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SYMPOSIUM: INJURIES IN OVERHEAD ATHLETES

Hip Injuries in the Overhead Athlete

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Abstract

Background The overhead athlete is at risk for shoulder and elbow injuries. However, the mechanics associated with overhead sports also place athletes at risk for hip injuries. Advancements in hip arthroscopy have identified femoroacetabular impingement (FAI) and instability as potential contributors to labral and chondral pathology in this athletic population.

Questions/purposes We therefore determined whether hip function improves after arthroscopic treatment of FAI in overhead athletes and the rate at which overhead athletes returned to preinjury level of play.

Methods We retrospectively identified high-level baseball and lacrosse players (varsity high school, collegiate, and professional) who underwent arthroscopic treatment for FAI. Thirty-four athletes with an average age of 21.4 years met study criteria. There were 16 baseball players and 18 lacrosse players. All patients completed modified Harris hip scores and were assessed for ability to return to preinjury level of play. The minimum followup was 12 months (average, 25 months; range 12–41 months).

Results Mean modified Harris hip scores improved from 70 to 92. Thirty-three of 34 patients were able to return to preinjury level of sports participation.

Conclusions Arthroscopic management of hip injuries in the high-level overhead throwing athlete can result in a high rate of return to play. Mechanical overload of the hip from impingement and secondary instability can have a substantial effect on hip function and may be the cause of deterioration in athletic performance in some cases.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
This work was performed at Hospital for Special Surgery.

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Introduction

While developmental and acquired hip pathomorphology are typically linked to pelvic girdle pain, altered hip mechanics may also lead to abnormal movement patterns in the overhead athlete. Although upper-extremity injuries receive far more attention, pathologic stress on the torso, shoulder, and elbow may originate in the hip. Studies of pitching mechanics demonstrate shoulder and elbow forces are strongly linked to pelvic rotation [26] and leg drive is correlated to wrist [8] and throwing velocity [24]. If stride distance and lead-leg foot placement are compromised by decreased hip strength and ROM, an overhead athlete will not be able to properly generate torque from the pelvis and lower extremity. Thus, if optimal leg drive is not achieved, the upper extremity will generate a greater proportion of forces required for the overhead activities. Understanding hip positional requirements during overhead athletic activities in conjunction with detailed mechanical anatomic considerations will allow for a more comprehensive explanation for the etiology of hip injuries in the throwing athlete.

Femoroacetabular impingement (FAI) and instability of the femoroacetabular joint are noted causes of labral and chondral pathology in the hip [1, 3, 9, 15, 17, 18, 21, 23]. Understanding of FAI and instability is important to appreciate how athletes participating in overhead activities may be affected by intraarticular hip pathology. Cam impingement is defined as loss of normal femoral head-neck offset or head asphericity. The labrum is susceptible to compression injury, while the acetabular cartilage is subject to excessive sheer forces [2, 6]. On the acetabular side, pincer impingement can be further described as focal or global overcoverage [7]. Although frequently underrecognized, femoral torsion and neck-shaft angle also have a critical role in joint mechanics [25]. Fortunately, better understanding of pathologic hip anatomy has led to effective treatments. Impingement is a complex three-dimensional problem that will affect athletes in a variety of ways, depending on the anatomy and location of the impingement combined with the mechanical forces that the joint is subjected to during the phases of the throw.

We determined (1) whether overhead athletes with FAI would benefit from arthroscopic treatment, as measured by validated hip function scores (modified Harris hip score, Hip Outcome Score); and (2) the rate of return to preinjury level of play in this athletic cohort.

Patients and Methods

From January 2007 to December 2010, we identified varsity high school, collegiate, and professional athletes involved in overhead sports baseball and lacrosse. We included athletes with a clinical diagnosis of FAI with pain on flexion, adduction, or internal rotation or pain with straight flexion in the study. Prior analysis of our practice has shown 21% of high-level athletes treated for FAI participated in overhead sports [14]. Radiographic inclusion criteria were plain radiographs demonstrating the presence of a crossover sign on an AP pelvic radiograph, an elevated alpha angle (> 50°) on a Dunn lateral view, and Tönnis Grade 1 or less arthrosis. MRI confirmed the presence of intraarticular pathology involving injury to the labrum and transition zone cartilage adjacent to the area of impingement but with overall preservation of the cartilage within the hip. We excluded patients if they had had prior hip surgery, had plain radiographs with greater than Tönnis Grade 1 arthrosis, or radiographic evidence of substantial dysplasia (Tönnis angle > 15° or lateral center-edge angle < 18°). CT scans with three-dimensional reconstructions were obtained on all patients to allow for an accurate mechanical diagnosis, looking at size and location of the alpha angle, acetabular version at 1, 2, and 3 o'clock, femoral version, anterior inferior iliac spine morphology, and femoral neck-shaft inclination. We identified 29 men and five women with an average age of 21.4 years (range, 16–35 years) from registry data. Eighteen athletes participated in lacrosse and 16 in baseball. The level of competition was 29% varsity high school (n = 10), 44% college (n = 15), and 27% professional athletics (n = 9). No patients were lost to followup. The minimum followup was 12 months (mean, 25 months; range, 12–41 months). No patients were recalled specifically for this study; all data were obtained from medical records. All patients provided informed consent, and the study was approved by the Institutional Review Board.

Nonoperative treatments included rest with activity modification, NSAIDs, positive temporary response to intraarticular injections, physical therapy, and manual therapy. All patients underwent arthroscopic treatment for FAI for persistent symptoms and inability to continue in athletic competition after nonsurgical treatment failed. Operative techniques varied with patient pathology but included acetabuloplasty, femoroplasty, and labral fixation or débridement. A single, fellowship-trained orthopaedic surgeon (BTK) in sports medicine and hip arthroscopy performed all the surgical cases. Of eight patients treated with bilateral hip arthroscopy, 75% were lacrosse players. Intraoperatively, labral fixation was performed in 38% of cases, with the remainder receiving labral débridement. During labral repair, on average, 2.13 (range, 1–5) suture anchors were implanted. Percutaneous femoral and acetabular osteochondroplasty were performed in 91% and 83% of cases, respectively. Impinging bone was resected on both the acetabular and femoral parts of the hip in 76% of cases. The psoas tendon was release in five hips, and there was one adductor tenotomy.

All patients were enrolled in a structured physical therapy regimen that included sessions before and the day after surgery with a specially trained physical therapist at our center. Patients then attended outpatient therapy minimum two times per week for 4 months. Weightbearing was restricted with crutches for the first 2 weeks, with an emphasis on normalizing gait pattern, passive motion, isometrics, and hip extension. A continuous passive motion machine was initiated in the recovery room and continued for 2 weeks. After 2 weeks, progressive weightbearing was encouraged and therapy focused on core and hip strengthening and improving ROM. The first office visit was at 6 weeks where an AP and Dunn lateral radiograph were obtained to access surgical changes and potential heterotopic ossification. Patients were then seen for followup after 3 months, 6 months, 1 year, and 2 years after surgery. ROM was assessed at each visit and objective strength testing was performed at 6, 12, and 24 months. A throwing program was initiated at 3 months postoperatively, and athletes were cleared to return to play at minimum 4 months, depending on progress and symptoms.

Patient-reported outcomes were prospectively collected using the modified Harris hip score [4], Hip Outcome Score [10], and Sport-specific Hip Outcome Score [10] preoperatively and at 6 and 12 months postoperatively. Preoperative scores were collected before 25 procedures. Postoperative scores were collected after 30 surgeries up until the point of return to play. Collectively, complete patient-reported scores were available before and after 23 arthroscopies. We retrospectively reviewed the records of athletes who met the study criteria to assess for demographic data, level of competition, postoperative outcomes scores, return to play status, and intraoperative findings. We compared means from the modified Harris hip score and Hip Outcome Score with a paired t-test to look for improvements in outcomes scores pre- and postoperatively.

Results

The average ($\pm$ SD) postoperative subjective outcome scores for modified Harris hip score, activities of daily living Hip Outcome Score, and Sport-specific Hip Outcome Score were 90 ± 12, 95 ± 9, and 86 ± 18, respectively. The average improvement for those with both pre- and postoperative scores was 22 ($p < 0.01$), 21 ($p < 0.01$), and 36 ($p < 0.01$), respectively. There was no difference between outcomes at 6 and 12 months. Thirteen patients reported return to play by their 6-month followup and the remaining 17 by their 12-month followup.

By 12 months after surgery, 33 of 34 athletes were able to return to their previous level of sport. One female college lacrosse player elected not to continue in collegiate sports due to mild hip pain. Furthermore, one professional baseball pitcher has resumed pitching but has yet to resign with a major league team.

Discussion

Hip biomechanics are important to overall athletic function. However, there is no literature that shows overhead athletes may return to prior level of competition after surgical correction of FAI. We therefore determined whether overhead athletes with FAI would benefit from arthroscopic treatment, as measured by validated hip function scores (modified Harris hip score, Hip Outcome Score), and the rate of return to preinjury level of play in this athletic cohort.

There are multiple limitations of this study. First, while short-term followup was adequate to determine return to play status, we cannot comment on longevity of athletic careers after arthroscopic treatment of FAI. Second, clinical data obtained at followup were available for 88% of surgeries, leaving the possibility of selection bias. However, return to play status was confirmed for all 34 patients. Pre- and postoperative data, allowing for assessment of change in outcome scores, were available for only 23 patients. This limitation is due to the evolution of our current prospective registry; not all patients seen in our hip preservation clinic were automatically entered into our database before surgery. Since March 2010, all patients seen in our clinic are routinely registered at the initial consultation and at postoperative visits at 6 weeks, 3 months, 6 months, 1 year, and 2 years. Third, our findings reflect those of a single surgeon's experience at a tertiary referral center. The findings might not reflect those of surgeons without substantial experience with these procedures. Finally, we excluded any patient with substantial arthrosis or dysplasia, conditions not typically amenable to arthroscopic treatment.

Our observations suggest overhead athletes have a very high return to play rate after hip arthroscopy for FAI. The 97% return to sports is likely a function of high patient expectations and a multidisciplinary approach, including careful indications, thorough correction of hip pathomorphology, labral repair as needed, and accelerated rehabilitation protocols. The majority of patients had osteoplasty of both femur and acetabulum in an effort to address the underlying mechanical environment of the joint. The modified Harris hip score of 92 shows substantial improvement and is consistent with prior studies of high-level athletes [5, 19].

The high functional demands of overhead athletes may predispose them to hip injuries beyond the usual spectrum of FAI. One prior study has shown elite athletes participating in sports requiring high axial and torsional forces through the hips may predispose them to intraarticular pathologies [12]. Injury patterns of the shoulder commonly seen in the throwing athlete can be used to understand rotational instability of the hip. Just as excessive overhead throwing can lead to progressive laxity of the anterior shoulder capsule [13], repetitive forceful hip rotation can contribute to focal rotational instability. The most common injury pattern is forceful hip external rotation beyond normal physiologic limits, which stretches the iliofemoral ligament. Although less common, excessive internal rotation could potentially lead to ischiofemoral ligament laxity. Forces that may lead to instability frequently occur during overhead athletic activities that require rapid acceleration and deceleration in conjunction with hip rotation [16, 20]. In the presence of acquired capsular laxity, abnormal loading of the anterior-superior labrum can occur, resulting in chondrolabral damage [16, 22].

Overhead sports incorporate positional requirements and movement patterns that make the acetabular labrum susceptible to injury in the setting of FAI. During different phases of overhead activity, the labrum and capsuloligamentous structures will be at risk for injury. A summary of the labral tear, rotational instability location, and potential associated deformity is presented (Table 1). Overhead activities begin by establishing forward momentum with the lead leg striding forward, creating risk for pitchers. During the wind-up phase, pitchers move their lead leg through open-chain adduction-internal rotation to abduction-external rotation through an arc of flexion toward the intended target (Fig. 1). The athlete is at potential risk for labral impingement during this motion in the presence of cam or pincer deformities. While striding forward, abduction and external rotation occur in the lead and back hips (Fig. 2), creating the potential for posterior-superior impingement. Striding forward is critical to developing forward momentum. As the stride distance increases, hip abduction and the likelihood of lateral rim impingement also increases. Also, the back hip is subject to compressive and shear forces that may result in additional stress to the labrum and articular surfaces with resultant traumatic injuries.

Table 1. Labral tear and rotational instability location with potential associated deformity

Location	Deformity
Labral tear	
Anterior-superior	Anterior-superior cam
	Inferior-medial cam
	Excessive acetabular retroversion
	Excessive acetabular anteversion contre-coup
	Femoral retroversion
	Excessive femoral anteversion contre-coup
	Global overcoverage
	Superior focal acetabular
	Overcoverage
	Instability
Superior	Superior cam
	Coxa valgum
	Coxa varum
	Global overcoverage
	Superior focal acetabular overcoverage
Posterior-superior	Posterior-superior cam
	Excessive acetabular anteversion
	Excessive acetabular retroversion contre-coup
	Excessive femoral anteversion
	Femoral retroversion contre-coup
	Global overcoverage
	Superior focal acetabular overcoverage
Rotational instability	
Anterior	Excessive acetabular anteversion
	Excessive femoral anteversion
	Shallow acetabulum
Posterior	Excessive acetabular retroversion
	Excessive femoral retroversion
	Shallow acetabulum

As pitchers stride forward, acceleration is developed. During this action, the pelvis rotates forward and the lead hip moves into internal rotation, adduction, and flexion (Fig. 3), predisposing the joint to anterior-superior impingement. As the trunk and pelvis accelerate forward, the back hip continues to externally rotate, abduct, and extend. As external rotation increases, the likelihood of anterior rotational instability also increases. Hip external

Fig. 1 The wind-up phase of throwing is shown, with the lead leg moving through open-chain adduction-internal rotation to abduction-external rotation through an arc of flexion.

rotation and extension also increase the risk for posterior impingement and contrecoup injuries as the head-neck junction approximates the posterior rim of the acetabulum. Activities that require greater external rotation, such as during a forehand tennis stroke, may be at greater risk for these injuries (Fig. 4). Additionally, capsular laxity may be evident in hips with increased external rotation compared to the contralateral side [11].

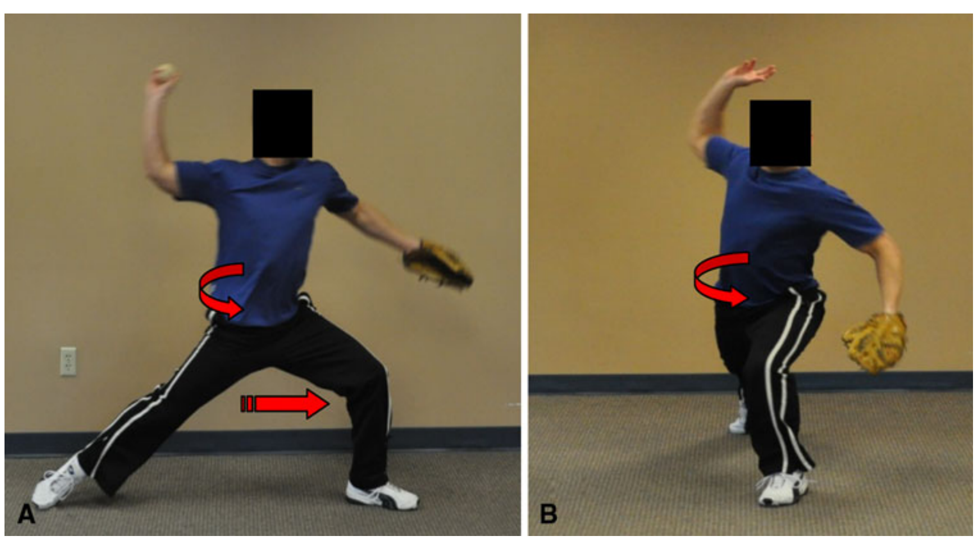
During the follow-through phase, body weight is moved onto the lead or nondominant leg with concurrent flexion, internal rotation, and adduction. During this forceful activity, the player may drag or even lift the back foot, indicating weight has shifted entirely (Fig. 5). As the lead hip moves into internal rotation, flexion, and adduction, there is greater risk for anterior-superior impingement as mentioned previously. With transition of body weight to the lead hip, additional stress to the labrum and articulating surfaces could result in traumatic injury. Lacrosse is an example in which excessive internal rotation may occur (Fig. 6), though the amount of internal rotation depends on foot position of the lead leg.

In conclusion, while overhead sports are commonly linked with injuries to the upper extremity, recently hip injuries have gained attention. Many of the common movements associated with throwing a baseball or football, shooting a lacrosse ball, or hitting a tennis ball place high demands on the hip. Repetitive activities performed by athletes with FAI are hypothesized to exacerbate chondrolabral hip lesions and

Fig. 2 Striding forward requires abduction and external rotation occurring in both the lead and back hips.

Fig. 4 Activities requiring greater external rotation, such as during a forehand tennis stroke, may increase the risk for anterior rotational instability and posterior impingement.

Fig. 3A–B The acceleration phase of throwing is shown in (**A**) side view and (**B**) front view, with the lead hip moving into internal rotation and adduction and the back hip continuing into external rotation, abduction, and extension.



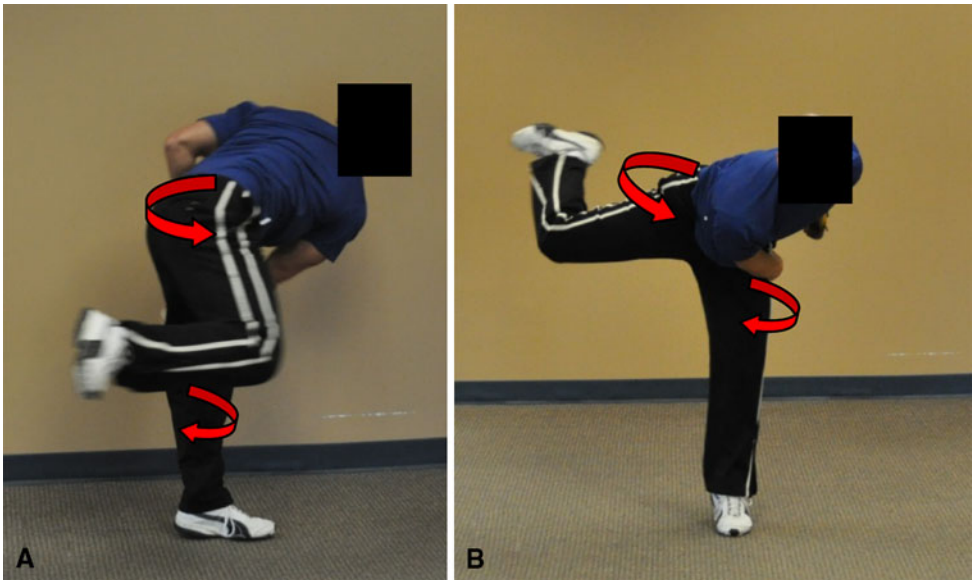


Fig. 5A–B The follow-through phase of throwing is shown in (**A**) side view and (**B**) front view, with increases in flexion, internal rotation, and adduction on the lead or nondominant side.

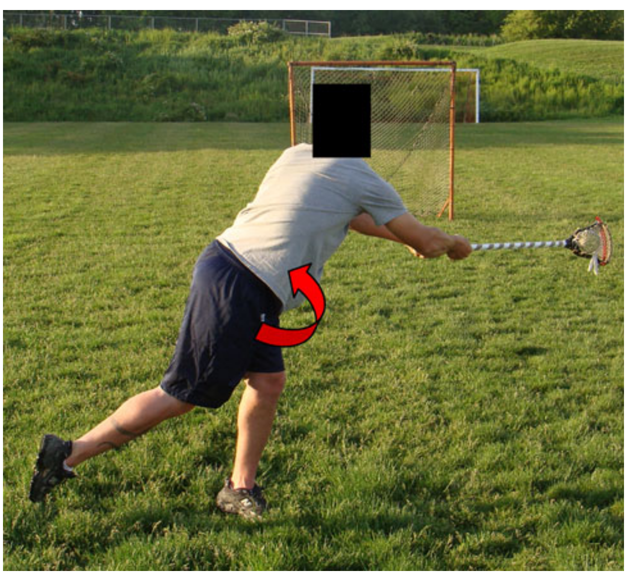


Fig. 6 Excessive hip internal rotation, seen with shooting a lacrosse ball, may increase the risk for posterior rotation instability and anterior-superior impingement.

rotational instability. By addressing the pathomorphology at the time of surgery, athletes may return to sport at a high level of function.

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