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Rotator Cuff Injuries in the Elite Athlete

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8.1 Prevalence of Rotator Cuff Tears in Throwers

Rotator cuff pathology is a common cause of dysfunction in the throwing athlete [1]. There are several possible etiologies of rotator cuff tears in the throwing athlete. One cause is a result of internal impingement as the rotator cuff is pinched between the glenoid and humeral head. A second cause is a result from the supraphysiological loads placed on the shoulder during the deceleration phase of the throwing cycle as the posterosuperior rotator cuff eccentrically contracts [2]. A prospective epidemiologic study which investigated injuries in collegiate baseball players over 3 years found that rotator cuff tendonitis represented 64% of the shoulder problems in all players and accounted for 15% of all musculoskeletal complaints reported. Rotator cuff tendonitis also represented the most common complaint among pitchers, infielders, and outfielders [3]. Despite representing the majority of shoulder complaints in throwing athletes, the prevalence of rotator cuff injury is likely underestimated in the throwing athlete. Magnetic resonance imaging (MRI) exams of asymptomatic professional baseball pitchers revealed findings consistent with rotator cuff tendonitis (68%) and partial-thickness rotator cuff tears (32%) [4]. These findings were echoed in a study following elite overhead athletes for 5 years, with 40% of asymptomatic shoulders having findings consistent with partial- or full-thickness rotator cuff tears [1]. Hence, rotator cuff tears in overhead athletes are common but may or may not be symptomatic.

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8.2 Pathophysiology of Rotator Cuff Tears in Throwers

Throwing athletes are of particular risk of rotator cuff injuries, commonly secondary to internal impingement. As described by Walch et al., abnormal impingement between the undersurface of the posterosuperior rotator cuff and superior labrum is often seen in late cocking and early acceleration phases of the throwing athlete [5]. With repetitive pathological contact, there is a consequent structural change resulting in superior labral lesions and articular-sided partial-thickness rotator cuff lesions along the posterosuperior cuff (i.e., posterior supraspinatus and superior infraspinatus) (Fig. 8.1) [6]. The development of internal impingement was investigated by Burkhart et al., who identified the etiology as a posterior capsular contracture, itself, secondary to eccentric contraction of the infraspinatus resisting the tensile forces placed on the posterior capsule during

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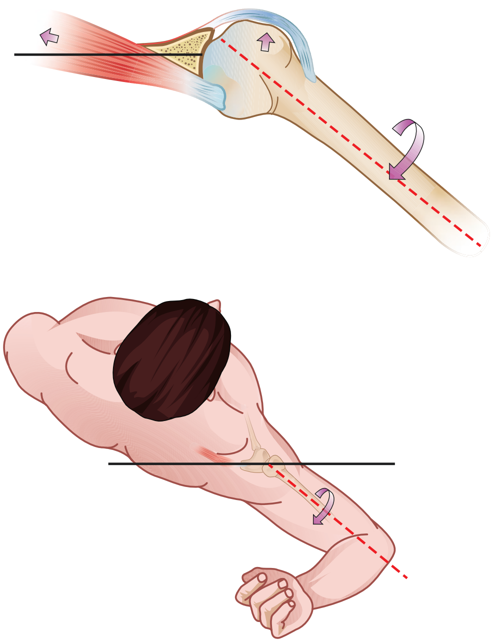

Fig. 8.1 Internal impingement of the undersurface of the rotator cuff against the posterior aspect of the labrum with shoulder in maximum abduction and external rotation [6]

the deceleration phase of throwing [7–9]. Repetitive eccentric contraction leads to a hypertrophic, contracted, and less compliant posterior capsule, shifting the center of rotation posterosuperior, further increasing shear forces on the rotator cuff, and limiting internal rotation. Finally, there is also be a tensile stress placed on the rotator cuff during the deceleration phase of throwing as the rotator cuff contracts in an attempt to center the humeral head. This violent contraction can lead to damage to the rotator cuff.

The complex interplay between glenohumeral motion and scapulothoracic kinematics is also important in rotator cuff function in the throwing athlete. Specifically, during the cocking phase of throwing, the articulation of the externally rotated and abducted glenohumeral joint is maintained by upward scapular rotation [10]. Imbalance in this dynamic interaction can lead to scapular dyskinesis and manifest as SICK (scapular malposition, inferior medial border prominence, coracoid pain, and dyskinesis of scapular movement) scapula [9]. With weakness of the periscapular and posterior rotator cuff musculature, the glenoid protracts, resulting in anterosuperior tilting of the glenoid fossa and tightening of the inferior glenohumeral ligament. An anterosuperior tilt of the glenoid fossa places the posterosuperior labrum and rotator cuff at risk for impingement and subsequent injury as described above.

8.3 Classification of Rotator Cuff Tears

The classification of rotator cuff injury can both suggest the etiology of injury and help guide treatment. Importantly, an acute process—such as a contusion—should be distinguished from a more chronic process. A rotator cuff contusion is an acute, traumatic injury, commonly seen with a direct impact such as a fall onto the shoulder, with hallmark findings on MRI. These MRI findings include increased signal intensity in rotator cuff tendon, bursa, and may concomitantly present with a bone bruise. Comparatively, chronic tendinopathy is consistent with an overuse process, with signal changes restricted to the rotator cuff tendon. This pathology is often seen with the repetitive and often supraphysiologic activities seen in overhead athletes leading to tensile failure. With a chronic change in tendon morphology and underlying disorganization of tendon fibers, rotator cuff tears may develop. Rotator cuff tears can be classified as full-thickness or partial-thickness tears. Partial-thickness tears can be further divided into articular-sided (Fig. 8.2), bursal-sided, or intratendinous tears. Partial articular supraspinatus tendon avulsions, or "PASTA" lesions, are common in the overhead athlete [11, 12]. Explanations for this include the relative hypovascularity of the articular side and differences in collagen organization compared to the bursal side of the rotator cuff [13, 14]. Partial-thickness articular-surface tears with intratendinous extension, or PAINT lesions, can also be seen, secondary to intratendinous shear forces during overhead

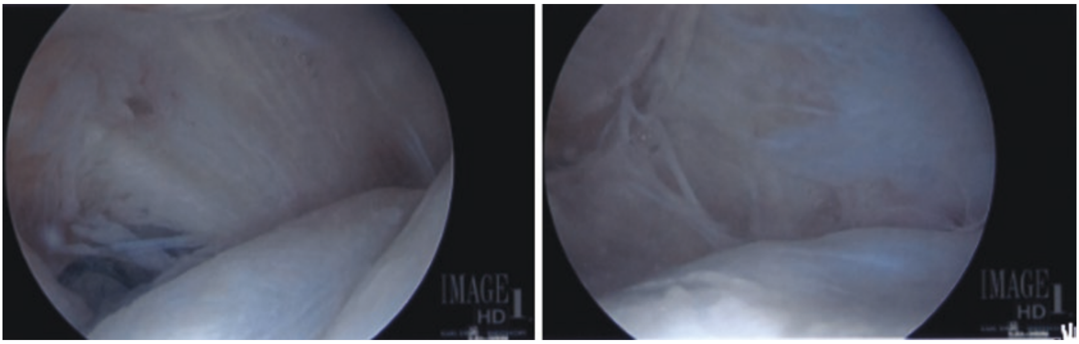

Fig. 8.2 Partial articular-sided supraspinatus tear

Fig. 8.3 Delamination of articular portion of tendon with retraction

Table 8.1 Ellman classification of partial-thickness rotator cuff tears [18]

Location	Depth	Area of defect
Partial-thickness tear		
(a) Articular surface (b) Bursal surface (c) Interstitial	<3 mm deep (<25% of tendon thickness) 3–6 mm deep (25–50%) >6 mm deep (>50%)	Base of tear × maximum retraction = mm^2

activity (Fig. 8.3) [15–17]. The Ellman classification of partial-thickness rotator cuff tears is presented in Table 8.1 [18]. Articular-sided partial-thickness rotator cuff tears are often seen in patients with additional pathology of the shoulder girdle, which includes glenohumeral internal rotation deficit (GIRD), scapular dyskinesia, and superior labral tears.

8.4 Clinical Presentation

Clinical presentation of a rotator cuff injury can be present within a spectrum of complaints. These complaints often vary by etiology, chronicity, and specific athletic limitations of the injury. Initially, a complete history should be obtained including duration of pain, duration (if any) of limitation of activities, and any prior treatments rendered (including if the athlete has been shut down from throwing and for how long). Presentation in a throwing athlete can vary from mild shoulder discomfort to an inability to throw. Overhead athletes may complain of decreased throwing velocity, loss of throwing accuracy, early fatigue, or instability. In contrast to these insidious complaints, athletes may also experience abrupt pain or "pop" (representing a rotator cuff or labral tear), commonly a result of an acute-on-chronic process [19].

8.5 Physical Examination

If acute, the mechanism of injury as well as the position of the arm can assist in the diagnosis. While an assessment of active range of motion can identify rotator cuff injury, comparing the arc of passive range of motion to the contralateral extremity may assist in diagnosing GIRD, loss of external rotation, or loss of total shoulder rotation. Physical exam should also extend to the motion and strength of the scapula and cervical spine proximally, and the elbow, distally. A complete neurovascular exam should also be performed. Careful assessment of the scapula will aid in the identification of weak periscapular musculature contributing to shoulder pathology. For instance, weakness in the serratus anterior may result in posteroinferior translation of the humerus in order to compensate for the lack of scapular elevation, causing worsening internal impingement. Similarly, excessive scapular internal rotation causes increase stress on the shoulder and elbow that can lead to injury [20]. These sites may not only cause referred pain but may present with concomitant pathologies. An accurate assessment of surrounding musculature is also important when determining appropriate rehabilitation protocols, as described below.

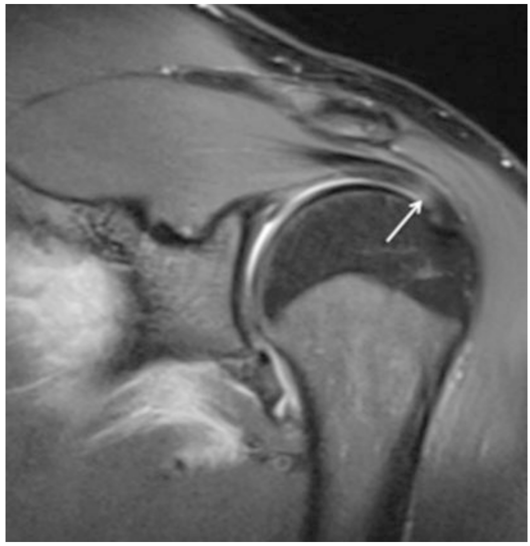

Fig. 8.4 Coronal MRI demonstrating a partial-thickness articular-sided rotator cuff tear in a throwing athlete (arrow)

8.6 Imaging

Following a thorough history and physical, imaging studies should be obtained. Plain radiographs can be used to assess humeral head positioning within the glenoid, assess acute bony injuries, as well as identify degenerative changes. Cystic changes appreciable on plain radiography in the greater tuberosity have been associated with partial-thickness articular-sided rotator cuff tears; however these are nonspecific [21]. Ultrasonography can be used to supplement diagnostic imaging and allows for dynamic assessment of rotator cuff injury, biceps tendon pathology, labral tears, and glenohumeral instability. While diagnoses of partial-thickness and full-thickness rotator cuff tears have demonstrated a sensitivity of 0.84 and 0.96, respectively, and a specificity of 0.89 and 0.93, respectively, it remains highly operator dependent [22, 23].

MRI remains the gold standard in assessing rotator cuff injuries (Fig. 8.4). A meta-analysis querying the accuracy of MRI in detecting partial-thickness and full-thickness rotator cuff tears demonstrated a sensitivity of 0.80 and 0.91, respectively, and a specificity of 0.95 and 0.97, respectively [24]. Augmenting imaging with contrast arthrography can also assist in the detection of rotator cuff tears, as well as additional intra-articular pathology. Moreover, placing the arm in abduction and external rotation improves the detection of rotator cuff tears [25]. Assessing signal uptake in the tendon or surrounding bursa, as well as differentiating between full and partial rotator cuff tears, is paramount in determining an accurate diagnosis as well as delineating a treatment algorithm. Care should be taken when interpreting MRI in throwing athletes, as abnormalities may represent adaptive changes rather than sources of pain. These changes include capsular remodeling with stretching of the anterior capsule and contracture of the posterior contracture, along with remodeling of the osseous architecture [26]. Furthermore, MRI identified abnormal signal changes in rotator cuff muscles of collegiate baseball pitcher, 40% of whom did not have positive findings on physical exam [27]. Importantly, a musculoskeletal radiologist with a complete history of injury is an invaluable partner in the interpretation of the aforementioned studies.

8.7 Nonoperative Management

Treatment of rotator cuff injuries in the elite athlete is not only guided by the pathology itself but is often nuanced by positional demands and time of year (i.e., in-season vs. postseason). Often a result from chronic overuse, rotator cuff injuries should first be treated with a thorough evaluation of sports-specific mechanics. Reviewing film of the athlete throwing prior to their injury can provide valuable information on their pitching mechanics and any flaws in their throwing motion. Initial management of the elite athlete is often rest. Rest includes complete shutdown from throwing activities for a variable period of time (often 3–6 weeks depending on the pathology). This period of rest is then followed by shoulder-specific rehabilitation protocols for elite athletes [28–31]. A therapeutic regimen that reduces pain and inflammation, restores range of motion, increases strength, and improves neuromuscular control for sports-specific efforts is often employed in addressing rotator cuff injuries conservatively. The foundation for the rehabilitation program is working scapular stabilization exercises. A properly positioned scapula provides a stable backbone for the glenohumeral joint during the throwing motion which is paramount in the overhead athlete.

Once pain has abated (either through cessation of activity or through use of mobilization techniques), joint stiffness should be addressed either through passive mobilization techniques or active-assisted exercises, if otherwise unattainable via active techniques alone. The sleeper stretch remains a salient example of active-assisted joint mobilization when addressing range of motion (Fig. 8.5) (specifically, glenohumeral internal rotation deficit) [28]. Furthermore, as it is important to examine the entire kinetic chain of the shoulder when first assessing a patient, it is important to address those pathologies in the rehabilitation protocols. For instance, range of motion of periscapular musculature is paramount when addressing the possible derangement in the thrower's kinetic chain. Once range of motion has improved, regaining or improving muscle tone should be addressed. A number of exercises have been developed to strengthen the rotator cuff muscles [32]. However, it is crucial to understand that rotator cuff strengthening cannot be done in isolation. As periscapular musculature is paramount in the overhead athlete and directly involved in the kinetic chain of the glenohumeral joint, programs which focus on scapulothoracic motion should not be neglected. The scapula serves as a fulcrum which connects the core to the upper extremity [6]. As aforementioned, abnormal scapular positioning can lead to impingement of the posterosuperior rotator cuff. Numerous techniques have been developed to balance the interplay between the periscapular muscles [33]. Targeting the serratus anterior as the antagonist to trapezius can help in resolving the malpositioned, anteriorly tilted scapula. Finally, neuromuscular coordination and sports-specific training should be initiated, with particular emphasis on proper mechanics and avoidance of any deleterious techniques. This often involves video assessment of the athlete's throwing motion to evaluate their hip to shoulder separation, knee flexion angle at front-foot contact and ball release, elbow flexion angle at ball release, and many others [34].

Fig. 8.5 Sleeper stretch

Often used as an adjunct to rehabilitation techniques, nonsteroidal anti-inflammatories and corticosteroid injections have been widely used to abate the pain and inflammation associated with rotator cuff injuries [35]. Both of these measures should be used with recognition of risks (i.e., gastrointestinal disturbances and tendon rupture, respectively). Corticosteroid injections have been evaluated in the professional setting, with Cohen et al. finding success in the treatment of rotator cuff contusions using corticosteroid injections [36]. Platelet-rich plasma (PRP) has also become available as an intra-articular agent, although current use of PRP has failed to demonstrate efficacy in treating rotator cuff tendinopathy [37].

8.8 Operative Management

If nonoperative treatment is unsuccessful, then operative treatment of rotator cuff tears is considered. Generally, indications for surgical intervention of a rotator cuff injury in an elite athlete are the same as that of a nonathlete, although the outcome is much more guarded. In the elite athlete, caveats such as position, performance limitations, in-season/off-season timing, and concomitant pathologies should be part of the decision-making process. Specifically, a collaborative discussion between the player, physician, and athletic training staff should be undertaken to determine whether a rotator cuff injury can be effectively managed nonoperatively until the off-season, or if the injury precludes elite performance, such that a player requires in-season operative intervention. While the demands of an elite athlete are often supraphysiologic compared to that of a nonathlete, the goal of full-thickness rotator cuff repair remains the anatomic restoration of the rotator cuff footprint.

The approach to partial-thickness rotator cuff tears in the elite athlete is evolving. In the general population, the treatment for these tears is debridement of articular-sided partial-thickness tears less than 50% and repair of those greater than 50% [38, 39]. As the results following rotator cuff repair in elite overhead athletes are not as reliable, many surgeons will consider debriding tears up to 75%, or even more. This stems from the lack of reliability in returning these athletes to an elite level of competition following repair. Approaching partial-thickness articular-sided rotator cuff tears is surgeon dependent. Small, articular-sided rotator cuff tears can be debrided until healthy tissue is reached. Should the tear be larger in depth or essentially complete, a possible approach is converting this to a full-thickness rotator cuff tear and anatomic restoration of the tendinous footprint using suture anchors. Tensioning these partial-thickness rotator cuff tears may create a length-tension mismatch, and alternatively, a transtendinous repair can be used to restore the tendon to a more anatomic position [38]. However, it is important to recognize the supraphysiologic demands placed on elite athletes when compared to that of the general population: Rudziki and Shaffer suggested that partial-thickness tears should approach 75% in elite athletes prior to repair due to the possible failure of repair secondary to exaggerated stresses [23]. This algorithm is expanded by Shaffer and Hultman, who recommend debridement of partial-thickness articular-sided tears when less than 75% and transtendinous repair when greater than 75% [40]. When addressing intratendinous tears, they recommend debridement if the segment is less than 1 cm and horizontal mattress repair if the tear exceeds 1cm [40] (Figs. 8.6 and 8.7). Furthermore, if the depth of the intratendinous segment will dictate the approach and if the depth is 1–2 cm, they recommend an arthroscopic approach,

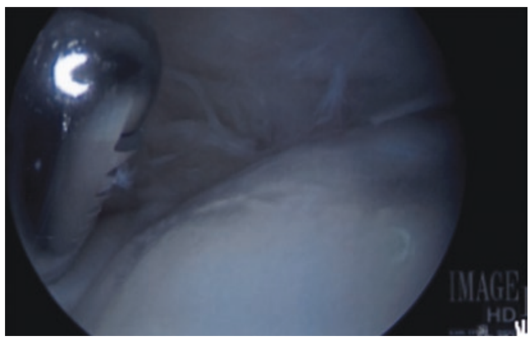

Fig. 8.6 Rotator cuff debridement

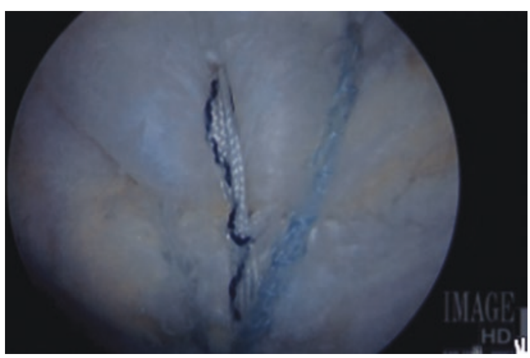

Fig. 8.7 Knotless rotator cuff repair

whereas if the depth exceeds 2 cm, they will consider a mini-open repair [40]. The authors recommend a conservative approach when treating partial-thickness rotator cuff tears in these elite throwing athletes. In players who fail an extended period of nonoperative management, these partial-thickness tears are almost always treated with a debridement, with repair reserved for select cases. In players with symptomatic full-thickness tears, a rotator cuff repair can be considered. Finally, the most important aspect of care of these patients is preoperative counseling and expectation management. A thorough discussion must be had regarding outcomes in the literature in these elite throwing athletes to ensure proper education and decision-making for all parties involved.

8.9 Return to Play

Prior to intervention, a thorough understanding between the player, surgeon, and athletic training staff regarding postoperative expectation is essential. Klouche et al. performed a meta-analysis on 25 studies examining the return to play following rotator cuff repair and found the return to preoperative level of play of 49.9% [41]. Another meta-analysis performed by Harris et al. found that rotator cuff surgery among major league pitchers was 55–73% [42]. When considering both partial- and full-thickness rotator cuff tears in the professional athlete, a systematic review by Reuter et al. found 48% of overhead athletes returned to their preoperative level of play, whereas 91% of contact athletes returned to preoperative level of play [43]. While the expectation of the player may be to return to a pre-injury level of play, Mazoue and Andrews found only 1 of 12 pitchers was able to return to a high level of competition following mini-open full-thickness rotator cuff repair [19]. Further, when examining rotator cuff repair of dominant shoulders in position players, one of two players was able to return to professional baseball. These findings have been expanded by Dines et al., who followed six Major League Baseball pitchers that underwent arthroscopic rotator cuff repair, and found a decrease in postoperative pitching statistics and innings pitched compared to preoperative levels [44]. Again, it is important to appreciate the specific positional demands of the athlete suffering from rotator cuff dysfunction. For instance, in sports with fewer repetitive overhead demands, such as football, return to play following rotator cuff repair has been much more promising: Tambe et al. followed 11 professional rugby players who underwent arthroscopic rotator cuff repair, all of whom returned to preoperative level of play [45]. In fact, Plate et al. found the return to play at 91% in contact sports compared to 40% in professional overhead athletes [46].

Although treatment of partial-thickness rotator cuff tears can vary, when treated with debridement, Payne et al. found that 9 of 14 overhead athletes with acute traumatic injuries were able to return to pre-injury levels of play [47]. They also found that 19 of 29, 13 were able to return to preoperative levels of play. More recently, Reynolds et al. found that 51 of 82 professional baseball pitchers were able to return to play; however only 27 of 82 (55%) were able to return to preoperative levels of play [48]. Intratendinous repair of partial-thickness rotator cuff tears has been investigated by Conway, who showed that 8 of 9 baseball players with intratendinous rotator cuff tears and concomitant SLAP tears were able to return to pre-injury levels of play [16].

8.10 Conclusion

Rotator cuff injuries in the elite throwing athlete are a complex and common cause of pain and dysfunction. Identification of the etiology is an important step in creating an initial treatment protocol. Coupling a thorough history and physical will aid in determining any common concomitant pathological processes, including scapular dysfunction, core weakness, or internal rotation deficit. Once a diagnosis is confirmed with appropriate imaging modalities, a multidisciplinary discussion between the player, physician, and athletic training staff should be employed to determine the most appropriate treatment plan for the player. Variables, including position, performance limitations, in-season/off-season timing, and concomitant pathologies, can guide the length and type of nonoperative management. Prior to surgical intervention, postoperative expectations should be clearly explained to the athlete and treatment team.

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