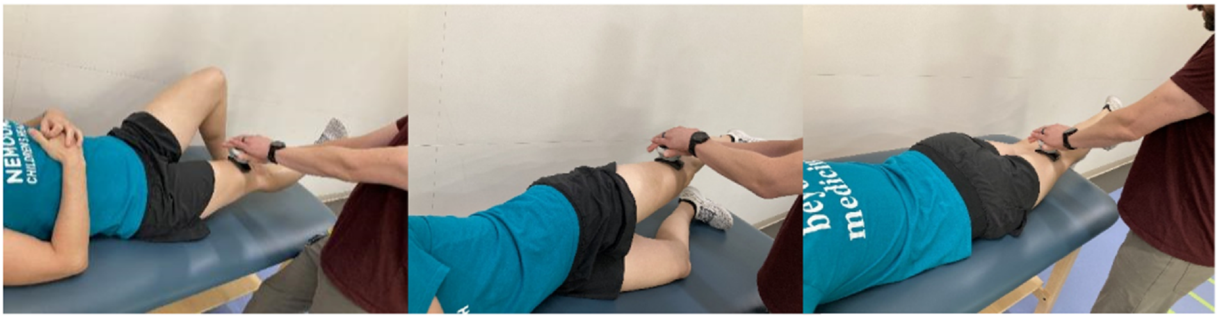

Figure 11. Testing position for handheld dynamometry of hip flexion (*left*), abduction (*middle*), and extension (*right*).

Figure 12. Prone strengthening techniques include psoas isometric exercises in neutral hip positioning (left), glute sets with bent knee hip extension (center), and quadruped glute set with bent knee hip extension (right).

Figure 13. Side-lying hip abduction against wall.

in reported functional assessments which indicates need for additional standardization for test selection after hip arthroscopy. A 2018 systematic review found no functional tests validated for return-to-play testing following hip arthroscopy [19]. In our review of the literature, we found 18 tests reported 1 time in the literature. The most utilized functional assessments included elements of functional hop tests (**Videos 1–4**) [26,27]. The second most cited functional test was the Star Excursion Balance Test or the Lower Quarter Y-Balance Test (**Video 5**) [24,28–31]. Neither functional test is specific to the hip but both are sensitive in revealing side-to-side differences in the athlete's ability to control movement outside of their base of support. These tests assess functional strength and proprioception needed for return to sport

Figure 14. Single leg lateral step down (*left*), banded standing hip external rotation (*center*), and banded standing clocks (*right*).

Figure 15. Single leg stance with cues to resist femoral internal rotation.

Figure 16. Dynamic single leg stance with resisted hip extension and abduction.

but require an uninvolved limb for comparison. The single leg squat test is also reported frequently in the literature (**Video 6**). This test of functional strength and proprioception is also based on limb symmetry. The athlete squats on one leg to a depth of at least 60° of knee flexion which is repeated until the onset of fatigue or loss of proper mechanics. The number of repetitions on each side is then compared to the contralateral lower extremity [24,29,32,33].

Supplementary material related to this article can be found online at doi:10.1016/j.jposna.2024.100051.

The following functional tests were reported multiple times in the literature: single leg vertical jump (**Video 7**), single leg stance, T-Agility Test (**Video 8**), lateral hop (**Video 9**), step down (Fig. 20), and side bridge test (**Video 10**). The T-Agility Test assesses general lower extremity power, agility, and speed but does not assess limb symmetry [26,27]. Normative values exist for college-aged males and females, rating performance from poor to excellent with limited applicability to younger athletes. The other tests provide a limb symmetry index (LSI) score. The single leg vertical jump assesses power, measuring the height of a single leg jump and comparison to the contralateral side [28,34]. The side bridge test (side plank) assesses qualitative pattern and trunk muscle strength. Single leg stance measures static balance to objectively measure limb symmetry and neuromuscular control [24,34]. The lateral hop test assesses endurance via the number of lateral hops performed in 30 seconds on each limb [27,34]. The step-down test compares the quality of movement when stepping down for 3 repetitions [32,33]. Other functional tests reported once in the literature were used in conjunction with other tests and are not specific to hip dysfunction, indicating the need for a battery of tests. Additional functional tests are reported by various isolated sources and more information about these tests can be found in Appendix 2 [26,27,29,30,35–37].

Factors and timeline for return to play

Despite inconsistencies in the literature and clinical practice, low complication and reoperative rates were evident at 2-year follow up with 88.4% of adolescents achieving minimally clinically important differences at 5-year follow-up after hip arthroscopy [3,4,8,38]. Return to sport and achievement of meaningful clinical outcomes are correlated with patient-reported satisfaction postoperatively [3,4,38]. Between 75% and 98.2% of athletes of all ages successfully return to preinjury athletic participation with a higher likelihood for return to play in the adolescent athlete [3,5,8,19,22]. Athletes who did not return to their baseline had lower preoperative baseline PRO scores [3]. Although return to sport rates are improving in adolescent athletes after hip arthroscopy, additional research is needed to determine accurate return to play rates.

Variability also exists regarding the timeline for return to play after hip arthroscopy. The majority of adolescent athletes return to sport within 4 to 7 months [6,19,39,40]. The inability to return to prior level of sports participation is correlated with a loss of interest or completion of an

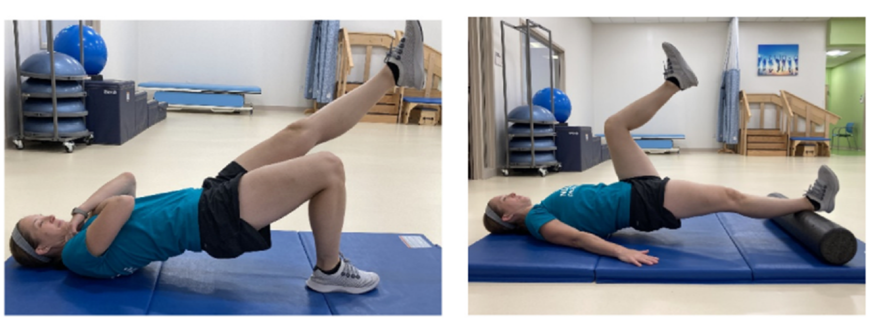

Figure 17. Single leg bridge progressions.

Figure 18. Modified side plank with hip abduction.

athletic career [39]. Poorer postoperative outcomes may be influenced by several risk factors including older age, longer preoperative symptomatic period, higher body mass index, prior hip surgery, hip dysplasia, acetabular retroversion, and level of preoperative joint arthritis [6].

Injury-prevention

Injury-prevention programs have been established to decrease the risk of injury in athletes by assessing risk factors [41]. Programs like the FIFA 11 and FIFA 11+ have been shown to decrease risk of lower extremity injuries in athletes [42]. A systematic review by Thorborg et al. concluded that utilization of the FIFA 11+ program resulted in a 41% reduction in hip and groin injuries [42]. However, these findings are not specific to labral injuries and FAI. Most labral tears are not related to one specific event with up to 74.1% not being related to a specific injury or cause [43–45]. More research is needed to assess modifiable risk factors and injury-prevention programs to determine interventions to reduce risk of future injury.

Patient-reported outcome measures

A wide variety of PRO measures are utilized for patients with FAI and labral pathology. These PRO's can assist health care providers when evaluating patient progress and determining readiness to return to sport. For these individuals, it is important a PRO adequately assess high level activities so a ceiling effect does not occur and to accurately evaluate age-appropriate function [19]. Many PRO's were created for older patients, limiting the application to active, young patients [46,47]. A number of systematic reviews have been conducted and recommended the following PRO's for patients with FAI and labral pathology, including The HOS, International Hip Outcome Tool-12 (iHOT-12), International Hip Outcome Tool-33 (iHOT-33), The Copenhagen Hip and Groin Outcome Score (HAGOS), Non Arthritic Hip Score, and the Hip disability and Osteoarthritis Outcome Score [47–52]. A 2018 consensus statement from 38 researchers and clinicians at the first international Hip-Related Pain Research Network meeting, concluded that the Copenhagen HAGOS and the short and long versions of iHOT-12 and iHOT-33 are the most appropriate PRO's to utilize for active, young and middle-aged adults [53]. More research is needed to identify and validate the best PRO for adolescent patients with hip pathology to fully capture the lifestyle and activity levels of young, healthy adolescent athletes.

Figure 20. Step down test.

Psychological and psychosocial assessment

Although physical improvements have been reported for adolescents after hip arthroscopy, social and emotional health scores may remain unchanged or limited compared to preinjury levels [54]. Prolonged

Figure 19. Dynamic hip stability progressions including band resisted lateral bound (*left*), dynamic forward single leg hop with diagonal medicine ball chop (*middle*), and skaters with medicine ball slam (*right*).

removal from sports and recreational activities for 6 to 9 months are contributing factors for changes in mental health for patients after hip arthroscopy. Assessment of both physical and psychological status, with referral to a sports psychologist, as needed, is crucial for effective management. This can be accomplished in several ways including the Tampa Scale for Kinesiophobia-11 and Adolescent Measure of Confidence and Musculoskeletal Performance [55,56]. These measures allow health care providers to screen for deficits in confidence and identify when additional referrals are warranted.

Summary

Hip arthroscopy is commonly utilized to successfully treat a variety of hip pathologies in the adolescent athlete, the goal of rehabilitation is to progress from local stability to global muscular and movement retraining based on the sport and level of participation for each patient. Current research highlights the introduction of circumduction-based exercises earlier in the rehabilitation process to prevent capsulolabral adhesions. Functional tests of the adolescent athlete with hip pathology include the Lower Quarter Y-Balance Test, functional hop test battery (including lateral hop), single leg squatting, step down, and side bridge tests. Additional consideration should be given to sport-specific movements and fitness-based tests to adequately assess readiness for return to play. Temporal and criterion-based progressions are necessary to ensure a safe return to sport in addition to a gradual return to activity.

Overall, the use of hip arthroscopy, in conjunction with effective postoperative rehabilitation in adolescent patients with acetabular labral tears and FAI, leads to significant improvement in pain and function, allowing the adolescent athlete to return to high levels of athletic participation. Additional research is needed to improve the standardization of the postoperative rehabilitation process, return to sport functional testing, creation of an age-appropriate PRO, and return to play timeline for adolescents after hip arthroscopy.

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Author contributions

Michelle Feairheller: Conceptualization, Writing – original draft, Writing – review & editing. **Paul Jenkins:** Conceptualization, Writing – original draft. **Lauren MacMillan:** Conceptualization, Writing – original draft, Writing – review & editing. **Sasha Carsen:** Writing – review & editing.

Declarations of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

View the video(s) on POSNAcademy here: http://www.kaltura.com/tiny/tagyd

Appendix 1. Hip Labral Repair Rehabilitation Protocol: Best Practice Guide[2,9,11,57]

Post-Operative Phase I (Immediate Post-Operative Phase): Weeks 0-4

Goals:

- Protect repaired tissue
- Restore ROM
- Control pain and inflammation
- Restore neuromuscular control
- Avoid intra-articular adhesions and irritation of iliopsoas
- Avoid hip flexor contracture

Brace

- None
- If needed based upon surgeon's recommendation

Weight-Bearing:

- Weight-bearing dictated by procedure and surgeon, typically Partial Weight-bearing (PWB) to Weight-bearing as Tolerated (WBAT)
  - o Foot flat weight-bearing up to 30% of bodyweight x 3-4 weeks with progression to full weight-bearing by 4 weeks or when able to ambulate without compensation

Precautions:

- Active/Passive Range of Motion (A/PROM) restrictions
- No flexion straight leg raise
- No resisted internal rotation (IR) or external rotation (ER) x 4 weeks
- No twisting or rotation of acetabulum on the femur under loaded conditions
- Modify sitting, sit to stand, and sleeping position

ROM:

- Extension: 0°
- Flexion (PROM): 90°
- Flexion (AROM): $<60°$ during ADL's only
- Abduction: 25-30°

- Adduction: 10°-20°
- Internal Rotation in prone and supine: 10°-20°
- External Rotation in prone and supine: 20°-30°
- Progress to full motion at week 3; no sharp anterior hip pain allowed

Therapeutic Exercises/Neuromuscular Re-education:

- Flexibility:
  o Hip/lower extremity flexibility based upon patient tolerance
  o Ankle/foot stretching/strengthening

- ROM:
  o Active/Active-assisted ROM (A/AAROM) within comfort and precautions
  o Heel slides to 90° AA/PROM
  o Passive hip circumduction (2-3 times per day)
  o Prone laying x 2 hours per day
  o Heel slides (beginning week 3)
  o Quadruped rocking (beginning week 3)
  o Stool rotations for IR/ER (beginning week 3)

- Lower quarter strengthening/neuromuscular control:
  o Isometrics: glute, quadriceps, hamstring
  o Ankle/foot strengthening
  o Open Kinetic Chain (OKC) knee flexion in prone
  o Double leg bridges
  o Pelvic tilts (beginning week 2)
  o Hip IR/ER isometric (beginning week 2)
  o Bridge progressions (beginning week 3)
  o Clamshells (beginning week 3)
  o Reverse clamshells (beginning week 3)
  o Standing hip abduction (beginning week 3)
  o Double leg press/shuttle 0-60° of hip flexion (beginning week 3)

- Core strengthening:
  o Transversus abdominis activation
  o Quadruped upper extremity lifts (beginning week 3)
  o Side bridge with adductor facilitation with knees bent (beginning week 3)

- Gait training:
  o As applicable based upon weight-bearing status and gait pattern
  o Weight shifts: double leg to single leg as dictated by weight-bearing (beginning week 3)

Cardio:

- Upright stationary bike with light to no resistance

Manual Therapy:

- Scar massage
- Soft tissue mobilization
- Grade 1 posterior capsule and long axis distraction hip mobilization (beginning week 3-4); no anterior mobilization until week 6

Modalities:

- Cryotherapy 2-8 times per day x 15-30 minutes as needed
- Continuous Passive Motion (CPM): If recommended by surgeon, CPM to 30-60° of hip flexion x 4-6 hours/day x 3-4 weeks; increase by 10° per day up to 90° as tolerated

Criteria for Progression to Phase II:

- Ability to perform strong glute and quad set
- Near full ROM
- Minimal pain
- Full weight-bearing

Post-Operative Phase II (Early Impairment): Weeks 4-8

Goals:

- Protect repaired tissue
- Restore ROM
- Restore normal gait pattern
- Progressively increase strength with global neuromuscular control
- Minimize impingement
- Release myofascial restrictions of hip musculature

Weight-Bearing:

- Progress to full weight-bearing (FWB) with non-antalgic gait

Precautions:

- A/PROM within comfort level
- No forceful or ballistic stretching
- No loaded and prolonged excessive hip flexion or flexion-adduction-internal rotation (FADDIR) position
- No flexion, adduction, extension straight leg raise

Therapeutic Exercises/Neuromuscular Re-education:

- Flexibility/ROM:
  - o Hip/lower extremity flexibility based upon patient tolerance
    - ■ Hip flexor, glute/piriformis, flexion-abduction-external rotation (FABER), hip ER/IR (hip extended and flexed), hamstring, quad, iliotibial band (ITB), prone press up
  - o Quadruped rocking

- Lower quarter strengthening/neuromuscular control:
  - o OKC side-lying hip abduction
  - o CKC strengthening
    - ■ Mini-squats
    - ■ Step ups
    - ■ Step down
    - ■ Wall squats/wall sits
  - o Progress double leg to single leg balance with focus on appropriate hip stabilization; progress to unstable surface/perturbations

- Core strengthening progressions
  - o Bent knee fall out
  - o Supine marching
  - o Trunk rotation
  - o Tall and half kneeling core strengthening
  - o Planks (modified to full prone and side planks)

- Gait training:
  - o Continued gait training as needed
  - o Lateral weight shifts (add band resistance)
  - o Lateral and backwards walking (without resistance; progress to banded resistance)

Cardio:

- Upright stationary bike, elliptical, aquatic therapy

Manual Therapy:

- Scar massage
- Soft tissue mobilization
- Low grade hip joint mobilizations

Modalities:

- Cryotherapy after activity for 15-20 minutes and as needed

Criteria for Progression to Phase III:

- Pain-free gait
- Full and pain free ROM
- No pain
- Hip flexion strength >60% of the uninvolved side
- Hip strength (all other motions) >80% of the uninvolved side
- Manual muscle testing of hip musculature at least 4+/5

Post-Operative Phase III (Late Impairment): (Weeks 8-12)

Goals:

- Restore muscular endurance and strength
- Improve low impact cardiovascular fitness
- Optimize global neuromuscular control and proprioception
- Minimize impingement
- Release myofascial restrictions of hip musculature
- Focus on core control

Precautions:

- No forceful or ballistic stretching
- No treadmill jogging/running
- No loaded and prolonged excessive hip flexion or FADDIR position
- No high impact sport specific activity

Therapeutic Exercises/Neuromuscular Re-education:

- Flexibility:
  o Flexibility focused on hip flexors and adductors

- ROM: as needed

- Lower extremity strengthening/neuromuscular re-education:
  o Hip rotation strengthening
  o Closed Kinetic Chain (CKC) strengthening
    ▪ Progression of lunges, step down, squats, single leg squats, deadlifts, single-leg Romanian deadlifts
    ▪ Multidirectional progressions
  o Bridge progressions
  o Single leg proprioceptive activities; progress to unstable surface/perturbations

- Core: Core strengthening progressions

Cardio:

- Upright stationary bike, elliptical, aquatic therapy, stair climber

Manual Therapy:

- Scar massage
- Soft tissue mobilization
- Low grade hip joint mobilizations

Modalities:

- Cryotherapy after activity for 15-20 minutes and as needed

Criteria for Progression to Phase IV:

- Full hip ROM
- Hip flexion strength >75% of the uninvolved side
- Hip strength (all other motions) >80% of the uninvolved side
- Isokinetic strength testing: quadriceps and hamstring peak torque and total work ≤30% deficit at 180°/sec
- Lateral step down (6” step): ≤3/6 errors

- Lower quarter Y balance test (anterior reach only): ≤ 4 cm difference compared to uninvolved side
- Adequate cardiovascular fitness
- Demonstration of exercises with proper body mechanics

Post-Operative Phase IV (Functional Restoration and Return to Sport Specific Activity): Weeks >12

Goals:

- Progress towards returning to running, plyometric, agility activities, sport specific activity
- Progress towards return to sport/activity
- Normalize lower quarter strength, power, and force development
- Normalize lower quarter neuromuscular control
- Consider participation in an injury-prevention/transitional therapy program

Precautions:

- Progressive introduction of dynamic and high impact activities

Therapeutic Exercises/Neuromuscular Re-education:

- Flexibility: as needed

- ROM: as needed

- Lower extremity strengthening/neuromuscular re-education:
  o Lunge matrix/CKC tri-planar movements
  o Dynamic balance drills
- Core strengthening: progress lumbo-pelvic strength and endurance
- Plyometric/sport specific progressions:
  o Functional/sport specific agility drills
  o Dynamic warm up
  o Sport specific drills
  o Double-leg plyometrics progressing to single leg/multi-plane as tolerated

Cardio:

- Progressive return to run (starting at week 12/when criteria are met)
- Stationary bike, elliptical, aquatic therapy, stair climber

Criteria for Progression to Return to Sports/Activity:

- Full, pain-free ROM
- Completion of sport-specific loading and functional training program at full speed without complications or pain
- Cardio respiratory fitness at pre-injury levels
- Hip strength testing ≥90% of the uninvolved side
- Dynamic balance ≥90% of the uninvolved side
- Functional hop test battery ≥90% Limb Symmetry Index (LSI) of the uninvolved side
- Lateral hop test ≥90% LSI of the uninvolved side
- Lateral step down (6” step)”: ≤2/6 errors
- Lower quarter Y balance test (anterior reach only): ≤ 4 cm difference for anterior reach compared to uninvolved side, ≤ 6 cm difference for posteromedial and posterolateral reach compared to uninvolved side, composite core ≥90% (each side)
- Drop vertical jump using Landing Error Scoring System (LESS): ≤2 errors
- Tuck Jump Test: Score <6 (if patient age and skill level appropriate)
- Surgeon clearance

Patient-Reported Outcome Measures:

- International Hip Outcome Tool (iHOT-12 or iHOT-33)
- The Copenhagen Hip and Groin Outcome Score (HAGOS)
- Hip Outcome Score (HOS)

*Please note, this rehabilitation protocol has been created from the current, best available evidence as well as from several current pediatric children’s hospital protocols.

Pediatric children’s hospital rehabilitation protocols included in combination protocol:

1. Children's Hospital of Philadelphia
2. Connecticut Children's Medical Center
3. Nemours Children's Hospital
4. Washinton University Orthopaedics- St. Louis Childrens' Hospital

Other reference articles:

Adler KL, Cook PC, Geisler PR, et al. Current concepts in hip preservation surgery: part II- rehabilitation. *Sports Health.* 2016;8(1):57-64.

Cianci A, Sugimoto D, Stracciolini A, et al. Nonoperative management of labral tears of the hip in adolescent athletes: description of sports participation, interventions, comorbidity, and outcomes. *Clin J Sport Med.* 2017;29(1):1-5.

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Appendix 2. Functional testing of the hip [24,29–47,62,76,77,79–84]

Test	Description	Scoring	Age Validation	Citation
Functional Hop Tests	A battery of single limb hops including single, triple, cross-over hop for distance and a 6-meter timed hop to assess power, functional strength, stability and controlled movement	Limb Symmetry Index (LSI)	9 Years and up	• Spencer-Gardner 2014 [28] • Vogler 2017 [27] • Kemp 2013 [49] • Kollock 2015 [34] • Kemp 2016 [37] • Tijssen 2016 [31] • Draovitch 2012 [26] • Warming 2021 [58]
Y- Balance Test/Star Excursion Balance Test	Single limb balance reaching outside base of support in various directions	LSI and composite norms	12 years and up	• Spencer-Gardner 2014 [28] • Reiman 2014 [24] • Vogler 2017 [27] • Kivlan 2012 [39] • Smith 2017 [30] • Tijssen 2016 [31] • Schweirtz 2020 [59]
Single Leg Squat	Subject stands on one leg with contralateral hip flexed to 45°and squats to 60° without use of upper extremities	LSI/ clinician assessment of quality of movement	9 years and up	• Reiman 2014 [24] • McGovern 2019 [32] • McGovern 2018 [33] • Kivlan 2012 [29] • Agresta 2013 [60]
Single Leg Vertical Jump	Subject stands on one foot and jumps as high as possible; measured with force plates, assessment device or chalk	LSI/comparison to normative data	14 years and up	• Spencer-Gardner 2014 [28] • Kollock 2015 [34] • Rodriguez-Rosell 2017 [61]
Single Leg Stance	Subject stands on one foot for maximum duration	LSI/quality assessment/ age-matched normative data	4 years and up	• Reiman 2014 [24] • Kivlan 2012 [29] • Condon 2014 [62]
Agility T-test	Subject sprints forward 10 m, shuffles laterally to the left 5 m, shuffles laterally to the right 10 m, shuffles laterally to the right 5 m back to center and backpedals10 m to the start line	Comparison to normative data	12 years and up	• Vogler 2017 [27] • Draovitch 2012 [26] • Uzin 2020 [63]
Lateral Hop Test	Subject jumps on one foot as many times as possible laterally for 30 s from one strip of tape to the other 40 cm apart	LSI	28 years of age ± 4 and up	• Vogler 2017 [27] • Kollock 2015 [34] • Gustavson 2006 [64]
Step Down Test (Single Leg Step Down Test)	Subjects stands on a 15 cm box and lowers down one limb to ground and back up	Quality of movement scoreor a 60 s timed test compared for limb symmetry	Ages 16-40	• McGovern 2019 [32] • McGovern 2018 [33] • Ophey 2019 [65] • Burnham 2016 [36]
Side Bridge Test/ Side Plank Test	Subject is side-lying with weight supported on forearm and raises trunk to straight position; maximum hold time is recorded	Side-to-side comparison of time, comparisons to normative data	Ages 20-28	• Kemp 2013 [49] • Kemp 2016 [37] • Juan-Recio 2022 [66]

Vail Sport Test	Subject performs a series of skill/ endurance tests including: 3 min of single leg squats, lateral bounding x 100 s, diagonal bounding x 100 s, forward box lunges x 2 min	Criterion-referenced scoring	Unknown	• Kuhns 2017 [35] • Reiman 2014 [24]
Tuck Jump	Subject jumps bringing knees to level of hips for 10 s / often recorded	Criterion-referenced scoring/ movement quality	12 years and up	• Kuhns 2017 [35] • Read 2016 [67]
40-yard Sprint	Subject runs a 40- yard sprint following appropriate warm up	Normative data	High school and above	• Vogler 2017 [27] • Mann 2015 [68]
Beep test, PACER, Multi-stage Shuttle Run	Subjects runs between 2 lines, 20 m apart in time with recorded beeps that get faster each cycle	Scoring is based on number of cycles completed	Children and adults	• Vogler 2017 [27] • Mayorga-Vega 2015 [68]
Hexagon Hop	Subject starts in the center of a hexagon with 24-inch sides, jumping to each side and back to center completing the cycle 3 times	Scoring is based on time and movement quality assessment	College-aged	• Vogler 2017 [27] • Beekhuizen 2015 [69]
Medial Hop for Distance	Subject hops 3 times in a row in the frontal plane and distance is recorded	Scoring is based on distance and compared to normative data	18-21 years	• Vogler 2017 [27] • Kivlan 2016 [70]
Deep Squat/Overhead Squat	Subject performs a maximal squat with arms overhead; tester determines point score for movement	Scoring based on quality of performance	10 years and up	• Kivlan 2012 [29] • Abraham 2015 [71]
Single Leg Rise/Single Leg Sit-to-Stand	Subject stands up from sitting at a height of 46 cm using only uninvolved leg 5 times; repeated on the involved leg	Scoring on quality of movement and limb symmetry	18 years and up	• Kemp 2016 [37] • Woon 2021 [72]
Double Leg Lowering	Subject lowers legs while performing abdominal bracing from a supine position with both knees extended and hips at 90°	Scoring based on angle of the hips when anterior pelvic rotation begins	12 years and up	• Smith 2017 [30]
Drop Jump Video	Subject stands on a 30 cm box, steps off box forward, lands, immediately jumps as high as possible and then lands in a stable position	Quality of movement analyzed with motion analysis software	12 years and up	• Smith 2017 [30]
Fig. 8 Drill	No standardized performance description	N/A	No validity reported in literature	• Dratovitch 2012 [26]
Line Drill	No standardized performance description	N/A	No validity reported in the literature	• Dratovitch 2012 [26]
Zig Zag test	Subject runs through a course of cones 10'x16', cutting and pivoting at every cone	Scored based on time it takes to complete course	No validity reported in the literature but highly reliable	• Dratovitch 2012 [26]

Appendix 2: Recommendations for functional testing of the hip based upon a review of the literature for adolescent athletes.

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