Posterior Shoulder Instability in Throwing Athletes: A Case-Matched Comparison of Throwers and Non-Throwers

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Purpose: To evaluate the results of arthroscopic capsulolabral repair for the treatment of posterior shoulder instability in a throwing athlete cohort when compared with non-throwers. **Methods:** Forty-eight overhead-throwing athletes undergoing arthroscopic posterior capsulolabral reconstruction were case matched with 48 non-throwing athletes. These cohorts were followed as they underwent posterior capsulolabral reconstruction by measuring shoulder pain, function, return to sport, and operative failures. Operative details such as intra-articular pathology and repair construct were also recorded. **Results:** At a mean follow-up of 37 months (range, 12 to 97 months) postoperatively, no statistical differences were noted between throwers and non-throwers regarding American Shoulder and Elbow Surgeons scores, stability, strength, or range of motion. Sixty percent of throwing athletes were able to return to their preinjury level of competitive throwing. Throwers with a discrete labral tear intraoperatively had a 10-fold increased likelihood of returning to sport (odds ratio, 9.6; $P = .012$). Similarly, throwers who had suture anchor constructs showed a 10-fold increased likelihood of returning to play compared with anchor-less repairs (odds ratio, 9.6; $P = .012$). Non-throwers showed no variability by labral findings or fixation techniques. Pitchers had equivocal outcome scores when compared with other throwers but had poorer return-to-play rates (50% *v* 60% full return). **Conclusions:** Arthroscopic capsulolabral plication for unidirectional posterior shoulder instability is an effective treatment for overhead-throwing athletes. Intraoperatively, achieving an adequate capsular plication and stabilizing the repair with suture anchors will give this athletic population the best odds of returning to competitive sports. **Level of Evidence:** Level III, retrospective comparative study.

Posterior shoulder instability has become an increasingly recognized pathology among athletes. Several recent studies have documented the effectiveness of arthroscopic capsulolabral reconstruction in returning these injured athletes to their preinjury sports activities.[1-3] These studies indicate that successful restoration of the native capsulolabral anatomy resolves symptoms of pain and instability while generally maintaining the required strength and range of motion (ROM) for competitive sports participation.[1,2] With the goal of restoring capsulolabral anatomy, repair constructs using suture anchors have recently been shown to improve the likelihood of a successful return to sport and limit operative failures.[2]

The significant demands placed on the glenohumeral joint in overhead-throwing sports put these athletes at a significant risk of developing posterior shoulder instability.[4] The act of delivering an overhead throw exerts one of the most violent sets of forces across a single joint of any human motion. The posterior capsulolabral structures are at risk at 2 distinct positions during overhead-throwing motions. The first stress to the posterior capsulolabral complex occurs during the late cocking phase. In this position, while abducted to 90°, the humerus maximally externally rotates within the glenoid. Often, the humerus rotates posterior to the plane of the scapular body into a position of hyperangulation. The excessive external rotation leads to internal impingement of the rotator cuff muscles against the posterior glenoid and capsulolabral complex. This internal impingement can lead to labral degeneration and tearing with repetitive insult.[5] A second stress to the posterior capsulolabral complex occurs during the follow-through phase of the throwing motion. The humerus rotates at a speed of greater than

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7,000° per second from the late cocking phase through the release phase of the throwing cycle. After delivery, the humerus continues to rapidly adduct, flex, and internally rotate through the follow-through phase, placing a significant amount of stress across the posterior capsulolabral complex to prevent posterior translation.[6-8] Again, with repetitive insults, the posterior structures are susceptible to injury. This repetition-induced injury mechanism is of highest concern among overhand pitchers because their throw count is substantially higher than that of players in other positions.

To further complicate posterior capsulolabral injuries in overhead-throwing athletes, this cohort often has a baseline level of capsular laxity in their throwing arm to accommodate the wide spectrum of glenohumeral motion their sport requires.[5,9] This anatomic adaptation can make the diagnosis of posterior capsulolabral pathology subtle to detect and complicate the balance of adequate motion and constraint during operative reconstruction. Despite the increased prevalence as well as diagnostic and therapeutic issues specific to overhead-throwing athletes, there has only been a single report detailing outcomes after arthroscopic posterior capsulolabral reconstruction.[4] The cohort of throwing athletes was relatively small (n = 27), and they were compared with a larger cohort (n = 80) of non-throwing athletes without case matching.

In this study we sought to evaluate the results of arthroscopic capsulolabral repair for the treatment of posterior shoulder instability in a throwing athlete cohort when compared with non-throwers. Our hypothesis was that throwing athletes would show diminished outcomes regarding postoperative shoulder function (i.e., stability and American Shoulder and Elbow Surgeons [ASES] scores) and return-to-play rates compared with non-throwers because of the added demands of throwing on their performance. We also hypothesized that a subset of pitchers would show the poorest postoperative results because of the high, repetitive demands they place on their posterior glenohumeral complex during sports participation.

Methods

Patient Selection

Patients undergoing arthroscopic posterior capsulolabral reconstruction for posterior shoulder instability were followed up in the perioperative period. For the study, the inclusion criteria were athletes participating in competitive sports at the high school, collegiate, or professional level; a minimum 1-year follow-up; the presence of unidirectional posterior instability; and the absence of symptoms of instability in any direction other than posterior. Patients who displayed inferior shoulder laxity or multidirectional instability and patients with habitual or psychogenic voluntary shoulder subluxations were excluded from the study.

A retrospective analysis was performed to determine the effect that participation in competitive throwing sports had on postoperative recovery and function. The primary cohort of this study consisted of competitive throwing athletes. All were diagnosed with unidirectional posterior shoulder instability in their dominant extremity and subsequently underwent arthroscopic capsulolabral reconstruction. A subset of athletes in this cohort (n = 23) were previously analyzed in a publication by the senior author (J.P.B.) and colleagues on posterior capsulolabral injuries in throwers.[4] A separate cohort of athletes with similar histories of unidirectional posterior instability and capsulolabral reconstruction who did not participate in overhead sports was generated by matching patients by age, sex, level of sport, and duration of follow-up. All operations were performed between January 1998 and December 2009 by the senior author (J.P.B.). Institutional review board approval was obtained, and all patients were informed about the study and agreed to participate before the initiation of the study.

Patient Evaluation

All patients were followed up prospectively with clinical examinations, radiographs, and subjective grading scales. Recorded patient demographic data included age, sex, sport, position (throwers *v* non-throwers), type of sport (contact *v* noncontact), level of competition, and length of follow-up.

All patients considered for this study complained of symptoms of posterior shoulder instability, including posterior shoulder pain, clicking, a sensation of subluxation or instability with motion, and apprehension with shoulder motion. The initial clinical examination included a thorough examination of the athlete's shoulder, including palpation for tenderness, evaluation of impingement, measurement of ROM and strength, and evaluation of stability. With specific regard to posterior glenohumeral instability, the Kim test,[10] the circumduction test, the jerk test,[11] the posterior load-and-shift test,[5] and the posterior stress test[12] were all performed. The sulcus test was used to identify patients with inferior stability, and athletes with a positive finding who did not undergo correction with external glenohumeral rotation were subsequently excluded from this study. Standard radiography and magnetic resonance arthrography (MRA) were performed on all patients in conjunction with the clinical examination to aid in the diagnosis and evaluation of capsulolabral abnormalities. The purpose of the MRA was to identify the specific anatomic pathologies, namely posterior labral tears and patulous posterior capsules.

Both preoperatively and at the latest follow-up, patient outcome was evaluated using the ASES

shoulder score (range, 0 to 100), which combines a subjective functional scale measuring activities of daily living (ADL) (0 to 3 for each of 10 tasks, with a total score of 0 to 30) and a subjective pain scale (0 to 10, with 10 being the worst). In determining the overall ASES score, equal weight is given to the cumulative ADL score and the amount of pain that the patient has. This measurement is obtained by the following formula as published by Richards et al.[13]: Overall ASES score = ([10 − Pain score] × 5) + ([5/3] × ADL score). Because the ASES scale does not measure stability, a previously described subjective stability scale (0 to 10, where 0 indicates completely stable and 10 indicates completely unstable) was also added preoperatively and at each follow-up.[1,2] In addition, patient-described strength (0 to 3, where 0 indicates none, 1 indicates markedly decreased, 2 indicates slightly decreased, and 3 indicates normal) and ROM (0 to 3, where 0 indicates poor, 1 indicates limited, 2 indicates satisfactory, and 3 indicates full) scales were evaluated at the latest follow-up. Intraoperative findings and specific surgical procedures performed were correlated with the aforementioned subjective and objective outcomes.

Operative Treatment

Patients who met our inclusion criteria and in whom nonoperative management failed were selected for surgery. All procedures were performed by the senior author (J.P.B.). Before each operation, an examination under anesthesia was performed but the findings were not recorded. At the start of each operation, a diagnostic arthroscopy was performed specifically to identify pathology within the posterior capsulolabral complex, including a patulous capsule, capsular tears, labral fraying, and labral tears. Once the pathologic abnormalities were identified, the procedure was tailored to the specific injury pattern. One of 3 different procedures was performed based on the preoperative clinical examination, MRA, examination under anesthesia, pathologic findings at diagnostic arthroscopic surgery, and surgeon experience: (1) capsulolabral plication without suture anchors, (2) capsulolabral plication with suture anchors, or (3) capsulolabral plication with suture anchors and additional plication sutures.[2] In general, shoulders with a patulous capsule without a discrete labral tear underwent capsulolabral plication with or without suture anchors. Those with labral tears underwent capsulolabral plication with suture anchors. In patients with a labral tear, after the capsulolabral repair, the capsule was evaluated for residual laxity, and additional plication sutures were placed as indicated. The techniques for each of these operative repairs have been previously described.[1] Regardless of the capsulolabral reconstruction technique implemented, the greatest intraoperative challenge was achieving an optimal level of glenohumeral stability while maintaining adequate capsular laxity to permit sport-specific ROM. To judge posterior glenohumeral stability restoration, patients were taken out of traction while in the lateral decubitus position, and posterior load-and-shift and posterior stress tests were performed. Appropriate balancing in these patients, especially the overhead-throwing athletes, relied heavily on operator experience.

Postoperative Rehabilitation

Immediately after surgery, the patient was placed in an UltraSling (DonJoy, Carlsbad, CA), which immobilizes the shoulder in approximately 30° of abduction while preventing internal rotation. The sling was used for 4 to 6 weeks, depending on the amount of capsular laxity found at the time of surgery. Patients began active wrist and elbow motion as well as gentle passive scaption exercises immediately. Active elevation of the arm was not allowed until the fourth week.

When sling immobilization was discontinued, gentle passive ROM exercises, including pain-free internal rotation, were advanced. Active-assisted ROM exercises and isometric internal and external rotation exercises were also initiated at this time. By 2 to 3 months postoperatively, the patient progressed to full passive and active ROMs. At this time, strengthening exercises with an emphasis on the rotator cuff and periscapular and posterior deltoid muscle groups were initiated.

At 4 months postoperatively, all throwing athletes were started on a regimented throwing protocol as a part of their rehabilitation. Their throwing distance and speed were closely monitored and slowly advanced over a period of 2 to 3 months. Once a throwing athlete was able to perform full-speed throwing for 2 consecutive weeks without symptoms, return to full competition was permitted. In the non-throwing athletes, isokinetic testing was performed at 6 months. Once an athlete was able to achieve 80% strength and endurance compared with the contralateral side, a sport-specific rehabilitation protocol was initiated. All athletes were required to achieve full ROM without pain, full strength, and endurance comparable with the contralateral side before returning to competition.

Statistical Analysis

The preoperative and latest follow-up ASES scores, stability scores, functional scores, and pain-level findings were compared using a paired-sample Student t test. Comparisons between groups, including delineation by throwers and non-throwers, were made by use of the Student t test. Outcome comparisons between multiple groups, which included intraoperative findings and surgical fixation methods, were analyzed by χ^2 modeling for nonparametric data. Statistical analyses were performed with significance set at $P < .05$.

Table 1. Summary of Patient Characteristics

	Throwers	Non-Throwers
Total, n	48	48
Sex, n		
Male	34	34
Female	14	14
Mean age, y	17.8	17.6
Mean follow-up, mo	37	37
Level of participation, n		
Professional	1	1
College	9	9
High school	38	38

NOTE. The study comprised a total of 96 matched dominant shoulders.

Results

Patient Demographic Characteristics

This study included 48 overhead-throwing athletes, along with 48 matched non-throwing athletes, for a total of 96 patients (Table 1). All of these athletes had injuries to their dominant arm. In each cohort 14 participants were female patients (29%). The majority of individuals were high school competitors, 38 (78%), and only 1 professional athlete was included in each group (2%). The mean age was 17.8 years for throwers and 17.6 years for non-throwers. The mean follow-up period was 37 months (range, 12 to 97 months for throwers and 12 to 79 months for non-throwers) for both groups of athletes. No statistically significant difference was found for age or follow-up time between the groups. When contact sport activity was considered, a significantly larger proportion ($\chi^2 = 11.0$, $P = .001$) of athletes in the non-thrower group (n = 36, 75%) reported contact activities than throwing athletes (n = 20, 42%).

Outcomes

Table 2 displays the preoperative and postoperative scores for shoulder performance in both the throwing and non-throwing athletes.

ASES Scores. The mean preoperative ASES score for throwing athletes was 47.1 (range, 3 to 85). At latest follow-up, the mean ASES score had improved to 84.6 (range, 25 to 100). This change was statistically significant ($t = 13.4$, $P < .001$). Non-throwers had a mean preoperative ASES score of 46.0 and mean postoperative score of 85.7. No statistical differences were noted between preoperative and postoperative ASES scores between throwers and non-throwers. By ASES criteria, 36 patients (75%) had excellent outcomes (ASES score >80), 9 (19%) had good outcomes (ASES score of 60 to 80), 2 (4%) had satisfactory outcomes (ASES score of 40 to 60), and 1 (2%) had a poor outcome (ASES score <40). Thus 94% of throwers had excellent or good outcomes based on the ASES criteria postoperatively. In comparison, among the matched non-throwers, 39 (81%) had excellent outcomes, 5 (10%) had good outcomes, 2 (4%) had satisfactory outcomes, and 2 (4%) had poor outcomes. No statistically significant difference in ASES scores was found between throwers and non-throwers.

Stability. Evaluating the patient-described stability scale (where 0 indicates stable and 10 indicates grossly unstable), the mean preoperative stability score was 7.3 (range, 0 to 10) for throwers. Postoperatively, the stability score had improved to 2.3 (range, 0 to 8). This was statistically significant ($t = 12.2$, $P < .001$). Non-throwers had a mean preoperative score of 7.5 and a mean postoperative score of 1.8. No significant differences were noted between throwing and non-throwing athletes at the preoperative and postoperative time points. As described previously, the stability score has been grouped into excellent (0 to 2), good (3 to 4), satisfactory (5 to 6), and poor (7 to 10). In the throwing cohort, 23 athletes (48%) had excellent outcomes, 22 (46%) had good outcomes, 2 (4%) had satisfactory outcomes, and 1 (2%) had a poor outcome.[4] Thus 94% of throwing athletes had excellent or good outcomes by the stability scale. In comparison, 31 non-throwing athletes (65%) had excellent outcomes, 13 (27%) had good outcomes, 3 (6%) had satisfactory outcomes, and 1 (2%) had a

Table 2. Summary of Patient Results

	Throwers (48 Shoulders)					Non-Throwers (48 Shoulders)				
	Preoperative Score		Latest Follow-up Score			Preoperative Score		Latest Follow-up Score		
Outcome Measure	Mean ± SD	Range	Mean ± SD	Range	*P* Value	Mean ± SD	Range	Mean ± SD	Range	*P* Value
ASES (0-100, with 0 being worst)	47.1 ± 16	3-85	84.6 ± 15	25-100	< .05	46 ± 18	16-94	85.7 ± 17	31-100	< .05
Stability (0-10, with 0 being most stable)	7.3 ± 2.4	0-10	2.3 ± 1.8	0-10	< .05	7.5 ± 1.6	4-10	1.8 ± 1.9	0-8	< .05
Pain (0-10, with 10 being worst pain)	6.8 ± 2.4	0-10	2 ± 1.8	0-9	< .05	6.4 ± 2.3	0-10	1.7 ± 2.2	0-9	< .05
Function (0-30, with 0 being worst)	19.0 ± 5.2	8-30	26.9 ± 4.1	6-30	< .05	16.8 ± 5.9	5-28	26.3 ± 4.4	11-30	< .05

ASES, American Shoulder and Elbow Surgeons shoulder assessment score.

poor outcome. Thus 92% of non-throwers had excellent or good outcomes regarding shoulder stability. No statistically significant differences in stability scale scores were noted between the athlete groups.

Pain. By use of a standardized subjective pain scale (0 to 10, where 0 indicates no pain and 10 indicates severe pain), the mean preoperative pain score for throwers was 6.8 (range, 0 to 10). At the latest follow-up, the mean pain score was 2.0 (range, 0 to 9). This change was significant ($t = 10.9$, $P < .001$). For non-throwing athletes, the mean pain score was 6.4 before surgery and 1.7 at the latest follow-up. No significant differences were found in pain levels between throwers and non-throwers before or after surgical intervention.

Function. When the functional scale portion of the ASES scoring system (0 to 30, with 0 being the worst) was analyzed, the mean preoperative functional score for throwers was 19.0 (range, 8 to 30). At the latest follow-up, the mean functional score was 26.9 (range, 6 to 30). This improvement was statistically significant ($t = 10.9$, $P < .001$). For the non-throwing athletes, the mean functional score was 16.8 before surgery and 26.3 at the latest follow-up. No significant differences were found in shoulder function between the 2 groups of athletes at either time point.

Range of Motion. A patient-described subjective ROM scale (0 to 3, where 0 indicates poor, 1 indicates limited, 2 indicates satisfactory, and 3 indicates full) was recorded at the latest follow-up visit. Among throwing athletes, 24 (50%) reported full ROM, 20 (42%) reported satisfactory motion, and 4 (8%) reported limited motion. The mean reported ROM for throwers was 2.4 (range, 1 to 3). Among non-throwing athletes, 31 (65%) reported full ROM, 15 (31%) reported satisfactory motion, and 2 (4%) reported limited motion. The mean reported ROM for non-throwers was 2.6 (range, 1 to 3). No statistical differences were noted between the 2 athlete groups ($\chi^2 = 2.3$, $P = .32$).

Strength. A patient-described subjective strength scale (0 to 3, where 0 indicates none, 1 indicates markedly decreased, 2 indicates slightly decreased, and 3 indicates normal) was recorded at the latest follow-up visit. Among throwing athletes, 27 (56%) reported normal strength, 18 (38%) reported slightly decreased strength, and 3 (6%) reported markedly decreased strength. The mean reported strength level for throwers was 2.5 (range, 1 to 3). Among non-throwing athletes, 24 (50%) reported normal strength, 20 (42%) reported slightly decreased strength, and 4 (8%) reported markedly decreased strength. The mean reported ROM for non-throwers was 2.4 (range, 1 to 3). No statistical differences were noted between the 2 athlete groups ($\chi^2 = 0.42$, $P = .81$).

Return to Sport. Of the 48 throwers, at the latest follow-up, 7 (15%) did not return to sport because of their shoulder injury, 12 (25%) returned at a limited level, and 29 (60%) returned to their preinjury level of play. Thus 41 throwing athletes (85%) returned to sport overall postoperatively. Among non-throwing athletes, 6 (13%) did not return to sport because of their shoulder injury, 8 (17%) returned at a limited level, and 34 (71%) returned at the same level. Thus 42 non-throwing athletes (88%) returned to sport postoperatively. No statistical discrepancies were noted in return-to-play rates between the throwing and non-throwing groups ($\chi^2 = 1.3$, $P = .53$).

Operative Evaluation

Surgical Findings. Figure 1 displays the intraoperative pathoanatomy findings by athlete group. Of the 48 throwers, 33 (69%) had a full-thickness labral tear, 6 (13%) had a partial-thickness labral tear, and 9 (19%) had an intact labrum. All throwers with an intact labrum (n = 9, 19%) had operative findings consistent with a patulous posterior capsule. Among throwing athletes with labral pathology (n = 39), 41% (n = 16) were also found to have a patulous posterior capsule. Overall, 25 throwing athletes (52%) had a patulous posterior capsule. Among the non-throwing athletes, 26 (54%) had a full-thickness labral tear, 10 (21%) had a partial-thickness labral tear, and 12 (25%) had an intact labrum. All non-throwers with an intact labrum (n = 12, 25%) had operative findings consistent with a patulous posterior capsule. For non-throwers with labral pathology (n = 36), 64% (n = 23) were also found to have a patulous posterior capsule. Overall, 35 throwing athletes (73%) had a patulous posterior capsule.

χ^2 Analyses showed a significantly higher rate of encountering a patulous posterior capsule in non-throwers compared with throwers ($\chi^2 = 4.44$, $P = .035$). No statistically significant difference was found in the patterns of labral pathology between throwing and non-throwing athletes ($\chi^2 = 2.32$, $P = .32$). Furthermore, no differences were noted in preoperative or postoperative outcomes for pain, function, ASES, or stability scores when we compared intraoperative capsular and labral findings. Interestingly, when return-to-sport rates were compared with intraoperative findings, a significantly larger percentage of throwing athletes with labral tears had a successful return to competition compared with athletes with intact labra ($\chi^2 = 9.8$, $P = .005$). Ninety-two percent of throwers with labral tears (36 of 39) were able to return to sport, as compared with 55% (5 of 9) with intact labra on operative intervention. Simple logistic

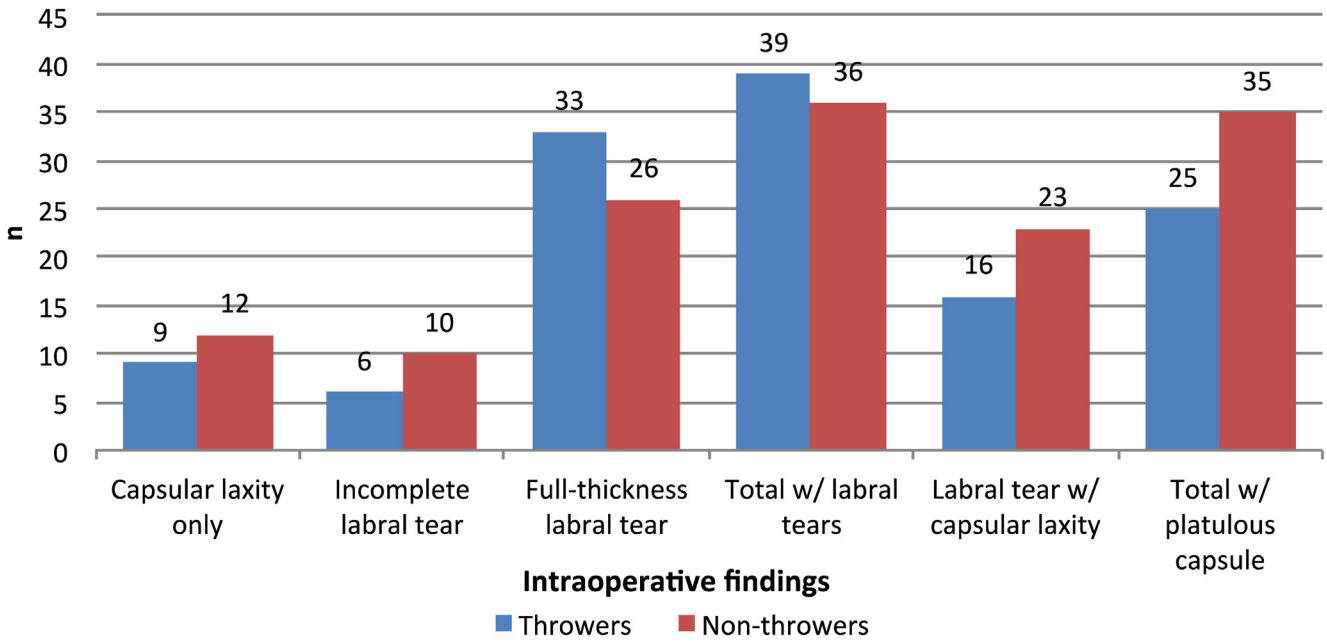

Fig 1. Description of intraoperative anatomic findings regarding posterior labrum and posterior capsule for both throwers (blue) and non-throwers (red) at time of repair.

regression showed that throwing athletes with an identifiable labral tear had a nearly 10-fold increase in the likelihood of returning to play compared with those with an intact labrum at the time of surgery (odds ratio [OR], 9.6; $P = .012$). For non-throwers, 89% of athletes with labral tears and 83% with intact labra were able to return to sport. This finding did not show statistical significance on χ^2 testing ($\chi^2 = 1.2$, $P = .54$).

Surgical Procedures. Figure 2 displays the distribution of operative procedures by athlete group. Of the surgical procedures performed within the thrower group, 9 (19%) were capsulolabral plications without suture anchors, 31 (65%) were capsulolabral plications with suture anchors, and 8 (17%) were capsulolabral plications with suture anchors and supplemental plication sutures. In the non-throwing athlete group, 14 cases (29%) were capsulolabral plications without suture anchors, 25 (52%) were capsulolabral plications with suture anchors, and 9 (19%) were capsulolabral plications with suture anchors and supplemental plication sutures.

χ^2 Analyses failed to show any statistical differences in the frequencies of operative procedures between the 2 groups ($\chi^2 = 1.79$, $P = .41$). Again, no differences were noted in preoperative or postoperative outcomes for pain, function, ASES, or stability scores when we compared reconstruction techniques. Similar to the intraoperative pathoanatomy findings, when we compared return-to-sport rates with operative procedures, a significantly larger percentage of throwing athletes who underwent a capsulolabral plication with suture anchors (with or without additional plication sutures) had a successful return to competition compared with athletes with intact labra ($\chi^2 = 9.8$, $P = .005$). Of throwers with anchor fixations, 92% (36 of 39) were able to return to sport, as compared with 55% (5 of 9) with anchorless fixations. By logistic regression analyses, the addition of anchors to the capsulolabral reconstruction yielded a nearly 10-fold increase in the likelihood of returning to play for the throwing athlete (OR, 9.6; $P = .012$). For non-throwers, 86% of athletes with anchor fixations and 93% with anchorless fixations were able to return to sport. This finding did not show statistical significance on χ^2 testing ($\chi^2 = 6.4$, $P = .17$).

Failures

According to the ASES scoring system, at the latest follow-up, there were 3 failures (6%) in the throwing group and 4 failures (8%) in the non-throwing group when we considered function and pain (ASES score <60). According to the stability scale, 2 throwers (4%) and 2 non-throwers (4%) had postoperative instability (stability score >5) at latest follow-up. Postoperative failures occurred in 2 throwers (4%) and 1 non-thrower (2%) regarding both the ASES and stability scores. In throwers, 2 failures occurred in athletes with intact labra but patulous capsules and 1 failure occurred in an athlete with a full-thickness labral tear. Regarding operative procedures, 2 athletes underwent capsular plication alone and 1 underwent an anchor fixation repair. In non-throwers, 2 failures occurred in the setting of an intact labrum and 2 failures occurred in the setting of full-thickness labral tears. Regarding operative procedures, 1 athlete underwent capsular plication

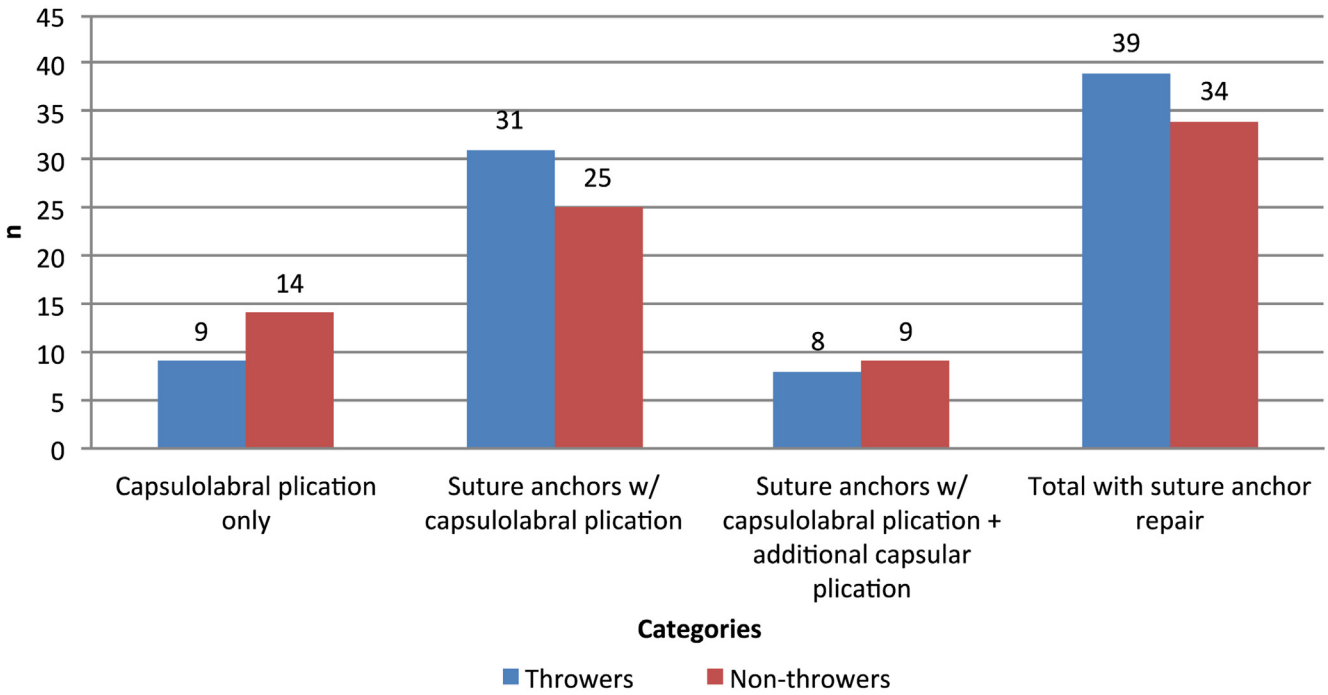

Fig 2. Description of surgical techniques used to address posterior capsulolabral instability in both thrower (blue) and non-thrower (red) groups.

alone and 3 underwent an anchor fixation repair. Trends toward increased failure rates were observed in throwers found (1) to have intact labra on intra-operative inspection (22% with intact *v* 2% with tear) and (2) to undergo capsulolabral reconstructions performed without suture anchors (22% without anchors *v* 2% with anchors). Given the overall low failure rate, accurate statistical comparisons were not possible. Of note, all failures involved recurrent instability episodes and all occurred within 7 months of the surgical procedure. All patients in whom initial posterior capsulolabral plication failed subsequently underwent revision with a repeat arthroscopic capsulolabral plication with a suture anchor construct.

Pitchers

Overhand (baseball) pitchers comprised 18 athletes (38%) in the overhead-throwing cohort. Their mean age was 18.5 years. Of these pitchers, 13 (72%) competed in high school, 4 (22%) competed at the collegiate level, and 1 (6%) competed in professional sports. All of these athletes were male. No substantial demographic differences, aside from sex, were noted between pitchers and the entire throwing cohort. The preoperative and postoperative shoulder scores for the pitching subgroup are shown in Table 3. Significant improvements were noted regarding stability, pain, function, and ASES scores between the preoperative and postoperative time points. No significant differences were noted for any outcome when we compared pitchers with other throwing athletes. Of the pitchers, 16 (89%) had excellent outcomes (ASES score >80) and 2 (11%) had good outcomes (ASES score of 60 to 80) by ASES criteria. According to the stability score criteria, 10 pitchers (56%) had excellent outcomes (stability score of 0 to 2) and 8 (44%) had good outcomes (stability score of 3 to 4). One hundred percent of pitchers reported full or satisfactory ROM at last

Table 3. Summary of Patients Results

	Pitchers: 18 shoulders				
	Preoperative		Latest Follow-up		
Outcome Measure	Score	Range	Score	Range	*P*
ASES (0-100, 0 being wost)	48.4 ± 17	20-82	89.5 ± 9.4	67-100	<0.001
Stability (0-10, 0 being most stable)	6.9 ± 3.0	0-10	1.9 ± 1.4	0-4	<0.001
Pain (0-10, 10 being worst pain)	6.8 ± 2.6	0-10	1.4 ± 1.4	0-4	<0.001
Function (0-30, 0 being worst)	19.5 ± 6.1	8-27	27.9 ± 2.2	22-30	<0.001

NOTE. Scores are listed as mean ± standard deviation unless otherwise indicated.
ASES, American Shoulder and Elbow Surgeons shoulder assessment score.

follow-up (50% per group). At last follow-up, 10 pitchers (56%) reported normal strength whereas the remainder (n = 8, 44%) reported slightly decreased strength.

Of the pitchers, 44% were noted to have a patulous capsule at the time of surgery and 15 (83%) were found to have a labral tear intraoperatively. Anchorless capsular plications had been performed in 2 pitchers (11%), whereas the remainder (n = 16, 89%) underwent capsulolabral plications with suture anchors. Overall, 9 pitchers (50%) were able to return to competitive pitching at a level equivalent to or better than their preinjury performance, 6 (33%) were able to return to competitive sports but at a lower level of performance, and 3 (17%) were unable to return to sport. Of the pitchers who were unable to return to sport, 1 had undergone an anchorless repair construct whereas 2 had undergone anchor-based repairs. No failures based on the stability or ASES scoring systems were found in the subgroup of pitchers.

Discussion

In this study we found that throwing and non-throwing athletes had remarkably similar recovery rates after arthroscopic capsulolabral repair. ASES, stability, pain, and function scores showed no differences between the 2 sets of athletes either preoperatively or postoperatively. Ninety-four percent of throwing athletes had good or excellent outcomes regarding both ASES and stability scores postoperatively. No statistical differences were noted regarding postoperative strength and ROM between the athlete groups, but subtle trends toward improved strength and decreased ROM in throwers may be present.

When we considered return-to-play rates, again, no statistical differences were apparent between throwing and non-throwing athletes. In the throwing group, 60% of athletes returned to baseline performance levels and 25% returned to play but at a lower level of performance. Fifteen percent of throwing athletes were unable to return to their sport after surgery. These rates are similar to those reported by Radkowski et al.[4] and an improvement over most return-to-play rates previously reported.[8,14-16] Compared with the overall return-to-play rates in the largest cohort of athletes undergoing capsulolabral reconstruction,[2] 5% fewer patients returned to sport overall (15% *v* 10%) and to preinjury performance (60% *v* 65%). Of note, intraoperative findings of an intact labrum and surgical repair with anchorless constructs both predicted a significant decrease in the return-to-sport rate in the throwing population. These athletes had a nearly 10-fold lower rate of return to play compared with throwers found to have a discrete labral tear or managed with anchored fixation constructs. These differences were not noted in the non-throwing group. There were also no differences noted within any preoperative or postoperative scores based on operative findings or repair techniques for any group.

When we considered the subset of overhand pitchers, improvements were seen across all outcome measures at the time of last follow-up and no differences were noted in outcomes between pitchers and other throwing athletes. Overhand pitchers had a return to baseline performance in 50% of cases, and another 33% were able to return to a lesser level of performance. Given the equivocal outcome scores of pitchers and other throwing athletes, it is likely that this discrepancy in return-to-play data is due to the repetitive, high-stress demands of overhand pitching on the postoperative shoulder.

It is essential to note that return-to-play "level" was a purely subjective opinion of the recovering athlete. Factors such as time away from competition, graduation, unrelated injury, and change of sport all factored into the athlete's determination of his or her postoperative performance in throwing activities. It is quite difficult to truly ascertain the percentage of patients who had an incomplete return to preinjury performance due specifically to shoulder dysfunction. Taking a strict approach to return-to-play outcomes, a 60% return-to-play rate is still a relative improvement over previous studies.[8,14-16] If a less strict approach to defining successful return to play is taken, 85% of athletes were able to participate in competitive throwing sports, regardless of their performance level, after their operative repair. This is a substantial increase in the rate of return to play compared with prior studies and techniques.

The impact of intraoperative findings and reconstruction techniques highlighted differences between throwing and non-throwing athletes. In throwers, the presence of an intact labrum at the time of surgical evaluation and the choice of anchorless capsulolabral plication fixation were shown to yield a nearly 10-fold decrease (OR, 9.6) in the likelihood of returning to play after surgery. This finding is interesting because there is nearly 100% overlap in throwers who were found to have intact labra and who ultimately underwent an anchorless capsulolabral repair. There are 2 potential explanations for the decreased return-to-play rates in this subset. First, it is possible that athletes with posterior shoulder instability despite an intact labrum may provide clinicians with a difficult task of determining optimal capsular laxity. With the increased demands on glenohumeral ROM in throwing populations, clinicians may be biased toward performing a less aggressive capsular plication than they would in the general athletic population. Given the repetitive, high-degree stresses that throwing athletes are known to impart on their posterior capsular structures, it is likely for their soft-tissue repairs to gradually stretch as they

resume throwing activities. Clinicians treating these athletes should recognize that symptomatic capsular laxity with the absence of a discrete labral tear may indicate that a more aggressive capsular plication is indicated. At the same time, this must be balanced by the significant ROM demands that overhead throwing places on the glenohumeral joint. Coincident with that consideration is the second possible explanation that a lack of suture anchor fixation led to the lower return-to-play rates in these athletes. Suture anchors have been shown to have a beneficial effect on return-to-play rates in the general athletic population.[2] Anchor fixation may add to the strength and durability of the soft-tissue repair construct, which again would be of significant benefit in a population known to place high, repetitive forces across the posterior capsulolabral complex.

Posterior shoulder instability has become an increasingly discussed pathology among a variety of athletes.[1-3] Stresses to the posterior capsulolabral complex in overhead-throwing athletes have been well documented over several decades.[5-8] Despite the known inherent risk of posterior instability in these athletes, there is a relative paucity of data regarding their outcomes after injury. Multiple studies documenting the postoperative recovery of athletes undergoing posterior capsulolabral reconstruction included throwing athletes in their analyses but did not consider outcomes specific to the throwing population.[17-21] Among the available studies that have documented outcomes in throwing populations, the results have tended to show relatively poor performance. These studies include descriptions of open capsular shifts,[8,14] open labral staplings,[15] and arthroscopic capsular plications.[16] Success rates, determined by return-to-play rates and overall satisfaction, were 50% at best in these series.

Before this study, the only literature to date specifically analyzing outcomes in overhead-throwing athletes was published in 2008.[4] This study compared a group of 27 throwers with 71 non-throwing athletes across all levels of sports after arthroscopic capsulolabral reconstruction. The results indicated that 55% of throwing athletes returned to their preinjury level of performance, with another 30% returning to sport but not achieving the same level of performance. When postoperative ASES scores, stability scores, strength, and ROM were considered, no substantial differences were noted between the throwing and non-throwing athletes.

Our study served as a continuation of the previous study.[4] Because of an expanded overall population of athletes who had undergone arthroscopic capsulolabral reconstruction, it was possible to analyze the postoperative outcomes in a group of overhead-throwing athletes compared with a matched group of non-throwers. To create a well-matched sample of non-throwing athletes, pairwise matching was performed to link each overhead thrower to a comparison non-thrower by age, sex, level of competition, and duration of follow-up. The intent in comparing matched groups was to neutralize as many variables as possible to best isolate the effect of throwing status on postoperative outcomes after capsulolabral reconstruction.

Other benefits to the increased sample size included an improved ability to define a competitive throwing athlete. To start, recreational athletes were excluded from this study because their postoperative demands are generally lower than those of actively competing athletes. Furthermore, throwing athletes were narrowed to those involved in pure overhead sports, excluding such activities as ultimate disc and water polo. Another benefit of the expanded number of athletes available for study was the added capability to study the effects of surgical findings and surgical procedures on outcome. In a recent study of 200 athletes undergoing capsulolabral reconstruction, both intraoperative findings and surgical procedures were found to affect outcomes in the general athlete population.[2] The study showed that labral injuries led to higher rates of pain and, subsequently, lower ASES scores before surgical intervention but that this discrepancy between intact and torn labra disappeared after surgical repair. More significantly, the study showed that the implementation of suture anchors into the operative repair construct had a significant benefit on postoperative return-to-play rates. The authors hypothesized that the addition of suture anchors to the repair may provide added strength and longevity to the construct.

Limitations

This study has some notable weaknesses that must be mentioned. First, although this study did compare a matched cohort of throwers with non-throwers, these cohorts were generated in a retrospective fashion. Despite our attempts to provide uniform cohorts by matching age, sex, level of competition, and duration of follow-up, a prospective evaluation of 2 separate cohorts would be statistically superior. Although our sample size is large, a post hoc power analysis showed our level of power to be insufficient (<0.8) for certain calculations when comparing throwers with non-throwers. This finding may indicate an inability to accurately detect significant differences between these 2 groups regarding preoperative and postoperative outcome scores. It should be noted that post hoc power calculations are controversial, and in this study it is unlikely that any statistical differences identified by enlarging our sample size would detect clinically relevant differences in outcomes. In addition, although we report that our mean follow-up time was 37 months for

both athlete cohorts, our inclusion criteria only required a 1-year period of postoperative follow-up. In 12 patients (25%) in both cohorts, the follow-up duration fell within the 12- to 23-month range. A study composed entirely of athletes with 2-year postoperative follow-up would improve our long-term assessment of posterior capsulolabral reconstruction. An additional potential limitation is that the mechanism of posterior instability onset, specifically traumatic versus atraumatic, was not recorded for this study. This has been evaluated and found to be insignificant in a previous study of posterior shoulder instability in a general athlete population,[1] but it may have affected outcomes in this throwing cohort.

Furthermore, although the scoring systems used in this study are consistent with our previous studies and were used because these data served as a continuation of prior studies, newer scoring systems, such as the Disabilities of the Arm, Shoulder and Hand or Single Assessment Numeric Evaluation scoring systems, have been described, whose use may have improved our clinical data. These have not been extensively studied in posterior glenohumeral instability, and future studies may be warranted. The uniqueness of posterior instability may also warrant a specific scoring system as our understanding of the pathology improves. Specifically, our descriptions of stability and ROM outcomes as subjective, patient-reported outcomes would be improved by including objective data from the preoperative and follow-up time points. These data would ideally have included passive and active ROM performance, as well as the presence of posterior instability examination findings, such as the jerk test or posterior load-and-shift test.

Lastly, interpretation of our data regarding outcomes based on anatomic pathology (labral tears *v* patulous capsules) and surgical repair technique (plication *v* anchored repair) was difficult as described previously because of the overlap of these subsets. An ideal means to evaluate the outcomes of posterior shoulder instability by anatomic pathology and surgical technique would be a study with 4 subgroups (labral tear and anchor, labral tear and plication, patulous capsule and anchor, and patulous capsule and plication). A study with this methodology would provide the most meaningful data to determine the role of anatomic pathology and surgical techniques in posterior shoulder instability outcomes.

Conclusions

Arthroscopic capsulolabral reconstruction is a successful means of addressing symptomatic posterior glenohumeral instability in overhead-throwing athletes. Their scoring outcomes, return-to-play rates, and failure rates are all similar to those of their nonthrowing counterparts. The most important factors in optimizing the outcomes in the throwing population are to adequately address the degree of pathologic capsular laxity at the time of surgical intervention and to provide a stable construct, likely with suture anchor fixation, that will withstand the high demands of a return to throwing activities. In addition, it is important to prescribe a regimented, gradual resumption of throwing activities in the postoperative period to gradually reintroduce the repaired shoulder to the stresses of the throwing motion. With appropriate patient selection, adequate capsulolabral plication, and a gradual return to throwing activities, arthroscopic posterior capsulolabral reconstruction is a valuable method for addressing posterior shoulder instability in the throwing athlete.

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