Five-Year Outcomes and Return to Sport of Runners Undergoing Hip Arthroscopy for Labral Tears With or Without Femoroacetabular Impingement

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Background: Recent evidence has demonstrated a high rate of return to running after hip arthroscopy for femoroacetabular impingement at short-term follow-up. The midterm outcomes and rates of continued running of these patients are unknown.

Purpose: To evaluate midterm rates of return to running and outcomes after hip arthroscopy.

Study Design: Case series; Level of evidence, 4.

Methods: Data were prospectively collected for patients who underwent hip preservation surgery between July 2008 and November 2011. Patients were excluded for preoperative Tönnis osteoarthritis grade $\geq$2, previous ipsilateral hip conditions or hip surgery, or workers' compensation status. All patients who participated in mid- to long-distance running before their surgery and intended on returning after their operation were considered for inclusion. Preoperative and minimum 5-year postoperative measures for the following patient-reported outcome scores (PROs) were necessary for inclusion in the final cohort: the modified Harris Hip Score, Non-arthritic Hip Score, Hip Outcome Score–Sports Specific Subscale, and visual analog scale (VAS) for pain. All patients were counseled about the risks of continued running after hip arthroscopy.

Results: Sixty patients (62 hips) were eligible for inclusion, of which 50 (83.3%; 52 hips) had minimum 5-year follow-up. There were 10 male hips and 42 female hips. Mean $\pm$ SD age at surgery was 32.4 $\pm$ 12.4 years (range, 14.9-62.4), and mean body mass index was 22.9 $\pm$ 3.2 (range, 17.7-30.1). Latest follow-up was recorded at a mean 69.3 $\pm$ 8.5 months (range, 60.0-92.1 months). Level of competition included 39 recreational, 7 high school, 4 collegiate, and 2 professional athletes. There were significant improvements in all PROs and VAS scores preoperatively to latest follow-up. Mean modified Harris Hip Score improved from 67.5 to 88.2; mean Non-arthritic Hip Score, from 65.9 to 88.3; mean Hip Outcome Score–Sports Specific Subscale, from 49.5 to 81.0; and mean VAS, from 5.2 to 1.5. At latest follow-up, patient satisfaction was 8.4. Thirty-nine patients (78.0%, 41 hips) had returned to running postoperatively. When stratified by level of competition, 79% (31 of 39) of recreational, 100% (7 of 7) of high school, 50% (2 of 4) of collegiate, and 50% (1 of 2) of professional athletes returned to running.

Conclusion: Hip arthroscopy for all levels of runners is associated with a significant increase in PROs and a low risk of complications. The rate of return to running is moderately high after hip arthroscopy at midterm follow-up. Hip arthroscopy may be considered for runners presenting with symptoms of femoroacetabular impingement that fail nonoperative treatments. Patients should be educated on the rate of return to running over time and the risks of continued running after hip arthroscopy.

Keywords: hip arthroscopy; femoroacetabular impingement; FAI; return to sport; running; patient-reported outcomes

Running is a common exercise activity for many people, with an estimated 45 million runners in the United States.[21] It has a low cost of entry and is a common choice among people looking to start exercising.[28] Despite its atraumatic nature, injury rates range from 37% to 56% and are often associated with increased running mileage, a faster pace, or an increased number of running days per week.[10,14,31,32] Forty-seven percent of runners report experiencing an injury in the past 2 years, and those injured have a higher risk for reinjury.[14,32] Fifty percent to 75% of these injuries are thought to be overuse injuries, given the repetitive nature of running.[31] The most common lower extremity injuries include medial tibial stress syndrome, Achilles tendinopathy, and plantar fasciitis.[18,31] Seventy percent of runners will seek medical treatment, so the ability to accurately diagnosis and treat running-related injuries is essential for the practicing orthopaedic surgeon.[14]

The American Journal of Sports Medicine
1–8
DOI: 10.1177/0363546519836429

Hip injuries associated with running include muscle strains of the biceps femoris and rectus femoris, iliotibial band syndrome, greater trochanter bursitis, femoral neck stress fractures, snapping hip syndrome, and intra-articular pathology, including labral tears.[24] With the increased prevalence of hip arthroscopy, more attention has been paid to the surgical management of extra- and intra-articular pathology, especially femoroacetabular impingement (FAI). Endoscopic management of snapping caused by the iliotibial band and iliopsoas has shown good outcomes while allowing associated intra-articular pathology to be addressed.[4,13,15,16,25] Additionally, running may exacerbate prior hip instability, resulting in labral tearing and ligamentum teres disruption, especially in the setting of acetabular dysplasia.[12]

Hip arthroscopy has been demonstrated in the literature to be an excellent treatment option for intra- and extra-articular hip pathology. Multiple studies showed improvements in patient-reported outcome scores (PROs) and high rates of return to sport (RTS) at short-term follow-up. These studies included athletes from many sports, with RTS rates of 80% for all athletes and 90% for professionals.[1,6-8,33] Levy et al[17] showed an RTS rate of 94% among runners after hip arthroscopy, with a decrease in miles run after the procedure but improvement in PROs at 2-year follow-up. While these studies described high rates of RTS at the same level of competition, documented subjective ability level is lacking.

Running is generally considered a high-impact activity, with forces across the joint increased by >5 times the body weight.[30] Therefore, we counsel patients on the risks of running after hip arthroscopy and that avoidance of any painful activities may be best for the long-term health of their hips. Furthermore, we suggest that lower-impact activities, such as cycling and swimming, may be better tolerated than impact activities. On the basis of this information, some patients may decide not to return to running, despite being physically capable.

As the demands of each sport are quite different, there is a strong need for sport-specific hip arthroscopy outcome studies. These studies will help guide athletes and providers when choosing a treatment plan that maximizes the chances of RTS. The purpose of this study is to present 5-year PROs and RTS data for a population of professional, amateur, and recreational runners.

METHODS

Patient Selection Criteria

Data were prospectively collected and retrospectively reviewed for all patients who underwent primary hip arthroscopy by the senior author (B.G.D.) between July 2008 and November 2011. Patients who met any of the following criteria were excluded from our study: preoperative Tönnis osteoarthritis grade ≥2, previous ipsilateral hip conditions or hip surgery, or workers' compensation status. All patients who participated in mid- to long-distance running (1-5 and >5 miles per day, respectively) before their surgery and underwent hip arthroscopy with the aspiration of returning to running were considered for inclusion. The patients from this group who had preoperative and minimum 5-year postoperative measures for the following PRO scores were included in our final cohort: the modified Harris Hip Score (mHHS), Non-arthritic Hip Score (NAHS), Hip Outcome Score–Sports Specific Subscale (HOS-SSS), and visual analog scale (VAS) for pain. All patients participated in the American Hip Institute Hip Preservation Registry. While the present study represents a unique analysis, data on some patients in this study may have been reported in other studies. All data collection received institutional review board approval.

Indications for Surgery

A detailed patient history, physical examination, and radiographic analysis were conducted for all surgical candidates. Gait, range of motion, strength, points of tenderness, and signs of impingement or mechanical symptoms (snapping, catching, locking) were noted during physical examination. Patients were assessed for signs of FAI, acetabular version, dysplasia, and Tönnis osteoarthritis grade with a series of preoperative radiographs (standing and supine anteroposterior pelvis, false-profile, modified Dunn, and cross-table lateral). Magnetic resonance arthrography was used to diagnose intra-articular injuries, such as labral tears and chondral damage. Before being recommended for surgery, all patients had pain interfering with the activities of daily living for at least 3 months and failed to improve with activity modification, nonsteroidal

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One or more of the authors has declared the following potential conflict of interest or source of funding: A.W.C. has received educational support from Arthrex and Smith & Nephew, hospitality payments from Arthrex and Stryker, and research support from Arthrex and DJO. V.O.D. has received educational funding from SeaPearl, research support from Arthrex, and hospitality payments from Stryker and Tornier. B.G.D. has ownership interests in Hinsdale Orthopedic Associates, the American Hip Institute, SCD#3, North Shore Surgical Suites, and Munster Specialty Surgery Center; has received research support from Arthrex, ATI, Kaufman Foundation, and Pacira Pharmaceuticals; has received consulting fees from Adventist Hinsdale Hospital, Arthrex, MAKO, Medacta, Pacira Pharmaceuticals, and Stryker; has received educational support from Arthrex, Breg, and Medwest; has received royalties from Arthrex, DJO Global, MAKO Surgical, Stryker, and Orthomerica; has received speaking fees from Arthrex and Pacira Pharmaceuticals; and has received travel and lodging from Arthrex, Medacta, and Stryker. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

anti-inflammatory drugs, cortisone injections, and physical therapy. All patients were counseled on the risks of continued running after hip arthroscopy.

Surgical Technique

All hip arthroscopies were performed by the senior surgeon (B.G.D.), with the patient placed in the modified supine position on a traction table with a well-padded perineal post. The joint was accessed through the standard anterolateral and midanterior accessory portals, and a capsulotomy was performed with a beaver blade. Once the scope was inside of the joint, a routine diagnostic arthroscopy was conducted to evaluate the condition of the ligamentum teres, intra-articular cartilage, and labrum. The capsule was then elevated from the labrum with electrocautery. A 5.5-mm round bur was used to address any bony deformities of the acetabulum and femoral neck as indicated by preoperative findings and fluoroscopic guidance. The ligamentum teres was debrided in the case of a tear, and an iliopsoas fractional lengthening was performed for patients with painful internal snapping or an iliopsoas impingement lesion. Full-thickness chondral defects were treated with microfracture. Labral tears were repaired, resected, debrided, or reconstructed with a hamstring allograft to achieve stability. The capsule was then repaired, plicated, or released depending on the Beighton score and acetabular coverage. Any trochanteric or gluteus medius pathologies were addressed with the posterolateral and accessory distal lateral portals.

Rehabilitation

Patients were fitted for an X-Act ROM Brace (DJO Global Vista) and instructed to use crutches with toe-touch weightbearing for 2 weeks. Physical therapy was to be started the day after surgery. Postoperative treatment plans were tailored for any patients who underwent labral reconstruction, gluteus medius repair, or microfracture.

Outcomes Evaluation

PROs were collected for all patients preoperatively and postoperatively at 3 months, 12 months, and annually thereafter. Each patient had preoperative and minimum 5-year postoperative measures for the mHHS, NAHS, HOS-SSS, and VAS for pain. All PROs were scored from 0 to 100, with 100 representing the best possible outcome. VAS was scaled from 0 to 10 (no pain to worst possible pain), and patient satisfaction was rated 0 to 10 (not satisfied to extremely satisfied). Postoperative complications, second-look arthroscopies, and conversions to total hip arthroplasty were also recorded.

Statistical Analysis

All statistical analysis was performed with Microsoft Excel. The data were evaluated for normality and equal variance with the Shapiro-Wilk and F tests, respectively. All parametric continuous data were compared with a 2-tailed Student t test, and all nonparametric continuous data were compared with a Wilcoxon signed-rank test. Categorical data were assessed with the chi-square and Fisher exact tests.

TABLE 1
Patient Characteristics

	n (%) or Mean ± SD (Range)
Hips[a]	52
Left	20 (38.5)
Right	32 (61.5)
Sex	
Male	10 (19.2)
Female	42 (80.8)
Age at surgery, y	32.4 ± 12.4 (14.9-62.4)
Body mass index	22.9 ± 3.2 (17.7-30.1)
Follow-up, mo	69.3 ± 8.5 (60.0-92.1)

[a]Patients with follow-up, n = 50 (83.3%).

RESULTS

Patient Characteristics

A total of 60 patients (62 hips) were eligible for inclusion in our study, of which 50 (83.3%; 52 hips) had minimum 5-year follow-up. There were 10 male hips and 42 female hips. Mean ± SD age at surgery was 32.4 ± 12.4 years (range, 14.9-62.4), and mean body mass index was 22.9 ± 3.2 (range, 17.7-30.1). Latest follow-up was recorded at a mean 69.3 ± 8.5 months postoperatively (range, 60.0-92.1 months). There were 39 recreational athletes, 7 high school athletes, 4 college athletes, and 2 professional athletes. All patient characteristics are summarized in Table 1.

Intraoperative Findings

Table 2 summarizes the findings revealed during diagnostic arthroscopy. Labral tears were characterized with the Seldes classification system. There were 22 (42.3%) type 1 tears, 17 (32.7%) type 2 tears, and 12 (23.1%) combined type 1 and 2 tears. The cartilage was assessed with the acetabular labrum articular disruption (ALAD) and Outerbridge classification systems. Thirty-one (59.6%) hips had ALAD defects $\geq$2; 27 (51.9%) had acetabular Outerbridge defects $\geq$2; and 9 (17.3%) had femoral head Outerbridge defects $\geq$2. Ligamentum teres tears were evaluated with the Domb and Villar classification systems. There were 25 (48.1%) hips with ligamentum teres tears.

Arthroscopic Procedures

The majority of patients were treated with labral repair (67.3%), acetabuloplasty (75.0%), and femoroplasty (51.9%). Debridement of the ligamentum teres was performed in 24 (46.2%) hips and iliopsoas fractional lengthening in 23 (44.2%) hips. The capsule was repaired or plicated in 31

TABLE 2
Intraoperative Findings[a]

	n (%)
Seldes tear type	
0	1 (1.9)
1	22 (42.3)
2	17 (32.7)
1 and 2	12 (23.1)
ALAD	
0	5 (9.6)
1	16 (30.8)
2	20 (38.5)
3	8 (15.4)
4	3 (5.8)
Outerbridge: acetabular	
0	3 (5.8)
1	22 (42.3)
2	14 (26.9)
3	9 (17.3)
4	4 (7.7)
Outerbridge: femoral head	
0	43 (82.7)
1	0 (0)
2	1 (1.9)
3	1 (1.9)
4	7 (13.5)
LT percentile class (Domb)	
0: 0%	27 (51.9)
1: >0% to <50%	15 (28.8)
2: 50% to <100%	10 (19.2)
3: 100%	0 (0)
LT grade (Villar)	
0: No tear	27 (51.9)
1: Complete Rupture	0 (0)
2: Partial Tear	24 (46.2)
3: Degenerate Tear	1 (1.9)

[a]ALAD, acetabular labrum articular disruption; LT, ligament teres.

TABLE 3
Procedures

	n (%)
Labral treatment	
Repair	35 (67.3)
Debridement	13 (25.0)
Resection	3 (5.8)
Capsular treatment	
Repair/plication	31 (59.6)
Release	21 (40.4)
Acetabuloplasty	39 (75.0)
Femoroplasty	27 (51.9)
Ligamentum teres debridement	24 (46.2)
Iliopsoas fractional lengthening	23 (44.2)
Acetabular chondroplasty	16 (30.8)
Femoral head chondroplasty	4 (7.7)
Synovectomy	8 (15.4)
Removal of loose body	5 (9.6)
Trochanteric bursectomy	5 (9.6)
Gluteus medius/minimus repair	1 (1.9)
Acetabular microfracture	1 (1.9)
Femoral head microfracture	2 (3.8)

(59.6%) hips and released in 21 (40.4%). All additional arthroscopic procedures are detailed in Table 3.

Outcomes at Latest Follow-up

There were significant improvements in all PROs and VAS scores preoperatively to latest follow-up: mean mHHS, from 67.5 to 88.2; mean NAHS, from 65.9 to 88.3; mean HOS-SSS, from 49.5 to 81.0; and mean VAS, from 5.2 to 1.5. At latest follow-up, patient satisfaction was 8.4. All outcome scores at 2 and 5 years are summarized in Table 4. Table 5 depicts RTS stratified by surgical procedure.

TABLE 4
Patient Reported Outcomes[a]

PROs	Preoperative	Minimum 5-y Follow-up	*P* Value
mHHS	67.5 ± 12.1	88.2 ± 12.5	<.0001
NAHS	65.9 ± 16.4	88.3 ± 11.4	<.0001
HOS-SSS	49.5 ± 21.0	81.0 ± 19.0	<.0001
iHOT		79.6 ± 17.4	
SF-12			
Mental		57.3 ± 4.8	
Physical		51.9 ± 6.3	
VR-12			
Mental		62.5 ± 4.7	
Physical		53.5 ± 5.1	
VAS	5.2 ± 2.0	1.5 ± 1.6	<.0001
Patient satisfaction		8.4 ± 2.3	

[a]Values are presented as mean ± SD. HOS-SSS, Hip Outcome Score–Sports Specific Subscale; iHOT, International Hip Outcome Tool; mHHS, modified Harris Hip Score; NAHS, Non-arthritic Hip Score; PRO, patient-reported outcome; SF-12, 12-Item Short Form Health Survey; VAS, visual analog scale; VR-12, Veterans RAND 12-Item Health Survey.

Return to Running

Patients were allowed to return to running 3 months postoperatively after completing their course of physical therapy and demonstrating the ability to perform 30 consecutive single-legged squats with good stability. Of the 50 patients (52 hips) included in our study, 39 (78.0%; 41 hips) were able to return to running postoperatively. Of the 41 hips, 15 (36.6%) were less competitive; 20 (48.8%) returned to the preinjury level of competition; and 6 (14.6%) were more competitive. As for perceived ability to run versus preinjury levels, 13 (31.7%) felt as though they were at a lower level; 16 (39.0%) claimed that their ability returned to the same level; and 12 (29.3%) were able to run at a higher level. When stratified by return to previous level of competition, 79% (31 of 39) of recreational athletes returned, as compared with 100% (7 of 7) of high school athletes, 50% (2

TABLE 5
Return to Sport Stratified by Surgical Procedure[a]

	Patients Who Underwent Procedure, n (%)	
	Total	RTS
Labral treatment		
Repair	35 (67.3)	28 (80.0)
Debridement	13 (25.0)	10 (76.9)
Resection	3 (5.8)	3 (100)
None	1 (1.9)	0 (0)
Capsular treatment		
Repair/plication	31 (59.6)	24 (77.4)
Release	21 (40.4)	17 (81.0)
Acetabuloplasty	39 (75.0)	32 (82.1)
No acetabuloplasty	13 (25.0)	9 (69.2)
Femoroplasty	27 (51.9)	22 (81.5)
No femoroplasty	25 (48.1)	19 (76.0)
LT debridement	24 (46.2)	17 (70.8)
No LT treatment	28 (53.8)	24 (85.7)
IFL	23 (44.2)	18 (78.3)
No IFL	29 (55.8)	23 (79.3)
Acetabular chondroplasty	16 (30.8)	11 (68.8)
No acetabular chondroplasty	36 (69.2)	30 (83.3)
Femoral head chondroplasty	4 (7.7)	3 (75.0)
Synovectomy	8 (15.4)	7 (87.5)
Removal of loose body	5 (9.6)	3 (60.0)
Trochanteric bursectomy	5 (9.6)	5 (100)
Gluteus medius/minimus repair	1 (1.9)	1 (100)
Acetabular microfracture	1 (1.9)	0 (0)
Femoral head microfracture	2 (3.8)	2 (100)

[a]IFL, iliopsoas fractional lengthening; LT, ligamentum teres; RTS, return to sport.

TABLE 6
Level of Competition and Ability Pre- and Postoperatively Among Nonrecreational Athletes

Preoperative Competitive Level	5-y Postoperative Competitive Level	5-y Postoperative Ability Level
7 high school	2 less	1 higher, 1 lower
	3 same	2 same, 1 lower
	2 more	2 higher
2 college	1 less	Same
	1 same	Lower
1 professional	Same	Lower

of 4) of college athletes, and 50% (1 of 2) of professional athletes. The 10 nonrecreational athletes' competition and ability levels are detailed in Table 6.

Outcomes of Patients Who Did Not Return to Running

Significantly lower PROs were seen among the patients who did not return to running at latest follow-up (mHHS, 89.8 vs 79.8; NAHS, 89.2 vs 81.7; HOS-SSS, 85.9 vs 60.8; International Hip Outcome Tool, 80 vs 69.4) (Table 7). However, these patients also had lower preoperative scores that were significant or approached significance: mHHS, 61.0 vs 69.9 (P = .023); NAHS, 60.2 vs 68.0 (P = .164); HOS-SSS, 41.3 vs 53.3 (P = .104). These differences in pre- and postoperative scores accounted for the insignificant differences in the delta, or change, in pre- to postoperative PROs. VAS scores significantly improved for both groups of patients, and patient satisfaction was not significantly different.

Complications, Secondary Arthroscopies, and Conversions to Total Hip Arthroplasty

Postoperatively, there was 1 (1.9%) case of foot numbness and 1 (1.9%) case of a pulmonary embolism. Seven hips underwent secondary arthroscopy: 5 (13.5%) for continued pain at a mean 29.0 ± 22.6 months and 2 for new injuries. Of the 2 new injuries, 1 patient initially returned to sport after the first surgical procedure but reinjured the hip performing gymnastics on the uneven bar event, while the other patient reinjured the operative hip at 3 months postoperatively while doing a rotational single-legged exercise with a medicine ball. Overall, of the 7 patients who underwent a second procedure, 4 (57.1%) were able to return to running. Two of these patients returned to sport both before and after their second surgical procedure. The other 2 patients were able to return only after the second procedure. Revision procedures included femoroplasty (6 patients), removal of loose body (4 patients), capsular release (3 patients), labral repair (3 patients), iliopsoas bursectomy and fractional lengthening (2 patient), capsular plication (2 patients), excision of heterotopic ossification (1 patient), labral debridement (1 patient), and microfracture (1 patient). One patient (1.9%) converted to total hip arthroplasty at 34.9 months. At the time of arthroscopy, this patient had acetabular cartilage damage consistent with ALAD 3 and Outerbridge 3 as well as femoral head chondromalacia of Outerbridge 2.

DISCUSSION

The purpose of this study was to report minimum 5-year outcomes, RTS, and ability level among runners who underwent hip arthroscopy. A total of 52 hips among 50 runners had ≥5-year follow-up and were included in this study. All PROs and VAS scores were significantly higher at 5 years postoperatively than preoperatively (P < .001). Satisfaction at latest follow-up was 8.4. Five hips (9.6%) required secondary arthroscopies for persistent pain, and 2 (3.8%) required secondary arthroscopy for new injuries. There was 1 conversion to total hip arthroplasty. The RTS rate at minimum 5-year follow-up was 79%.

Running was shown to increase the hip joint load by up to 5.2 times the body weight.[30] FAI was also shown to increase contact pressures at the acetabular cartilage in addition to increasing the maximum shear stress on bone.[23] While FAI may make it more difficult to RTS in the short term, long-term effects include an increased risk for development of osteoarthritis.[11,27] Additionally, patients are counseled on the risks of running after hip

TABLE 7
Comparison of PROs Between Patients Who Did and Did Not Return to Sport[a]

	Return to Sport		
	Yes	No	*P* Value
mHHS			
Preoperative	69.9 ± 11.7	61.0 ± 12.1	.023
Latest	89.8 ± 11.0	79.8 ± 15.4	.026
P value	<.001	.016	
Δ	19.9 ± 14.8	18.8 ± 21.5	.837
NAHS			
Preoperative	68.0 ± 15.5	60.2 ± 19.2	.164
Latest	89.2 ± 11.4	81.7 ± 13.0	.021
P value	<.001	.056	
Δ	21.2 ± 18.5	21.5 ± 27.3	.961
HOS-SSS			
Preoperative	53.3 ± 20.7	41.3 ± 23.9	.104
Latest	85.9 ± 14.9	60.8 ± 19.9	<.001
P value	<.001	.069	
Δ	32.7 ± 23.1	19.6 ± 31.9	.131
VAS			
Preoperative	5.1 ± 2.0	5.6 ± 2.2	.494
Latest	1.3 ± 1.5	2.0 ± 1.9	.314
P value	<.001	.004	
Δ	–3.7 ± 2.2	–3.7 ± 3.2	.529
iHOT	80.0 ± 18.5	69.4 ± 19.8	.046
Patient satisfaction	8.5 ± 2.1	7.7 ± 2.9	.860

[a]Values are presented as mean ± SD. HOS-SSS, Hip Outcome Score–Sports Specific Subscale; iHOT, International Hip Outcome Tool; mHHS, modified Harris Hip Score; NAHS, Non-arthritic Hip Score; PRO, patient-reported outcome; VAS, visual analog scale.

arthroscopy and that avoidance of painful activities may be best for the long-term health of their hips. Lower-impact activities, such as cycling and swimming, are also suggested. Therefore, while the pathologic processes of the hip may greatly limit a runner's ability to RTS, some patients decide not to return to running, despite being physically capable. Our data can be used to help guide runners and surgeons considering hip arthroscopy regarding the overall outcomes and likelihood of RTS.

Multiple studies examined RTS among athletes of all sports and competition levels after hip arthroscopy. A review by Casartelli et al[7] that included >1000 athlete hips treated surgically for FAI demonstrated an 82% RTS at the same level with no difference between open and arthroscopic procedures. Malviya et al[19] showed a 73% RTS among recreational athletes, 88% among professional athletes, and 90% among high school athletes at 1.4-year follow-up (range, 1.4-1.8 years). Byrd and Jones[5] demonstrated an RTS of 95% among professional athletes and 85% among collegiate athletes at a mean 19 months (range, 12-60 months). Sansone et al[26] showed an RTS of 73% with a 52% rate of return to the same level of play among top-level athletes (Hip Sports Activity Scale level 7 or 8) at 1-year follow-up. Weber et al[33] showed similar rates of return between high-level amateurs and recreational athletes, 88% vs 94%, at 2-year follow-up.

Sport-specific cohorts have been examined. Byrd and Jones[6] studied a population of intercollegiate and professional baseball players and showed a 95% rate of RTS, with 90% returning to their previous levels of competition at a mean 4.3 months after surgery. McDonald et al[20] demonstrated that 82% of professional hockey players RTS after hip arthroscopy. However, there was a trend toward decreased games played and points scored. Amenabar and O'Donnell[1] showed a 96% rate of RTS in their population of professional Australian rules football players, with 62% of patients playing at last follow-up (mean, 52.5 months).

There have been limited data focusing on how runners do after hip arthroscopy. In a survey of high-volume hip arthroscopists, Domb et al[9] demonstrated that running was considered a medium-risk sport for RTS after hip arthroscopy. Levy et al[17] looked at a population of 51 competitive or recreational runners and demonstrated an RTS rate of 94% for all runners with 2-year follow-up. In addition, 100% of competitive runners in their population were able to RTS, with 64% returning at the same level or better; 88% of recreational runners were also able to RTS. We demonstrated an RTS rate of 78% for all runners. Although our RTS rate is lower than that of Levy et al,[17] our data represent 5-year outcomes versus 2-year outcomes, suggesting that RTS levels may decrease over time. There are a few important differences between the populations. Ours contained 7 patients with Tönnis grade 1 changes, while Levy et al[17] had patients with only Tönnis grade 0. Additionally, 75% of our athletes identified as recreational runners, as compared with 51% in the Levy et al[17] study.

It is important to remember that the decision to RTS is complicated. Not only does each sport place different physical demands on athletes, but different levels of competition result in different motivations for returning. Professionals often have limited windows of play with considerable socioeconomic factors influencing the decision to RTS.[3,7,20] Recreational athletes may be more likely to alter their activity levels and transition from high- to low-demand activities, especially if recommended by their surgeons.[22] In our population, 7 of the 11 runners who did not RTS reported participating in lower-demand activities, including cycling, elliptical, and yoga. Multiple factors, such as self-motivation, aging, pain, encouragement from others, and adapting to new physical limitations, were also shown to be important to the decision to RTS.[29] It is an individual decision that each athlete must make. Unfortunately, the RTS measure does not always accurately reflect the complex nature of this decision. Objective measures—such as running pace or miles run per week, as Levy et al[17] calculated—may be more accurate markers of surgical success in the running population and should be evaluated going forward.

In addition to RTS data, we looked at PROs at 5 years. Our runners showed significant improvements in mean mHHS (from 67.5 to 88.2), mean NAHS (from 65.9 to 88.3), mean HOS-SSS (from 49.5 to 81.0), and mean VAS (from 5.2 to 1.5), with overall patient satisfaction of 8.4. Our data are comparable with the 2-year follow-up results seen by Levy et al,[17] who showed improvements of mean mHHS from 62.0 to 79.7 and mean HOS-SSS from 47.7 to 83.7.

The changes in PROs seen among runners compare with those of other athletes. Weber et al[33] showed increases in mHHS scores from 60.5 to 78.9 ($P < .001$) among recreational athletes and 58.8 to 78.3 among high-level athletes ($P < .001$). Brunner et al[2] demonstrated an increase in NAHS from 54.4 to 85.7 at a mean 2.4 years in a mixed population of athletes. Casartelli et al[7] showed improvements in HOS-SSS from 48 to 79 for all athletes.

Patient-reported levels of competition and ability were variable. Of the 10 nonrecreational runners, 3 were less competitive; 5 were the same; and 2 high school runners were at a higher level of competition. Ability levels varied similarly: 4 lower, 3 same, and 3 higher. Changes in level of competition can be deceptive in a 5-year study, as most high school and college careers are 4-year intervals. Thus, some athletes, regardless of injury or surgery, become "less competitive" if they do not continue competitive running once they graduate or move on from high school or college. It is not known whether the 2 high school runners and 1 college runner were less competitive because of life changes or issues related to their hips.

Patients who were unable to RTS demonstrated significantly lower PROs at latest follow-up. Patients in the Levy et al[17] study who had cartilage delamination showed a statistically significant decrease in HOS-SSS scores versus those who did not, 77.8 vs 89.1, and a trend toward lower HOS-ADL and mHHS scores. These data are comparable with work by Domb et al,[8] which showed significant decreases in PROs among patients unable to RTS versus those who did.

These data can be used to aid surgeons and educate athletes when considering surgical treatment with respect to postoperative expectations and chances of RTS. Runners should be cautioned that despite surgery, they may not be able to RTS, may return at a lower level of activity, or may have difficulty continuing to run as time passes.

Strengths

Our study has several strengths. First, our population of runners contains mixed levels of competition. Second, we were able to follow patients for a minimum of 5 years after surgery while collecting data on PROs and RTS.

Limitations

This study has the inherent limitations of a retrospective case series. The cohort is limited to patients who indicated participation in running, a possible selection bias. Responses about sport-related abilities were also self-reported, a possible source of reporting bias. We did not assess quantitative variables about running performance, such as miles run per week or pace. A single surgeon performed all procedures with a specific cohort of patients, which may limit the study's generalizability.

CONCLUSION

Hip arthroscopy for all levels of runners is associated with a significant increase in PROs and a low risk of complications. The rate of return to running is moderately high after hip arthroscopy at midterm follow-up. Hip arthroscopy should be considered for runners presenting with symptoms of FAI that fail nonoperative treatments; however, patients should be educated on the rates of return to running over time.

REFERENCES

1. Amenabar T, O'Donnell J. Return to sport in Australian football league footballers after hip arthroscopy and midterm outcome. *Arthroscopy*. 2013;29(7):1188-1194.
2. Brunner A, Horisberger M, Herzog RF. Sports and recreation activity of patients with femoroacetabular impingement before and after arthroscopic osteoplasty. *Am J Sports Med*. 2009;37(5):917-922.
3. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 2-year follow-up. *Arthroscopy*. 2000;16(6):578-587.
4. Byrd JWT. Evaluation and management of the snapping iliopsoas tendon. *Instr Course Lect*. 2006;55:347-355.
5. Byrd JWT, Jones KS. Arthroscopic management of femoroacetabular impingement in athletes. *Am J Sports Med*. 2011;39(1):7S-13S.
6. Byrd JWT, Jones KS. Hip arthroscopy in high-level baseball players. *Arthroscopy*. 2015;31(8):1507-1510.
7. 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):819-824.
8. Domb BG, Dunne KF, Martin TJ, et al. Patient reported outcomes for patients who returned to sport compared with those who did not after hip arthroscopy: minimum 2-year follow-up. *J Hip Preserv Surg*. 2016;3(2):124-131.
9. Domb BG, Stake CE, Finch NA, Cramer TL. Return to sport after hip arthroscopy: aggregate recommendations from high-volume hip arthroscopy centers. *Orthopedics*. 2014;37(10):e902-e905.
10. Gallo RA, Plakke M, Silvis ML. Common leg injuries of long-distance runners: anatomical and biomechanical approach. *Sports Health*. 2012;4(6):485-495.
11. Ganz R, Parvizi J, Beck M, Leunig M, Nötzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res*. 2003;417:112-120.
12. Guanche CA, Sikka RS. Acetabular labral tears with underlying chondromalacia: a possible association with high-level running. *Arthroscopy*. 2005;21(5):580-585.
13. Ilizaliturri VM, Camacho-Galindo J. Endoscopic treatment of snapping hips, iliotibial band, and iliopsoas tendon. *Sports Med Arthrosc Rev*. 2010;18(2):120-127.
14. Jacobs SJ, Berson BL. Injuries to runners: a study of entrants to a 10,000 meter race. *Am J Sports Med*. 1986;14(2):151-155.
15. Kelly BT, Williams RJ, Philippon MJ. Hip arthroscopy: current indications, treatment options, and management issues. *Am J Sports Med*. 2003;31(6):1020-1037.
16. Kroger EW, Griesser MJ, Kolovich GP, Ellis TJ. Efficacy of surgery for internal snapping hip. *Int J Sports Med*. 2013;34(10):851-855.
17. Levy DM, Kuhns BD, Frank RM, 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):127-134.
18. Lopes AD, Hespanhol Júnior LC, Yeung SS, Costa LOP. What are the main running-related musculoskeletal injuries? A systematic review. *Sports Med Auckl NZ*. 2012;42(10):891-905.
19. Malviya A, Paliobeis CP, Villar RN. Do professional athletes perform better than recreational athletes after arthroscopy for femoroacetabular impingement? *Clin Orthop Relat Res*. 2013;471(8):2477-2483.
20. 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):915-919.

21. Mucha MD, Caldwell W, Schlueter EL, Walters C, Hassen A. Hip abductor strength and lower extremity running related injury in distance runners: a systematic review. *J Sci Med Sport*. 2017;20(4):349-355.
22. Naal FD, Schär M, Miozzari HH, Nötzli HP. Sports and activity levels after open surgical treatment of femoroacetabular impingement. *Am J Sports Med*. 2014;42(7):1690-1695.
23. Ng KCG, Lamontagne M, Labrosse MR, Beaulé PE. Hip joint stresses due to cam-type femoroacetabular impingement: a systematic review of finite element simulations. *PloS One*. 2016;11(1):e0147813.
24. Paluska SA. An overview of hip injuries in running. *Sports Med Auckl NZ*. 2005;35(11):991-1014.
25. Rath E, Tsvieli O, Levy O. Hip arthroscopy: an emerging technique and indications. *Isr Med Assoc J IMAJ*. 2012;14(3):170-174.
26. Sansone M, Ahldén M, Jonasson P, et al. Good results after hip arthroscopy for femoroacetabular impingement in top-level athletes. *Orthop J Sports Med*. 2015;3(2):2325967115569691.
27. Tanzer M, Noiseux N. Osseous abnormalities and early osteoarthritis: the role of hip impingement. *Clin Orthop Relat Res*. 2004;429:170-177.
28. Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. A retrospective case-control analysis of 2002 running injuries. *Br J Sports Med*. 2002;36(2):95-101.
29. Tjong VK, Cogan CJ, Riederman BD, Terry MA. A qualitative assessment of return to sport after hip arthroscopy for femoroacetabular impingement. *Orthop J Sports Med*. 2016;4(11):23259 67116671940.
30. van den Bogert AJ, Read L, Nigg BM. An analysis of hip joint loading during walking, running, and skiing. *Med Sci Sports Exerc*. 1999;31(1):131-142.
31. van Mechelen W. Running injuries: a review of the epidemiological literature. *Sports Med Auckl NZ*. 1992;14(5):320-335.
32. Walter SD, Hart LE, McIntosh JM, Sutton JR. The Ontario cohort study of running-related injuries. *Arch Intern Med*. 1989;149(11):2561-2564.
33. 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. *Arthroscopy*. 2017;33(4):748-755.