Return to Sport After Femoroacetabular Impingement Surgery and Sport-Specific Considerations: a Comprehensive Review

Kevin C. Parvaresh¹ · Daniel Wichman¹ · Jonathan Rasio¹ · Shane J. Nho¹

Published online: 9 March 2020

© Springer Science+Business Media, LLC, part of Springer Nature 2020

Abstract

Purpose of Review Recent advancements in surgical technology and techniques have improved functional results for operative treatment of femoroacetabular impingement syndrome (FAIS). Few studies have comprehensively evaluated the literature regarding return to sport criteria, timing, level, and rates. The purpose of this study was to review recent studies regarding return to play after surgical correction of FAIS. We will specifically evaluate the level of return to play and look to compare pre- and postoperative competition levels when available. We will also analyze timing of return to play from injury to surgery. Additionally, we will elucidate any sport-specific criteria that may determine readiness for return.

Recent Findings Athletes with FAIS treated non-operatively have a low rate of return to sport and are often functionally limited in their level of performance. Surgical management of FAIS includes hip arthroscopy as well as open techniques. Current literature suggests a high rate of return to sport after contemporary surgery for FAIS at 87–93% overall. Rate of return to the same level of competition following surgery for FAIS is 55–83% in pooled studies. Limited evidence is available comparing postoperative rehabilitation protocols and timing of return among different sports.

Summary Operative treatment of FAIS results in high rates of return to sport and functional performance. The results of this study may help educate patients preoperatively in regard to the likelihood of functional return to sport and sport-specific considerations. Further research evaluating rehabilitation protocols and return criteria may better elucidate timing intervals for patients to maximize function while limiting complications.

Keywords Femoroacetabular impingement syndrome · Hip arthroscopy · Hip preservation surgery

Introduction

Femoroacetabular impingement syndrome (FAIS) is a common problem in the athletic population that can significantly affect sports performance. FAIS is defined based on the 2016 Warwick Agreement as a triad of motion-related symptomatic hip pain, clinical signs of hip impingement, and imaging findings of abnormal hip pathomorphology [1••]. This recent distinction of FAIS as a triad is particularly important as the presence of imaging abnormalities in asymptomatic

individuals may be as high as 68% with athletes being three times more likely to have these abnormalities [2]. Therefore, accurate diagnosis of FAIS necessitates matching imaging abnormalities with patient presentation.

Presentation of FAIS is characterized by motion-related hip pain that is typically anterior but may also be located lateral, posterior, proximal, or distal [3]. Clinical examination is variable but impingement testing should reproduce the patient's symptoms [4]. Imaging assessment begins with standing radiographs including an anteroposterior view of the pelvis, lateral views, and a false-profile view [5]. Cross-sectional imaging, including computed tomography and magnetic resonance imaging or arthrography [4], may additionally be utilized to better identify three-dimensional morphology [6].

The pathoanatomy of FAIS is often multifactorial and includes both osseous and soft tissue abnormalities. Osseous pathomorphology may include cam, pincer, or mixed deformities [7]. Chondrolabral pathology commonly occurs in the anterosuperior region with cam deformities and in the

This article is part of the Topical Collection on *Outcomes Research in Orthopedics*

✉ Shane J. Nho
snho@rushortho.com

¹ Department of Orthopedic Surgery, Section of Young Adult Hip Surgery, Division of Sports Medicine, Rush Medical College of Rush University, Rush University Medical Center, Chicago, IL, USA

posteroinferior region with pincer deformities [8]. Natural history studies suggest a correlation between FAIS and the development of osteoarthritis [9], but validation studies are lacking. Moreover, although the prevention of osteoarthritis with early intervention has been theorized, no studies have directly shown the prevention of osteoarthritis.

Multiple studies have evaluated FAIS in the athletic population relative to sports performance. In the literature, return to sport (RTS) is often an ambiguous subject and therefore comparison studies may suffer from heterogeneous definitions. Comprehensive studies best assess RTS from a functional level before injury and after recovery [10]. In fact, the most recent consensus statement on RTS from the First World Congress in Sports Physical Therapy suggests defining return as a continuum ranging from participation to return to full performance (RTP) that matches or exceeds preinjury levels [11•]. Sport activity may be categorized based on mechanical loads placed on the hip [12]. In terms of level of competition, the Hip Sports Activity Scale (HSAS) was specifically validated in the FAIS population [13]. Together, these tools can be utilized to assess athletic outcomes among different treatment modalities for patients with FAIS.

Non-Operative Management of FAIS

Non-operative management of FAIS encompasses a spectrum of treatment options including activity modification, physical therapy, medications, and injections. These options have the advantage of being non- or minimally invasive with relatively low risk. Moreover, they allow athletes to continue competing and training as tolerated. As such, they are typically the first-line treatment for patients presenting with FAIS.

Injections for FAIS may be utilized for both diagnostic and therapeutic purposes. Diagnostic injections typically involve the use of a local anesthetic that is injected into the hip joint under image guidance. If symptoms improve, then the intra-articular pathology is likely the cause of dysfunction and may be appropriately addressed. Therapeutic injections, on the other hand, have the added benefit of potential symptomatic relief short or long term. Reports on the effectiveness of therapeutic injections are variable in intensity and duration. Traditionally, injections have been performed with corticosteroids. A recent systematic review found slightly greater effectiveness with hyaluronic acid (HA) injections over corticosteroids in patients with FAIS [14]. Newer formulations involving biologics, such as platelet-rich plasma (PRP), bone marrow aspirate concentrate (BMAC), and stem-cell adjuncts are currently being evaluated. Limited evidence is available regarding their efficacy.

Management of FAIS with physical therapy begins with a functional assessment of the athlete for specific limitations in flexibility, muscle balance, proprioception, and conditioning.

While there is no consensus on non-operative physical therapy regimens, most protocols emphasize core strengthening and muscle stabilization exercises [15]. Sport-specific training for RTS is highly variable among sports with multiple local and regional differences [1]. Regardless of the strategy, individualized treatment remains paramount for safely returning athletes to sport.

Overall literature supports a trial of non-operative management for initial treatment of FAIS [15], though studies directly evaluating operative versus non-operative treatment show mixed results. A prospective multicenter randomized controlled trial by Griffin et al. found significant improvements with surgery compared to non-operative treatment but did not include injections in the non-operative algorithm or provide any RTS data [16]. In contrast, Mansell et al. performed a randomized controlled trial in active duty military patients and found no differences in outcomes with surgical versus non-surgical management [17]. A recent prospective cohort study by Pennock et al. investigated management of FAIS in a group of adolescents and found 82% of patients experienced improvement without surgery [18•]. They also found no difference in outcome scores between operative and non-operative groups, but noted patients with cam and mixed deformities were more likely to progress to surgery than those with pincer. Together, these studies suggest individualized treatment strategies may be utilized in certain subgroups of patients to optimize clinical outcomes, though further research is needed to identify these populations.

Operative Management of FAIS

Patients suffering with FAIS who are unable to RTS despite non-operative measures may consider the risks and benefits of surgery relative to their ability to return to their desired level of sports performance. Surgical options include open, mini-open, and arthroscopic techniques. Open techniques traditionally involve surgical hip dislocation via a greater trochanteric osteotomy [19], while mini-open techniques typically combine osteoplasty via anterior approach with arthroscopic acetabuloplasty and labral treatment (Fig. 1) [20]. All three techniques have shown comparable efficacy in improving patient-related outcome (PRO) scores, though arthroscopic techniques are associated with fewer complications [21].

Literature shows surgical management of FAIS results in high overall rates of RTS, with current studies showing surgical RTS rates of 87–93% [22•, 23, 24]. The most recent evidence from the systematic review performed by Reiman et al. showed RTS rates for open, mini-open, and arthroscopic techniques were 89%, 89%, and 91%, respectively [22•]. When they adjusted for return to preinjury level of performance, they found return rates of 83%, 55%, and 74%, respectively. Despite these apparent differences, their meta-analysis

Fig. 1 Arthroscopic treatment of FAIS. **a** A characteristic anterosuperior labral tear. **b** Labral repair with suture anchors. **c** A completed femoroplasty for a cam lesion

revealed no statistically significant differences in RTS relative to surgical technique. Moreover, the patient populations and sports identified in these studies were heterogeneous, thus limiting the strength of comparison between these studies.

Return to Sport Timing

Multiple variables affect the decision regarding timing of return to sport following surgery for FAIS. A recent study by Kuhns et al. suggested a four-phase rehabilitation protocol in an effort to balance safety of recovery with efficient RTS following surgery [25]. Currently, however, there is no universal consensus on rehabilitation protocol or readiness testing for RTS. In fact, in a recent systematic review, Memon et al. found the criteria in 64% of FAIS RTS studies was simply completion of the rehabilitation protocol [23]. Even after completion of formal therapy, studies have shown dynamic strength is still significantly decreased postoperatively compared to healthy controls [26]. The majority of the literature reports on postoperative timing of RTS with an overall mean of 7 months and a range of 3.1 to 14.5 months [22•]. Multiple studies have found that athletes withdrawn from sport more than 8 months prior to surgery experienced a significantly slower RTS [27, 28]. Certainly, the decision to return depends on a number of factors including season timing and functional level, thus determining timing individually can be very subjective. The international consensus recommends development of homogenous sport-specific criteria to better assess readiness and timing for return to athletic participation [11•].

Sport-Specific Considerations

Sport-specific demographics in patients with FAIS are well reported in the literature. Nawabi et al. retrospectively reviewed a case series, showing the most common sports for patients with FAIS were soccer, hockey, and football [12].

Moreover, they found high-level athletes were more likely to be young, male, and have bilateral surgery compared with recreational athletes. High prevalence rates of FAIS have also been shown in basketball [29] and dance as well [30], though these studies were based on imaging parameters rather than the triad of components previously discussed for FAIS. Gender differences in sport vary, though males are more likely to have radiographic evidence of cam deformities while females are more likely to show evidence of acetabular dysplasia [31, 32]. These differences underscore the need for individualized surgical plans when approaching operative management for athletes with FAIS.

Type of Sport

Multiple studies have investigated RTS following surgery for FAIS within different sports. Table 1 shows available pooled data regarding RTS rates from individual studies categorized according to mechanical demand [12]. Very high rates of RTS (90–100%) have been shown in soccer [33, 34], basketball [35], lacrosse [36], yoga [37], cycling [45, 47], and swimming [48]. High rates (80–90%) have been found in football [38, 39], baseball [42, 43], running [45, 46], and high intensity interval training [49]. The lowest rate of return reported has been with crew, with one study showing 56% of rowers were able to RTS [41].

Despite the abundance of individual sport data, few studies have directly compared rates among different sports. Schallmo et al. recently studied RTS rates in professional athletes across a variety of professional sports in North America and found a high rate of return overall at 84.6% [40]. Stratifying by return relative to sport type, they found significantly higher rates in National Hockey League (NHL) athletes (91.8%, $p = 0.048$), average rates in National Basketball Association (NBA) players (85.7%, $p > 0.99$), and significantly lower rates in National Football League (NFL) offensive linemen (61.1%, $p = 0.01$).

Table 1 Available pooled data regarding RTS rates from individual studies categorized according to mechanical demand [12]

	Sport	RTS (%)	Average timing of return (months postoperative)
Cutting	Soccer [33, 34]	96	9.2
	Basketball [35]	100	7.1
	Lacrosse [36]	94.4	
Flexibility	Yoga [37]	93	5.3
Contact	Football [38, 39]	87–92.5	6
Impingement	Ice Hockey [40]	91.8	
	Crew [41]	56	8
Overhead	Baseball [42, 43]	77.4–95	4.3
	Golf [44]	100	4.7
Endurance	Running [45, 46]	78–94	8.5
	Cycling [45, 47]	97	4.5
	Swimming [48]	100	3.4
	High Intensity Interval Training [49]	88	9.8

Level of Competition

Level of competition may also has an impact on sports performance following surgery. In a comprehensive systematic review of RTS following hip arthroscopy for patients with FAIS, Reiman et al. found RTS rates at preinjury levels of 88% in professional athletes, 85% in collegiate athletes, and 80% in adolescent athletes [22•]. Multiple primary studies have also shown an 84–93% return to sport rate for adolescent athletes with 74–89% returning to the same or higher level of competition [50•, 51]. Recreational athletes have also returned to sport at rates as high as 94% [27]. Together these studies suggest a favorable rate of RTS following surgery for athletes of all levels with FAIS.

Quality of Performance

A number of studies have investigated subjective performance measures relative to postoperative sports participation. In a retrospective review of the Danish Hip Arthroscopy Registry, Ishoi et al. showed 59.1% of athletes returned to preinjury level of competition, with only 29.6% of those athletes reporting optimal performance [10]. In a secondary analysis, they found no significant differences in subjective difficulties among sports stratified as non-contact non-pivot, non-contact pivot, and contact pivot sports [52]. In contrast, more recent systematic reviews found slightly higher rates for RTP between 74 and 85% [22•, 23, 24, 53•]. Importantly, these reports must be contextualized with the understanding that professional demands following scholastic athletics may affect decisions to return to competition and subjective return to performance outcome data.

Objective performance measures following surgery for FAIS have been evaluated in the professional athlete

population in multiple studies. Schallmo et al. reported on objective performance outcomes in a variety of professional athletes. Despite a high rate of RTS overall, nearly all professional athletes experienced significant reductions in performance measures the first season after surgery. Specifically, they noted reductions in NHL performance (-35.1% , $p = 0.02$) and Major League Baseball (MLB) hitter performance (-12.7% , $p = 0.041$) and fastball velocity (-1.3% , $p = 0.004$). Although robust, the study was limited by short-term follow-up and lack of control comparisons. In contrast, Frangiamore et al. found no differences in performance measures between preinjury and postoperative values in MLB players [54]. McDonald also found no significant difference in performance measures in NHL players before and after surgery [55]. In a group of National Basketball Association (NBA) players, Begly et al. found no significant change in player efficiency pre- and postoperatively [35]. Similarly, Nwachukwu et al. found no significant change in offensive and defensive power ratings for National Football League (NFL) athletes pre- and postoperatively [38]. In a study of professional golfers, there was no significant difference in rates of hitting the green and driving distance was longer postoperative than preoperative [44]. Together, the results for objective performance remains mixed for professional athletes and highlight the need for more robust objective outcome studies for FAIS RTS research.

Risk Factors for Failure

A number of factors have been found to correlate with failure of surgical management for athletes with FAIS. Shorter preoperative symptom duration has been found to be significantly correlated with a higher rate and faster RTS [15, 16]. Depression has been shown to negatively correlate with

functional outcomes and return to sport [25, 26]. As expected, revision hip arthroscopy has been associated with significantly lower rates of RTS (58.8%) compared with primary procedures (86.7%, $p = 0.008$) [22]. Advanced arthritis has been shown to correlate with worse functional outcome and revision or conversion surgery in the athletic population [56, 57]. Advanced age as a risk factor has mixed reports in the literature. Although some studies suggest older age correlates with a higher risk of failure following hip arthroscopy [58, 59], other studies show there is no difference [27]. More robust studies are needed that specifically identify significant independent risk factors for RTS in the athletic population to appropriately educate patients preoperatively on prognostic criteria regarding surgical management.

Conclusion

Recent advances in arthroscopic technology and surgical techniques have improved clinical outcomes for athletic patients suffering with FAIS. Current literature shows that surgical treatment for FAIS allows a high rate of RTS and RTP. Factors affecting RTS include athlete demographics, duration of preoperative withdrawal from sport, severity of pathology, type of sport, competition level, and surgical technique. More detailed outcome scores may better delineate differences in quality of performance before and after surgery. Future studies may also better characterize sport-specific timing and functional readiness testing to safely and expediently return athletes to their desired level of competition.

Compliance with Ethical Standards

Conflict of Interest All authors report they have no conflicts of interest.

Human and Animal Right and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

- 1.•• Griffin DR, Dickenson EJ, O'Donnell J, et al. The Warwick Agreement on femoroacetabular impingement syndrome (FAI syndrome): an international consensus statement. *Br J Sports Med.* 2016;50(19):1169–76. <https://doi.org/10.1136/bjsports-2016-096743> **Consensus statement from an international panel of 22 expert clinicians and academics on femoroacetabular impingement syndrome (FAI). This statement is an**

international agreement regarding the key terminology, diagnosis, and treatment related to FAI.

2. Frank JM, Harris JD, Erickson BJ, et al. Prevalence of femoroacetabular impingement imaging findings in asymptomatic volunteers: a systematic review. *Arthrosc J Arthrosc Relat Surg.* 2015;31(6):1199–204. <https://doi.org/10.1016/j.arthro.2014.11.042>.
3. Clohisy JC, Knaus ER, Hunt DM, Leshner JM, Harris-Hayes M, Prather H. Clinical presentation of patients with symptomatic anterior hip impingement. *Clin Orthop.* 2009;467(3):638–44. <https://doi.org/10.1007/s11999-008-0680-y>.
4. Reiman MP, Goode AP, Cook CE, Hölmich P, Thorborg K. Diagnostic accuracy of clinical tests for the diagnosis of hip femoroacetabular impingement/labral tear: a systematic review with meta-analysis. *Br J Sports Med.* 2015;49(12):811. <https://doi.org/10.1136/bjsports-2014-094302>.
5. Clohisy JC, Carlisle JC, Beaulé PE, Kim YJ, Trousdale RT, Sierra RJ, et al. A systematic approach to the plain radiographic evaluation of the young adult hip. *J Bone Joint Surg Am.* 2008;90(Suppl 4):47–66. <https://doi.org/10.2106/JBJS.H.00756>.
6. Albers CE, Wambeck N, Hanke MS, Schmaranzer F, Prosser GH, Yates PJ. Imaging of femoroacetabular impingement-current concepts. *J Hip Preserv Surg.* 2016;3(4):245–61. <https://doi.org/10.1093/jhps/hnw035>.
7. Ganz R, Parvizi J, Beck M, Leunig M, Nötzli H, Siebenrock K. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop.* 2003;417:112–20. <https://doi.org/10.1097/01.blo.0000096804.78689.c2>.
8. Pfirrmann CWA, Mengiardi B, Dora C, Kalberer F, Zanetti M, Hodler J. Cam and pincer femoroacetabular impingement: characteristic MR arthrographic findings in 50 patients. *Radiology.* 2006;240(3):778–85. <https://doi.org/10.1148/radiol.2403050767>.
9. Kuhns BD, Weber AE, Levy DM, Wuerz TH. The natural history of femoroacetabular impingement. *Front Surg.* 2015;2. <https://doi.org/10.3389/fsurg.2015.00058>.
10. Ishoi L, Thorborg K, Kraemer O, Hölmich P. Return to sport and performance after hip arthroscopy for Femoroacetabular impingement in 18- to 30-year-old athletes: a cross-sectional cohort study of 189 athletes. *Am J Sports Med.* 2018;46(11):2578–87. <https://doi.org/10.1177/0363546518789070>.
- 11.•• Ardern CL, Glasgow P, Schneiders A, et al. 2016 Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *Br J Sports Med.* 2016;50(14):853–64. <https://doi.org/10.1136/bjsports-2016-096278> **Consensus statement from an international panel of 17 expert clinicians and academics on return to sport after injury. This statement is an international agreement regarding the decision making for return to sport and cognization of return to sport as a continuum, paralleled with recovery and rehabilitation.**
12. Nawabi DH, Bedi A, Tibor LM, Magennis E, Kelly BT. The demographic characteristics of high-level and recreational athletes undergoing hip arthroscopy for femoroacetabular impingement: a sports-specific analysis. *Arthrosc J Arthrosc Relat Surg.* 2014;30(3):398–405. <https://doi.org/10.1016/j.arthro.2013.12.010>.
13. Naal FD, Miozzari HH, Kelly BT, Magennis EM, Leunig M, Nötzli HP. The Hip Sports Activity Scale (HSAS) for patients with femoroacetabular impingement. *Hip Int J Clin Exp Res Hip Pathol Ther.* 2013;23(2):204–11. <https://doi.org/10.5301/hipint.5000006>.
14. Khan W, Khan M, Alradwan H, Williams R, Simunovic N, Ayeni OR. Utility of intra-articular hip injections for femoroacetabular impingement: a systematic review. *Orthop J Sports Med.* 2015;3(9):2325967115601030. <https://doi.org/10.1177/2325967115601030>.
15. Wall PDH, Fernandez M, Griffin DR, Foster NE. Nonoperative treatment for femoroacetabular impingement: a systematic review

- of the literature. *PM R.* 2013;5(5):418–26. <https://doi.org/10.1016/j.pmrj.2013.02.005>.
16. Griffin DR, Dickenson EJ, Wall PDH, Achana F, Donovan JL, Griffin J, et al. Hip arthroscopy versus best conservative care for the treatment of femoroacetabular impingement syndrome (UK FASHIoN): a multicentre randomised controlled trial. *Lancet Lond Engl.* 2018;391(10136):2225–35. [https://doi.org/10.1016/S0140-6736\(18\)31202-9](https://doi.org/10.1016/S0140-6736(18)31202-9).
 17. Mansell NS, Rhon DI, Meyer J, Slevin JM, Marchant BG. Arthroscopic surgery or physical therapy for patients with femoroacetabular impingement syndrome: a randomized controlled trial with 2-year follow-up. *Am J Sports Med.* 2018;46(6):1306–14. <https://doi.org/10.1177/0363546517751912>.
 18. Pennock AT, Bomar JD, Johnson KP, Randich K, Upasani VV. Nonoperative management of femoroacetabular impingement: a prospective study. *Am J Sports Med.* 2018;46(14):3415–22. <https://doi.org/10.1177/0363546518804805> **Prospective study evaluating the effect of nonoperative management for the treatment of FAI in a young athletic cohort. A majority of patients, 82%, could be managed nonoperatively with similar outcomes at 2 years. This demonstrated that nonoperative management should be first-line therapy in young athletic patients with symptomatic FAI.**
 19. Espinosa N, Beck M, Rothenfluh DA, Ganz R, Leunig M. Treatment of femoroacetabular impingement: preliminary results of labral refixation. Surgical technique. *J Bone Joint Surg Am.* 2007;89(Suppl 2 Pt.1):36–53. <https://doi.org/10.2106/JBJS.F.01123>.
 20. Laude F, Soriali E, Nogier A. Femoroacetabular impingement treatment using arthroscopy and anterior approach. *Clin Orthop.* 2009;467(3):747–52. <https://doi.org/10.1007/s11999-008-0656-y>.
 21. Matsuda DK, Carlisle JC, Arthurs SC, Wierks CH, Philippon MJ. Comparative systematic review of the open dislocation, mini-open, and arthroscopic surgeries for femoroacetabular impingement. *Arthrosc J Arthrosc Relat Surg.* 2011;27(2):252–69. <https://doi.org/10.1016/j.arthro.2010.09.011>.
 22. Reiman MP, Peters S, Sylvain J, Hagymasi S, Mather RC, Goode AP. Femoroacetabular impingement surgery allows 74% of athletes to return to the same competitive level of sports participation but their level of performance remains unreported: a systematic review with meta-analysis. *Br J Sports Med.* 2018;52(15):972–81. <https://doi.org/10.1136/bjsports-2017-098696> **Systematic review of 35 studies on return to sport following surgery in patients with FAI. Few studies (37%) clearly distinguished return to sport and return to sport to preinjury level. This makes it impossible to clearly state whether surgery for symptomatic FAI will return patients to pre-injury sport performance.**
 23. Memon M, Kay J, Hache P, Simunovic N, Harris JD, O'Donnell J, et al. Athletes experience a high rate of return to sport following hip arthroscopy. *Knee Surg Sports Traumatol Arthrosc.* 2019;27(10):3066–104. <https://doi.org/10.1007/s00167-018-4929-z>.
 24. Casartelli NC, Leunig M, Maffiuletti NA, Bizzini M. Return to sport after hip surgery for femoroacetabular impingement: a systematic review. *Br J Sports Med.* 2015;49(12):819–24. <https://doi.org/10.1136/bjsports-2014-094414>.
 25. Kuhns BD, Weber AE, Batko B, Nho SJ, Stegemann C. A four-phase physical therapy regimen for returning athletes to sport following hip arthroscopy for femoroacetabular impingement with routine capsular closure. *Int J Sports Phys Ther.* 2017;12(4):683–96.
 26. Hallberg S, Sansone M, Augustsson J. Full recovery of hip muscle strength is not achieved at return to sports in patients with femoroacetabular impingement surgery. *Knee Surg Sports Traumatol Arthrosc.* 2018;1–7. <https://doi.org/10.1007/s00167-018-5337-0>.
 27. Weber AE, Kuhns BD, Cvetanovich GL, Grzybowski JS, Salata MJ, Nho SJ. Amateur and recreational athletes return to sport at a high rate following hip arthroscopy for femoroacetabular impingement. *Arthrosc J Arthrosc Relat Surg.* 2017;33(4):748–55. <https://doi.org/10.1016/j.arthro.2016.10.015>.
 28. Levy DM, Kuhns BD, Frank RM, Grzybowski JS, Campbell KA, Brown S, et al. High rate of return to running for athletes after hip arthroscopy for the treatment of femoroacetabular impingement and capsular plication. *Am J Sports Med.* 2017;45(1):127–34. <https://doi.org/10.1177/0363546516664883>.
 29. Siebenrock KA, Ferner F, Noble PC, Santore RF, Werlen S, Mamisch TC. The cam-type deformity of the proximal femur arises in childhood in response to vigorous sporting activity. *Clin Orthop.* 2011;469(11):3229–40. <https://doi.org/10.1007/s11999-011-1945-4>.
 30. Harris JD, Gerrie BJ, Varner KE, Lintner DM, McCulloch PC. Radiographic prevalence of dysplasia, cam, and pincer deformities in elite ballet. *Am J Sports Med.* 2016;44(1):20–7. <https://doi.org/10.1177/0363546515601996>.
 31. Gerhardt MB, Romero AA, Silvers HJ, Harris DJ, Watanabe D, Mandelbaum BR. The prevalence of radiographic hip abnormalities in elite soccer players. *Am J Sports Med.* 2012;40(3):584–8. <https://doi.org/10.1177/0363546511432711>.
 32. Kapron AL, Peters CL, Aoki SK, Beckmann JT, Erickson JA, Anderson MB, et al. The prevalence of radiographic findings of structural hip deformities in female collegiate athletes. *Am J Sports Med.* 2015;43(6):1324–30. <https://doi.org/10.1177/0363546515576908>.
 33. Locks R, Utsunomiya H, Briggs KK, McNamara S, Chahla J, Philippon MJ. Return to play after hip arthroscopic surgery for femoroacetabular impingement in professional soccer players. *Am J Sports Med.* 2018;46(2):273–9. <https://doi.org/10.1177/0363546517738741>.
 34. Chahla J, Sherman B, Philippon MJ, Gerhardt M. Hip injuries in kicking athletes. *Oper Tech Sports Med.* 2019;27(3):138–44. <https://doi.org/10.1053/j.otsm.2019.04.006>.
 35. Begly JP, Buckley PS, Utsunomiya H, Briggs KK, Philippon MJ. Femoroacetabular impingement in professional basketball players: return to play, career length, and performance after hip arthroscopy. *Am J Sports Med.* 2018;46(13):3090–6. <https://doi.org/10.1177/0363546518801320>.
 36. Klingenstein GG, Martin R, Kivlan B, Kelly BT. Hip injuries in the overhead athlete. *Clin Orthop.* 2012;470(6):1579–85. <https://doi.org/10.1007/s11999-012-2245-3>.
 37. Frank RM, Ukwuani G, Allison B, Clapp I, Nho SJ. High rate of return to yoga for athletes after hip arthroscopy for femoroacetabular impingement syndrome. *Sports Health.* 2018;10(5):434–40. <https://doi.org/10.1177/1941738118757406>.
 38. Nwachukwu BU, Bedi A, Premkumar A, Draovitch P, Kelly BT. Characteristics and outcomes of arthroscopic femoroacetabular impingement surgery in the National Football League. *Am J Sports Med.* 2018;46(1):144–8. <https://doi.org/10.1177/0363546517729163>.
 39. Menge TJ, Bhatia S, McNamara SC, Briggs KK, Philippon MJ. Femoroacetabular impingement in professional football players: return to play and predictors of career length after hip arthroscopy. *Am J Sports Med.* 2017;45(8):1740–4. <https://doi.org/10.1177/0363546517700118>.
 40. Schallmo MS, Fitzpatrick TH, Yancey HB, Marquez-Lara A, Luo TD, Stubbs AJ. Return-to-play and performance outcomes of professional athletes in North America after hip arthroscopy from 1999 to 2016. *Am J Sports Med.* 2018;46(8):1959–69. <https://doi.org/10.1177/0363546518773080>.
 41. Boykin RE, McFeely ED, Ackerman KE, Yen Y-M, Nasreddine A, Kocher MS. Labral injuries of the hip in rowers. *Clin Orthop.* 2013;471(8):2517–22. <https://doi.org/10.1007/s11999-013-3109-1>.

42. Byrd JWT, Jones KS. Hip arthroscopy in high-level baseball players. *Arthrosc J Arthrosc Relat Surg*. 2015;31(8):1507–10. <https://doi.org/10.1016/j.arthro.2015.03.002>.
43. Jack RA, Sochacki KR, Hirase T, Vickery J, McCulloch P, Lintner DM, et al. Performance and return to sport after hip arthroscopic surgery in Major League Baseball players. *Orthop J Sports Med*. 2019;7(2):2325967119825835. <https://doi.org/10.1177/2325967119825835>.
44. Newman JT, Saroki AJ, Briggs KK, Philippon MJ. Return to elite level of play and performance in professional golfers after arthroscopic hip surgery. *Orthop J Sports Med*. 2016;4(4):2325967116643532. <https://doi.org/10.1177/2325967116643532>.
45. Stone AV, Beck EC, Nho SJ. Hip injuries in endurance athletes: the runner and cyclist. *Oper Tech Sports Med*. 2019;27(3):119–22. <https://doi.org/10.1053/j.otsm.2019.04.003>.
46. Chen AW, Craig MJ, Yuen LC, Ortiz-Declet V, Maldonado DR, Domb BG. Five-year outcomes and return to sport of runners undergoing hip arthroscopy for labral tears with or without femoroacetabular impingement. *Am J Sports Med*. 2019;47(6):1459–66. <https://doi.org/10.1177/0363546519836429>.
47. Frank RM, Ukwuani G, Clapp I, Chahla J, Nho SJ. High rate of return to cycling after hip arthroscopy for femoroacetabular impingement syndrome. *Sports Health*. 2018;10(3):259–65. <https://doi.org/10.1177/1941738117747851>.
48. Frank RM, Ukwuani G, Chahla J, Batko B, Bush-Joseph CA, Nho SJ. High rate of return to swimming after hip arthroscopy for femoroacetabular impingement. *Arthrosc J Arthrosc Relat Surg*. 2018;34(5):1471–7. <https://doi.org/10.1016/j.arthro.2017.11.030>.
49. Riff AJ, Ukwuani G, Clapp I, Movassaghi K, Kelly DM, Nho SJ. High rate of return to high-intensity interval training after arthroscopic management of femoroacetabular impingement syndrome. *Am J Sports Med*. 2018;46(11):2594–600. <https://doi.org/10.1177/0363546518776638>.
50. Litrenta J, Mu B, Ortiz-Declet V, et al. Hip arthroscopy successfully treats femoroacetabular impingement in adolescent athletes. *J Pediatr Orthop*. 2019. <https://doi.org/10.1097/BPO.0000000000001411> **Retrospective review of young athletic patients treated arthroscopically for symptomatic FAI with high rate of follow-up at 2 years. Most patients (84%) returned to sport by 2 years post-operatively with 76.5% reported a similar level of competitive ability as one year before surgery.**
51. Gwathmey FW, Lewis D. Femoroacetabular impingement in the adolescent athlete. *Oper Tech Sports Med*. 2019;27(3):152–8. <https://doi.org/10.1053/j.otsm.2019.04.008>.
52. Ishøi L, Thorborg K, Kraemer O, Hölmich P. The association between specific sports activities and sport performance following hip arthroscopy for femoroacetabular impingement syndrome: a secondary analysis of a cross-sectional cohort study including 184 athletes. *J Hip Preserv Surg*. 2019;6(2):124–33. <https://doi.org/10.1093/jhps/hnz017>.
53. Lovett-Carter D, Jawanda AS, Hannigan A. Meta-analysis of the surgical and rehabilitative outcomes of hip arthroscopy in athletes with femoroacetabular impingement. *Clin J Sport Med*. 2018. <https://doi.org/10.1097/JSM.0000000000000623> **Meta-analysis of 15 studies and 823 patients on return to sport after hip arthroscopy for symptomatic FAI. 88.3% returned to sport and 85.3% returned to pre-injury level. The severity of intra-articular damage affected the return to sport ability of patients included in the meta-analysis.**
54. Frangiamore SJ, Mannava S, Briggs KK, McNamara S, Philippon MJ. Career length and performance among professional baseball players returning to play after hip arthroscopy. *Am J Sports Med*. 2018;46(11):2588–93. <https://doi.org/10.1177/0363546518775420>.
55. McDonald JE, Herzog MM, Philippon MJ. Performance outcomes in professional hockey players following arthroscopic treatment of FAI and microfracture of the hip. *Knee Surg Sports Traumatol Arthrosc*. 2014;22(4):915–9. <https://doi.org/10.1007/s00167-013-2691-9>.
56. Thomas Byrd JW, Jones KS. Hip arthroscopy in athletes: 10-year follow-up. *Am J Sports Med*. 2009;37(11):2140–3. <https://doi.org/10.1177/0363546509337705>.
57. Byrd JWT, Jones KS, Bardowski EA. Influence of Tönnis grade on outcomes of arthroscopy for FAI in athletes: a comparative analysis. *J Hip Preserv Surg*. 2018;5(2):162–5. <https://doi.org/10.1093/jhps/hny011>.
58. Degen RM, Pan TJ, Chang B, Mehta N, Chamberlin PD, Ranawat AS, et al. Risk of failure of primary hip arthroscopy—a population-based study. *J Hip Preserv Surg*. 2017;4(3):214–23. <https://doi.org/10.1093/jhps/hnx018>.
59. Malviya A, Raza A, Jameson S, James P, Reed MR, Partington PF. Complications and survival analyses of hip arthroscopies performed in the National Health Service in England: a review of 6,395 cases. *Arthrosc J Arthrosc Relat Surg*. 2015;31(5):836–42. <https://doi.org/10.1016/j.arthro.2014.12.013>.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.