Shoulder Instability in the Young Athlete

Benton E. Heyworth, MD
Mininder S. Kocher, MD, MPH

Abstract
Shoulder instability is among the most common musculoskeletal injuries and overuse conditions in pediatric and adolescent athletes requiring orthopaedic care. Injury patterns in skeletally immature patients are unique to the developing musculoskeletal system and may be specific to the involved sport. It is helpful to have an outline of the basic diagnostic approaches and to review the literature that guides management principles in young athletes with shoulder instability.


As participation in youth sports continues to increase in number and intensity, musculoskeletal injuries and overuse conditions in pediatric and adolescent athletes are becoming more common.1-3 Although anterior cruciate ligament ruptures, meniscal tears, and osteochondritis dissecans lesions are often cited as evidence of these trends, upper extremity pathology in the young athlete is also occurring more frequently.4 Shoulder instability is among the most common conditions requiring orthopaedic care, and familiarity with its different forms and treatment methods is critical for all physicians who care for pediatric and adolescent athletes. This chapter describes the various types of shoulder instability common in young patients, outlines a basic diagnostic approach, and reviews the literature guiding management principles in this specific population.

Shoulder Anatomy and Maturation
The proximal humeral physis contributes approximately 80% of the longitudinal growth of the upper extremity and typically fuses at ages 14 to 22 years. The hypertrophic zone of the physis is particularly vulnerable to the acute macrotraumatic and chronic microtraumatic forces that can occur in athletic activities.5-9 Salter-Harris type I or II fractures of the proximal humerus should be ruled out for any suspected glenohumeral dislocation in a skeletally immature athlete.10

The capsuloligamentous and muscular structures of the shoulder serve as static and dynamic stabilizers. The dynamic stabilizers are the rotator cuff, deltoid, and scapulothoracic tendons and muscles, which exert a centralizing compressive force on the humeral head against the concavity of the glenoid during the midrange of motion. The static stabilizers (the glenohumeral ligaments, the capsule, the labrum, and the glenoid) function at the terminal range of motion to limit abnormal humeral head translation. Injury to these dynamic and static restraints creates a unique pattern of disability that can limit normal shoulder function in the young athlete.11

The young athlete’s stage of maturation is a unique factor contributing to injury patterns. A skeletally immature athlete has less muscular development than an adult. During the period of rapid growth, there is a predisposition to repetitive overuse injury in the developing physis, as seen in proximal humeral epiphysiolysis or Little League’s shoulder.12-14 Changes in soft-tissue laxity may play an important role. For example, in a newborn,
the predominantly synthesized collagen is elastic type III; as the child grows, the ratio of type III to less elastic type I collagen decreases with each passing year. The role of abnormal collagen or connective tissues, as seen in Ehlers-Danlos syndrome, and the wide range of etiologies contributing to generalized ligamentous hyperlaxity should be considered in all young patients with shoulder instability. Individual variations in the ratio of type I to type III collagen may predispose a young athlete to multidirectional instability (MDI) of the shoulder secondary to laxity of the capsuloligamentous structures.15–17

**Epidemiology**

Injury patterns in the shoulder of the young athlete are often specific to the involved sport. Similar to other acute traumatic injuries of the shoulder, such as acromioclavicular separations and clavicle fractures, traumatic glenohumeral dislocation is more common in contact sports, such as football, rugby, and lacrosse.18–20 Chronic overuse injuries of the shoulder are more common in overhead sports involving repetitive activity, including tennis, swimming, and baseball. Such injuries may include internal impingement and MDI, which generally should be considered more of a chronic condition than its traumatic anterior and posterior instability counterparts.21–23 MDI is also associated with ligamentous hyperlaxity syndromes and collagen disorders, such as Ehlers-Danlos syndrome, in both athletic and non-athletic youth populations.

Although the glenohumeral joint allows a greater arc of motion than any other joint in the body, it is also the most commonly dislocated joint in adolescents and adults. Up to 40% of all primary dislocations occur in patients younger than 22 years.24 Shoulder dislocations are relatively rare in skeletally immature patients; however, some studies have shown impressively high rates of injury in certain subpopulations of young athletes, such as hockey and football players.25,26 Cleeman and Flatow24 reported a 7% incidence of traumatic shoulder dislocations in a group of young hockey players.

**Patterns of Instability**

The three well-described anatomic patterns of glenohumeral instability are anterior, posterior, and multidirectional. Instability may also be classified according to the mechanism of injury; specifically as traumatic or atraumatic), which has important treatment considerations. Inferior, superior, and intrathoracic dislocations are extremely rare, usually associated with severe trauma and high complication rates, and generally not relevant to the discussion of shoulder conditions in athletes.

The most common glenohumeral instability pattern in young athletes is anterior instability, which accounts for 85% to 95% of all instability cases.8 Anterior instability is usually caused by a traumatic acute injury in contact sports or, less commonly, results from a microtraumatic repetitive overuse injury in pitchers or throwing athletes.27,28 A large percentage of shoulder instability in some studied populations, such as young military personnel, involves subluxation or partial dislocation episodes rather than complete, frank dislocation.20 Posterior labral injuries, also called reverse Bankart lesions, occur in approximately 2% to 10% of all patients with shoulder instability;29,30 have been linked to a specific pattern of direct blows to the arm or repetitive athletic activities;31,32 and can occur in association with seizures, electrocution injuries, and severe trauma. This injury pattern, in which macrotrauma or repetitive microtrauma usually occurs with the arm flexed, adducted, and internally rotated, can often be misdiagnosed or remain undiagnosed because of the complexity of symptoms and infrequency in presentation.30 MDI, in which subluxation or dislocation occurs in more than one direction, is also rare and accounts for less than 5% of shoulder instability cases.33 Understanding of the complex and varying pathophysiology of MDI continues to evolve, but it is seen more often in athletes who perform repetitive overhead activities such as throwers, swimmers, and gymnasts, and it is often bilateral. MDI also can be caused by congenital hyperlaxity, abnormalities of the glenoid, or weakness in the rotator cuff.8,34

**Diagnosis**

The diagnosis and basic understanding of a patient's shoulder instability can often be made based on a detailed history and physical examination. Patients with frank anterior dislocation of the glenohumeral joint will most often report having sustained a blow to the arm or hand, with the shoulder in a position of abduction and external rotation. The arm may have been outstretched to withstand a fall to the ground, or a player may have reached out to grab another player moving with speed. Posterior dislocation is much less common and initially may be missed. At the time of injury, the patient may report having withstood a direct blow with the arm in forward elevation, adduction, and internal rotation; that position is common in football lineman during play.35,36 Rates of subluxation, relative to frank dislocation, are high in this pattern of instability.

Players who sustain frank anterior or posterior dislocations may present to the emergency department before or after the dislocation has been reduced. In many instances, a spontaneous re-
duction will have occurred; this is more common with chronic, recurrent anterior instability and MDI. More commonly, however, manual reduction is needed and can be facilitated by sedating the patient. A variety of reduction maneuvers can be performed.

The physical examination of a patient with a suspected acute dislocation is critical, particularly if there is a substantial delay in obtaining radiographs. In such instances, a sideline reduction may be considered. The first step in treating a traumatic shoulder injury is a meticulous neurovascular examination because an injury to the axillary nerve can occur in association with glenohumeral dislocation and should be understood and documented before any intervention.18,37 A patient with an anterior dislocation will generally hold the arm at his or her side and will not tolerate attempted motion of the shoulder. A subacromial defect or concavity may be visible in the soft tissue, with the humeral head palpable anteriorly.

Although there is no consensus or guideline regarding the need for radiographic confirmation before reduction of a suspected glenohumeral dislocation, radiographs should be obtained whenever possible because of the possibility of a Salter-Harris fracture involving the growth plate. Radiographic assessment should include AP and Y-scaphular lateral views and an axillary lateral view to clearly establish the location of the humeral head in relation to the glenoid and assess for a possible fracture of the glenoid rim (a bony Bankart lesion) or the humeral head (a Hill-Sachs lesion). The West Point axillary view may be necessary if the patient cannot tolerate abduction, and the Stryker notch views may be helpful to assess for Hill-Sachs lesions.38-40

In the subacute setting or at an office visit after a dislocation, the physical examination should include a comprehensive shoulder assessment, with particular focus on instability maneuvers. Positive anterior apprehension and relocation tests are the classic findings associated with anterior instability, whereas a posterior jerk test is generally positive with posterior labral pathology.41-43 An inferior sulcus sign is usually positive with MDI.44-46 Load and shift testing in an appropriately relaxed patient, usually in the supine position, can detect the degree to which the humeral head can be subluxated or dislocated in the anterior or posterior directions.47,48

MRI or magnetic resonance arthrography should be obtained to confirm a suspected capsulolabral injury, such as a Bankart tear (a tear of the anteroinferior glenoid labrum), a posterior labral tear, or other associated injuries. Contrast material may not be needed to identify Bankart lesions and other shoulder conditions.49 However, magnetic resonance arthrography remains the gold standard for advanced imaging of traumatic labral pathology. Although a high rate of rotator cuff tearing has been reported in adults in association with shoulder dislocations,50 this finding has not been replicated in the pediatric or adolescent populations. However, in adolescents, superior labral anterior to posterior tears most commonly occur in association with shoulder instability patterns and concomitant anterior and posterior labral tears.50-52 Radiographs and MRIs of patients with MDI are often normal, other than the presence of a patulous capsule with increased volume. If a bony Bankart lesion or large Hill-Sachs lesion is appreciated on radiographs, some physicians recommend CT to better understand and quantify the size of the bony defect because large defects may require alternative procedures or procedures in addition to simple labral repair or capsularorrhaphy.53-55

Management of Anterior Instability

The appropriate first-line treatment of a young athlete with a traumatic anterior dislocation remains controversial.56,57 High rates of recurrent instability have been reported after a first dislocation in patients younger than 20 years.12,58-60 Rowe et al61 and Marans et al62 reported 100% redislocation rates in small studies of skeletally immature patients treated nonsurgically. Robinson et al63 prospectively assessed a series of 252 young patients (age range, 15 to 35 years) and reported that 56% of the patients had recurrent instability episodes at a mean follow-up of 13 months after nonsurgical management. Risk factors for redislocation included male sex and age younger than 20 years. The risk of dislocation recurrence continued to increase over a 5-year period (Figure 1). Although the causes of redislocation in young athletes are likely multifactorial, high-demand activities, collision sports, and ligamentous laxity have been proposed as contributors to the condition.64 In a randomized study of first-time dislocations, patients treated with arthroscopic repair had a 76% lower risk of redislocation than patients treated with arthroscopic lavage and had better functional scores, higher return to previous activity level, and greater satisfaction, along with lower treatment costs.65 In a prospective multicenter study, Hovelius et al66 reported on a large cohort of patients with primary anterior shoulder dislocations who were followed for 25 years. More than 50% of the patients ages 12 to 25 years at the time of the primary dislocation had a recurrent dislocation, and redislocation was at least twice as common in this group as a comparable group of older patients. There was a clear trend in the younger subgroups toward a greater risk of
recurrence with younger age. Notably, the rate of recurrence reported by Robinson et al\textsuperscript{63,65} for nonsurgically treated patients was 67% in all patients followed for 5 years, and the estimated probability for male teenagers ranged from 75% for a 19-year-old patient to 86% for a 15-year-old patient (Table 1).

In an attempt to reconcile the range of risk factors with subpopulations of dislocators, Bishop et al\textsuperscript{67} used expected-value decision analysis to assess the optimal treatment strategy for patients with primary traumatic anterior glenohumeral dislocations (Figure 2). The authors concluded that arthroscopic stabilization was preferred over nonsurgical care by most patients. Sensitivity analysis was used to model the decision-making process for pa-

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**Figure 1**  Graph showing the timing of the onset of instability in patients who had recurrent instability after a primary dislocation. (Reproduced with permission from Robinson CM, Howes J, Murdoch H, Will E, Graham CJ: Functional outcome and risk of recurrent instability after primary traumatic anterior shoulder dislocation in young patients. J Bone Joint Surg Am 2006;88(11):2326-2336.)

**Figure 2**  Decision tree reflecting decision analysis of surgical versus nonsurgical treatment of initial traumatic anterior glenohumeral dislocation. In this model, arthroscopic stabilization is the optimal management strategy. Per convention, utility data are placed to the right of the terminal nodes and probability data are placed under the terminal nodes. (Reproduced with permission from Bishop JA, Crall TS, Kocher MS: Operative versus nonoperative treatment after primary traumatic anterior glenohumeral dislocation: Expected-value decision analysis. J Shoulder Elbow Surg 2011;20(7):1087-1094.)
Variations of Classic Anterior Instability

Certain subpopulations of dislocators or those with variations of classic anterior instability warrant additional discussion. Pathologic anterior instability should not be considered limited to frank dislocation events. Many patients may have labral tears with subluxation events alone; evidence suggests that such patients should be evaluated similarly to young athletes with true dislocations. Owens et al. prospectively analyzed the outcomes of 38 military cadets (mean age, 20 years) who had first-time subluxation events. Of those in whom MRI was obtained, 96% showed signs of a Bankart lesion, and 93% had signs of a Hill-Sachs lesion. More than 50% of the patients were treated surgically. Of those treated nonsurgically, 31% had recurrent subluxations or dislocations. Another variation of classic anterior instability is associated with a humeral avulsion of the glenohumeral ligament lesion, which is generally believed to be as or more debilitating than a Bankart tear. Cordischi et al. reported on 14 young patients (ages 10 to 13 years) with dislocations who were followed for 5.6 years. The three patients with a humeral avulsion of the glenohumeral ligament required surgery, whereas the other 11 patients had successful outcomes without surgery. Although debate continues regarding the optimal treatment in patients with first-time anterior dislocations, surgical treatment is generally recommended in young athletes with recurrent anterior instability episodes, despite adherence to a sound rehabilitation regimen.

Nonsurgical Treatment

Nonsurgical treatment of a primary anterior dislocation usually begins with a short 1- to 3-week period of sling immobilization of the shoulder. Because studies have not supported a benefit from postdislocation immobilization, it is generally prescribed for comfort only. The optimal shoulder position for immobilization (internal or external rotation) is also controversial. A randomized controlled study reported a 40% lower recurrence rate after 3 weeks of immobilization in external rotation compared with internal rotation. These results have not yet been rigorously studied in multiple populations, and another randomized controlled study suggested that the two positions offer similar outcomes. A course of physical therapy should be initiated early and should focus on periscapular and rotator cuff strengthening exercises. Following an appropriate rehabilitation program, patients should be reexamined to assess instability at a minimum...
of 4 to 6 weeks after the dislocation. Persistently positive apprehension and relocation signs increase the risks for recurrence. A full range of motion, or at least fully functional range of motion for the specific sport, and strength symmetry should be present before clearance for return to play. There is no good evidence to support the effectiveness of protective shoulder braces, which are designed to control abduction and external rotation, in preventing recurrence. These braces are often poorly tolerated in the adolescent population; however, certain positional athletes, such as football lineman, may be reasonable candidates for a trial of bracing.

Surgical Treatment
Surgical treatment includes repair of the capsulolabral injury, with or without additional capsular restoration. Arthroscopic thermal capsulorrhaphy, which surged in popularity in the 1990s as an adjunctive and primary measure in shoulder instability surgery, has been more recently associated with concerning rates of chondrolysis, capsular tissue injury, recurrent instability, and revision surgery; its use is not recommended. Both arthroscopic and open methods of anterior shoulder stabilization surgery have been described. Recurrence rates after arthroscopic repair with suture anchors have improved over time because of new methods, equipment, and implants and are now equal to those of a classic open Bankart procedure. A meta-analysis that included studies of older arthroscopic techniques used in adults and children found that open procedures were more reliable for restoring stability and allowing the patient to return to work or sports. However, patients had better Rowe scores after arthroscopic repair, possibly because of lower rates of stiffness and better function. There have been few studies of arthroscopic repair of shoulder instability in adolescents only. A retrospective study of 32 shoulders in patients ages 11 to 18 years reported 5 redislocations (16%) 2 years after arthroscopic repair, with 2 of the redislocations occurring in one patient with familial hyperlaxity. Eleven of the patients returned to sports and had high scores on the Single Assessment Numeric Evaluation. Other studies, involving both adolescent and adult patients, have reported good results in adolescents.

Management of Posterior Instability
Isolated posterior instability in contact athletes has become better understood and appreciated in recent decades. Physical therapy is usually the first-line treatment, with a focus on strengthening of the posterior dynamic stabilizers, specifically the infraspinatus and teres minor muscles. When symptoms of persistent posterior pain or recurrent instability limit the activities of daily living, such as the ability to push a heavy door in nonathletic patients, or limit performance in young athletes, surgery may be considered. Generally, a posterior labral injury is seen on MRI but may appear intact in association with a reverse Hill-Sachs lesion or a suggestion of posterior capsular laxity. Good to excellent results have been reported in multiple studies of both arthroscopic and open posterior stabilization procedures, although one retrospective comparative study in patients ages 15 to 35 years suggested the best results were achieved in a stratified cohort of arthroscopically treated patients. When posterior instability recurs despite adequate arthroscopic treatment, an open approach should be considered. Good results have been reported in patients with a wide range of ages who had open treatment of recurrent posterior glenohumeral instability. A recurrence rate of 19%, no progressive articular degeneration seen at long-term follow-ups, and better results in younger patients and those without chondral defects have been reported. There are few published reports of outcomes for posterior instability in the pediatric and adolescent populations. A study by Kawam et al assessed the outcomes of seven shoulders in six patients ages 9 to 17 years who were treated with shoulder stabilization using Putti-Platt-type capsulorrhaphy. One of the six patients required revision surgery, but all shoulders were stable at a mean follow-up of 9.4 years. One patient was limited in racquet sport participation because of shoulder apprehension. Validated outcome measures were not used in the study. The authors concluded that patient selection is critical, with the following requisite criteria for surgical consideration: history and physical examination findings specific for recurrent isolated posterior instability, failure of a minimum of 6 months of conservative therapy, significant disability, and the absence of psychologic factors (such as habitual dislocation for secondary gain) influencing the clinical picture. More research is needed to improve the understanding of posterior instability in the younger patient and its optimal management.

Management of MDI
Nonsurgical management is the mainstay of MDI treatment and generally achieves good results. A vigorous physical therapy program focusing on rotator cuff and periscapular strengthening is necessary to optimize the role of the dynamic stabilizers, the function of which are critical in patients with deficient static (ligamentous) stabilizers. Burkhead and Rockwood reported an 80% rate of good or excellent re-
results with an appropriate exercise program for a series of patients subject to recurrent atraumatic dislocations. Surgery is indicated for patients with symptoms that are debilitating or severely limit activities after at least 6 months of compliant rehabilitation. Arthroscopic or open capsulorrhaphy should focus on the symptomatic direction of the instability. Newer arthroscopic techniques have achieved encouraging results in adults and adolescents, including a return to sports in 89% and a satisfactory outcome in more than 90%. Although MDI is commonly seen in the pediatric population, there are few reports focusing on younger patients. One study highlighted the association of MDI and the presence of Sprengel deformity, which should be assessed in all patients.

**Summary**

The incidence of shoulder injuries in pediatric athletes is increasing, along with participation in high-demand sports by children at younger ages. Injury patterns in skeletally immature patients are unique to the developing musculoskeletal system and may be specific to the involved sport. A prompt and accurate diagnosis coupled with proper treatment can prevent long-term sequelae and expedite return to play. Although many injuries respond well to a nonsurgical regimen of rest and rehabilitation, surgical management is necessary in certain circumstances. Injury prevention strategies are also critical and should be encouraged in young athletes with risk factors for primary or recurrent injury.

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