

Adolescent Shoulder Injuries: Consensus and Controversies

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Abstract

Adolescent participation in sports is at an all-time high. Younger patients also are competing with a greater intensity level, frequently playing organized sports throughout the year. Players are putting greater demands on their shoulders, making them more prone to injuries. Because these players are in the process of skeletal development, certain considerations are needed for this patient population. There is controversy regarding the appropriate treatment of these adolescent athletes— including debate on injury prevention; nonsurgical treatment versus surgical treatment; overuse injuries; and return to play after shoulder fractures, dislocations, and instability. It is valuable to review evidence in the current literature regarding recommendations for the treatment of shoulder injuries in adolescent athletes.

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Participation in athletics by adolescents continues to increase. Annually, approximately 45 million children and adolescents in the United States participate in organized youth athletics.¹ More than 7.3 million high-school athletes, representing more than 50% of the US high-school population, participated in sports during the 2006–2007 school year. This was the 18th consecutive year in which participation had increased.² Little League baseball recorded more than 2.6 million participants in 2007, and Pop Warner

football tallied 380,000 participants.^{3,4} The increased involvement in athletics and the demands of sports on teenagers have been accompanied by an increase in injuries. High-school athletes sustain an estimated 2 million injuries annually, resulting in approximately 500,000 physician visits and 30,000 hospitalizations each year.¹

There is a continuing trend for many young athletes to focus on a single sport and to subspecialize in that sport earlier in their careers. Countless athletes play on multiple

teams, year-round, in a given sport with limited rest. This can place exceptional demands on the musculoskeletal system of these young athletes, especially the shoulders of athletes who perform overhead activities such as baseball pitchers.

In this chapter, the spectrum of traumatic and overuse shoulder injuries in adolescent athletes are discussed. The management of these injuries in this population requires special considerations and is not without debate. The current consensus and controversies will be explored.

Fractures

Clavicular Fractures

The S-shaped clavicle is a strut connecting the shoulder girdle to the axial skeleton; its superficial location makes it susceptible to injury. Clavicular fractures are common in children, accounting for 10% to 15% of fractures in that population. Up to 90% of these fractures occur in the midpart of the shaft of the bone. Most fractures are caused by a direct fall onto the lateral aspect of the shoulder. Direct blows to the clavicle (for example, by a hockey or lacrosse stick) account for only approximately 10% of midshaft

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Figure 1 Clinical appearance (A) and AP radiograph (B) of an acute clavicular fracture in an 11-year-old boy. C, The clavicular fracture is healed 1 year after nonsurgical treatment.

fractures. An indirect mechanism (such as a force transmitted to the clavicle from a fall onto an outstretched hand) is estimated to cause less than 5% of these injuries.⁵

Regardless of the patient's age, nondisplaced clavicular fractures should be treated nonsurgically. Initially, patients can wear a simple arm sling. The figure-of-8 brace is no longer recommended because it causes greater discomfort without an improvement in outcome.⁶ A displaced clavicular fracture in a skeletally immature patient has excellent healing and remodeling potential with a low risk of nonunion.⁷ Therefore, good results can be expected with nonsurgical treatment of patients who are younger than 12 to 13 years and have substantial growth remaining.

The patient is allowed to return to sports activity when there is both clinical and radiographic evidence of union. The fracture site should be nontender, a full range of motion of the shoulder should have been reestablished, and arm strength should be comparable with that of the uninjured limb before the individual is cleared to play. This usually requires between 4 and 10 weeks, depending on the age of the patient, with younger patients having more rapid healing⁷ (Figure 1). Individuals be-

tween ages 15 and 20 years have less growth remaining and a decreased remodeling potential, thus management of these patients is controversial. A displaced clavicular fracture can be managed nonsurgically unless it is complicated by compromised skin or a neurovascular deficit. Three months may be required for adequate healing of a displaced clavicular shaft fracture in a patient between ages 15 and 20 years. McKee and associates⁸ used patient outcome measurements and strength testing to follow 30 patients in whom a displaced midshaft clavicular fracture had been treated nonsurgically. They found residual strength deficits compared with the uninjured side that correlated with a significant level of dysfunction as demonstrated by Constant shoulder scores ($P = 0.01$) and Disabilities of the Arm, Shoulder and Hand (DASH) questionnaires ($P = 0.02$). A recent systematic review of displaced midshaft clavicular fractures showed the nonunion rate to be 15.1% (24 of 159 patients) after nonsurgical treatment compared with 2.2% (10 of 460 patients) after open reduction and plate fixation.⁹ On the basis of these studies, surgeons should consider surgical treatment of displaced clavicular fractures in older adolescents.

Surgical fixation is an effective treatment of displaced clavicular fractures in skeletally mature patients, and it usually allows them to return to sports activity sooner than patients treated with nonsurgical methods (Figure 2). In a multicenter randomized trial of displaced midshaft fractures in 132 patients, patient-oriented outcomes and complication rates after nonsurgical management with a sling were compared with those after plate fixation.¹⁰ In this study, 7 of 65 patients treated with the sling went on to have a nonunion compared with 2 of 67 patients treated with plate fixation. In addition, a symptomatic malunion developed in nine patients treated nonsurgically compared with none in the surgical group. Patients treated with surgery had a significantly shorter time to radiographic union ($P = 0.001$) and significantly better DASH ($P < 0.01$) and Constant ($P = 0.001$) shoulder scores at 1 year. Compared with their nonsurgically treated counterparts, these patients also had an earlier return to normal function, a lower risk of nonunion, and increased satisfaction with their shoulders. The most frequent complication in the surgical group was symptoms caused by hardware. Additional investigation is required to

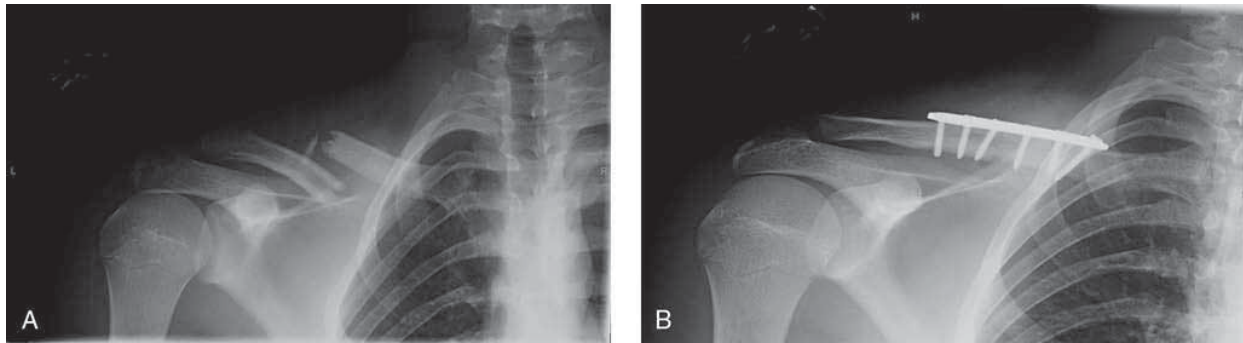


Figure 2 A, Displaced midshaft clavicular fracture. B, Open reduction and internal fixation of the displaced midshaft clavicular fracture with plate and screws.

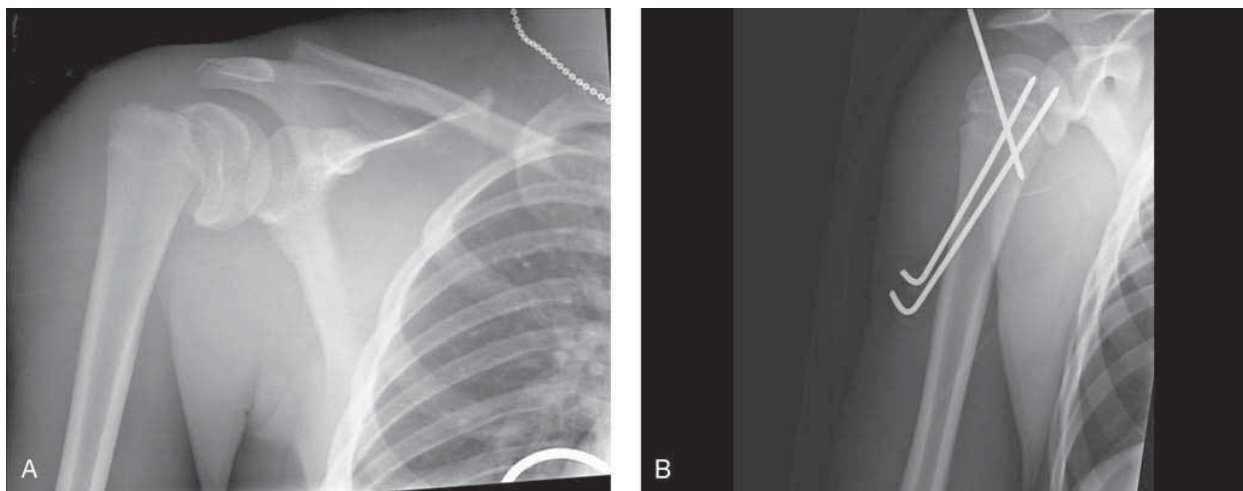


Figure 3 A, Displaced proximal humeral fracture in a skeletally immature patient. B, Percutaneous fixation of the fracture.

determine the ideal type of internal fixation of these fractures (pin fixation or plate fixation).

Proximal Humeral Fractures

Less than 5% of fractures in the adolescent age group involve the proximal part of the humerus. Proximal humeral fractures are most common between the ages of 11 and 17 years, and 20% of these injuries occur as a result of a traumatic event during athletic participation.⁷ The mechanism of injury is either a direct blow to the arm during contact sports or a fall onto the outstretched hand. Ad-

olescents most often sustain Salter-Harris type II injuries with metaphyseal extension.¹¹ Concomitant dislocation of the humeral head is possible and must be ruled out during the initial evaluation (Figure 3).

The proximal humeral physis accounts for 80% of the longitudinal growth of the humerus, which allows substantial healing and remodeling potential.¹² Good long-term results have been reported after sling immobilization in children younger than 11 years, regardless of the amount of displacement. In this age group, the fractures are almost always stable, and

pendulum exercises are initiated as soon as pain allows. Patients who have completed their growth or who are approaching skeletal maturity have a decreased potential for remodeling and therefore cannot tolerate more than a minimal amount of fracture displacement or angular malalignment.¹²

Gross displacement or angular deformities in adolescents should be treated with closed reduction. Longitudinal traction while external rotation, abduction, and flexion forces are applied to the distal fragment aligns the distal fragment with the

Table 1
Age Recommendations for Learning Various Pitches

Pitch	Age (year)
Fastball	8 ± 2
Change-up	10 ± 3
Curve ball	14 ± 2
Knuckle ball	15 ± 3
Slider	16 ± 2
Fork ball	16 ± 2
Screw ball	17 ± 2

Table 2
2007 Little League Rules for Pitch Count

Age (years)	Maximum Pitches Per Day
17-18	105
13-16	95
11-12	85
≤ 10	75

humeral head. Acceptable reduction in a child older than 11 years is less than 50% displacement and less than 40° of angulation.^{13,14} If the fracture is deemed stable after reduction, it is immobilized for 3 to 4 weeks. However, fracture reduction can be difficult to maintain, and stabilization with percutaneous pin fixation may be required (Figure 3, B). Open reduction is rarely necessary; however, it is recommended when an acceptable closed reduction cannot be achieved. An inability to achieve closed reduction is usually due to soft-tissue interposition.

Throwing Injuries

Several studies have demonstrated differences, most likely secondary to adaptive changes, between the shoulders of athletes who throw and those who do not. Structural changes in the skeletally immature proximal part of the humerus of baseball pitchers have been the subject of several studies. In one series of 79 male baseball players between ages 8 and 15 years, radiographs of

the proximal part of the humerus showed an increase in physal width in the dominant shoulder regardless of whether it was symptomatic.¹⁵ CT scans documented a significant increase in retroversion of the humeral head ($P < 0.001$) and glenoid ($P < 0.01$) in the dominant arm of 25 professional pitchers.¹⁶ These changes are believed to occur during skeletal immaturity in young pitchers and may be secondary to repetitive external rotation stresses, in accordance with Wolff's law.¹⁶⁻¹⁸

A comparison of the two shoulders of a throwing or nonthrowing athlete should show the rotational arcs, in 90° of abduction, to be within 5° of each other.¹⁶ However, when compared with the contralateral side, the dominant arm of throwers exhibits increased external rotation with an associated loss of internal rotation. These changes increase with age according to one study.¹⁵

Repetitive microtrauma can lead to pain and disability, particularly in adolescent throwing athletes. The risk of injury in adolescent throwers

has been shown to increase with age and the level of competition.¹⁷ To further understand why arm disorders developed in adolescent pitchers, Lyman and associates¹⁹ prospectively studied a cohort of 476 baseball pitchers ages 9 to 14 years for an entire season. One half of the athletes had elbow or shoulder pain during the season. Throwing breaking balls was associated with an increased risk for the development of symptoms. There was a 52% increase in the risk of shoulder pain associated with throwing curveballs and an 86% increased risk of elbow symptoms associated with throwing sliders. Shoulder pain ($P < 0.01$) and elbow pain ($P < 0.01$) were significantly correlated with the number of pitches thrown during a season. These findings suggested that placing limits on the number and type of pitches thrown might decrease the prevalence of shoulder and elbow symptoms in the adolescent thrower.

The American Sports Medicine Institute was commissioned by the USA Baseball Medical and Safety Advisory Committee to study pitching limits in youth baseball. They made recommendations regarding pitch counts and when young throwers should start throwing breaking pitches²⁰ (Table 1). The current Little League rules regarding pitch counts and rest requirements are shown in Tables 2 and 3.²¹ Lyman and associates¹⁹ discouraged pitching in multiple baseball leagues because this can be a means of circumventing pitch limits. They promoted educating aspiring pitchers on proper pitching mechanics despite failing to establish a relationship between elbow and shoulder symptoms and poor mechanics.

"Little Leaguer's shoulder" is characterized by progressive upper-

arm pain with throwing. It is seen most frequently in male baseball pitchers between the ages of 11 and 14 years.⁷ It is in this age range that growth in the proximal physis is at its peak, making it susceptible to injury.¹² The exact etiology of Little Leaguer's shoulder is unknown, but it seems to be related to repetitive rotational stress. The proximal part of the humerus is believed to bear much of this load as a result of decreased muscle development in this age group.²² In addition to age and rotational forces, the frequency of pitching and poor throwing mechanics may be risk factors.¹² The condition is best described as an epiphysiolysis. Findings on plain radiographs can include widening of the physis, metaphyseal sclerosis, osteopenia, and fragmentation^{12,23} (Figure 4). Conceptually, Little Leaguer's shoulder is believed to be a stress fracture or a Salter-Harris type I injury to the proximal humeral physis.¹² MRI can aid in the diagnosis when the findings on the initial radiographs are negative and suspicion is high.

Treatment of Little Leaguer's shoulder consists of activity modification and education. The athlete should refrain from throwing until symptoms resolve. The recommended time before the resumption of throwing activity depends on the duration of the symptoms. A gradual return to sports activity is advocated. The patient should be coached regarding proper pitching mechanics, and a preseason conditioning program should be instituted to emphasize strengthening of the periscapular, rotator cuff, and

core musculature as well as capsular stretching.

Symptoms of impingement are rare in adolescent throwers. They can be secondary to either external or internal sources. External impingement associated with a subacromial spur, a type III acromion, or hypertrophy of the acromioclavicular joint is particularly uncommon in adolescents.²⁴ Internal impingement is defined as an abutment of the articular side of the supraspinatus tendon and the greater tuberosity with the postero-

Table 3
2007 Little League Rules for Rest

Number of Pitches Per Day	Calendar Days of Rest
Pitchers ≤ 16 years old	
≥ 61	3
41 to 60	2
21 to 40	1
1 to 20	0
Pitchers 17 to 18 years old	
≥ 76	3
51 to 75	2
26 to 50	1
1 to 25	0

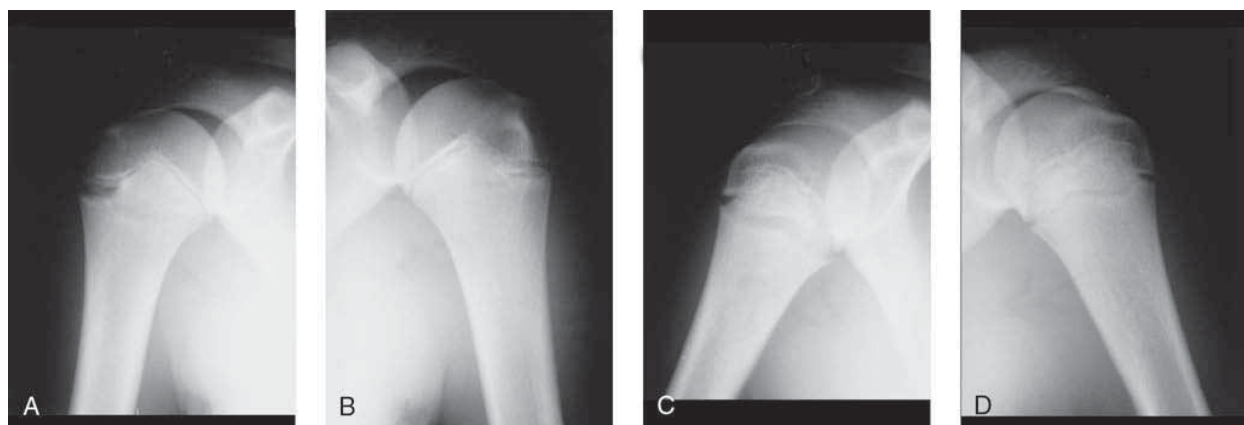


Figure 4 External rotation (A and B) and internal rotation (C and D) comparison radiographs of a skeletally immature patient with Little Leaguer's shoulder. Note the physeal widening in the right throwing shoulder (A and C) compared with the left shoulder (B and D). (Reprinted with permission from Carson WG Jr, Gasser SI: Little Leaguer's shoulder: A report of 23 cases. *Am J Sports Med* 1998;26:577.)

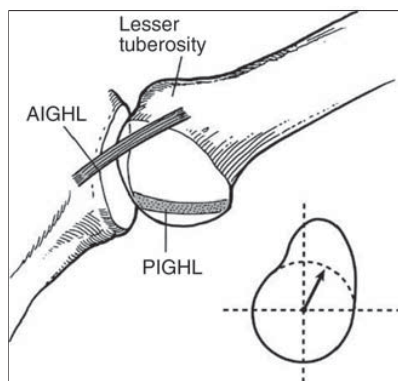


Figure 5 With abduction and external rotation of a normal shoulder, tension develops reciprocally and equally in the anterior and posterior bands of the inferior glenohumeral ligament. The center of rotation remains approximately at the glenoid bare spot. AIGHL = anterior band of the inferior glenohumeral ligament, PIGHL = posterior band of the inferior glenohumeral ligament. (Reprinted with permission from Burkhart SS, Morgan CD, Kibler WB: The disabled throwing shoulder: Spectrum of pathology. Part I: Pathoanatomy and biomechanics. *Arthroscopy* 2003;19:411.)

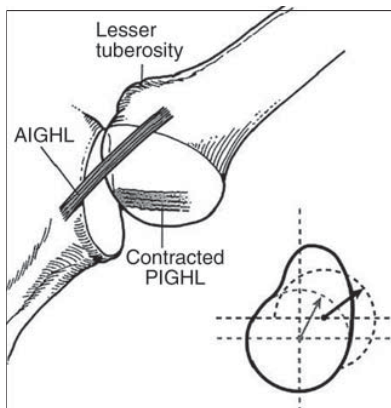


Figure 6 When there is contraction of the posterior aspect of the capsule, the posterior band of the inferior glenohumeral ligament shortens, the glenohumeral contact point shifts posteriorly, and the allowable arc of external rotation increases substantially (dotted lines). PIGHL = posterior band of the inferior glenohumeral ligament, AIGHL = anterior band of the inferior glenohumeral ligament. (Reprinted with permission from Burkhart SS, Morgan CD, Kibler WB: The disabled throwing shoulder: Spectrum of pathology. Part I: Pathoanatomy and biomechanics. *Arthroscopy* 2003;19:411.)

superior aspect of the glenoid rim and labrum in the extremes of abduction and external rotation. This position is encountered in the late cocking phase of pitching. Internal impingement is believed by many to be physiologic. However, some believe that repetitive collisions of the rotator cuff tendons with the glenoid labrum during pitching can lead to attritional injuries of the cuff and superior aspect of the labrum, resulting in shoulder dysfunction.²⁵

An alternative explanation for shoulder dysfunction in throwers was proposed by Burkhart and associates²⁶ who hypothesized that altered throwing mechanics are secondary to a pathologic cascade involving many factors. In this cascade, the essential lesion leading to shoulder dysfunction is a contracted posterior

part of the capsule, which causes a posterosuperior translation of the humeral head. Distraction loads on the posterior aspect of the capsule during follow-through are believed to lead to this pathologic change.²⁶ Clinically, this is manifested as a glenohumeral internal rotation deficit. The alteration in the position of the humeral rotation point on the glenoid causes increased shear stress on the superior aspect of the labrum and can lead to superior labral tears. Burkhart and associates²⁷ also proposed scapular dyskinesia as a contributor to a thrower's shoulder pathology. They believed that pathologic internal impingement is encountered in only extreme external rotation during the late cocking phase ($> 130^\circ$) and is usually en-

countered only in older elite athletes, not adolescents²⁶ (Figures 5 and 6).

The maintenance of shoulder health in adolescent throwers is achieved by an appropriate stretching and strengthening program as a normal part of their routine, not just in the preseason. Young pitchers should be coached regarding proper throwing mechanics, which involve the coordination of all muscle groups, including the lower-extremity and core musculature, to generate the forces required to pitch at high velocities. This coordinated muscle activity protects the involved joints by redistributing the forces to the distal segments.²⁷ Therefore, strengthening the core muscles of the thoracic and lumbar spine and the abdomen as well as the lower extremities should be a key component in a thrower's exercise program. A stable shoulder girdle is also critical to proper pitching mechanics, and strengthening the periscapular muscles is as important as strengthening the rotator cuff.^{22,27}

A glenohumeral internal rotation deficit is secondary to tightness of the posterior aspects of the capsule and rotator cuff, which can lead to altered shoulder mechanics and possibly to injury. Routine stretching of the posterior aspects of the capsule and rotator cuff should be part of a young pitcher's conditioning program. In their three-part summary on the disabled throwing shoulder, Burkhart and associates²⁶ described two studies to illustrate this point. In one prospective study, a cohort of tennis players was followed for 2 years. They were divided into two groups: one performed daily posterior capsular stretching exercises to minimize glenohumeral internal rotation deficit and the other did not. The group that performed the

stretching exercises had a 38% decrease in shoulder disorders. In the second study, major-league baseball players who performed daily stretches to maintain internal rotation to within 20° of that of the contralateral shoulder missed no innings of play and had no intra-articular problems or surgical procedures during three seasons. Thus, correcting or preventing a glenohumeral internal rotation deficit appears to be a key component of preventing injuries in throwers.

Pain in the shoulder of an adolescent is abnormal and should be evaluated. Young throwers should be discouraged from pitching while they have pain, as shoulder deconditioning and persistent improper mechanics may cause injury. Once structural damage to the shoulder has occurred, the treatment becomes surgical. Fortunately, structural damage is rare in adolescent pitchers.

The pathologic entities encountered most commonly, usually in older elite throwers, are partial-thickness tears of the rotator cuff and superior labrum anterior posterior (SLAP) lesions. Jazrawi and associates²⁵ reported excellent results in 76% of 73 baseball pitchers who were followed for 13 months following rotator cuff and labral débridement. There is some debate about the exact mechanism leading to superior labral tears. Burkhart and associates²⁶ described a “peel-back” mechanism, in which the biceps tendon is pulled posteriorly during abduction and external rotation, creating a torsional force on the posterosuperior aspect of the labrum. Jazrawi and associates²⁵ proposed the “weed-pull” theory, in which a posterior force is exerted on the superior aspect of the labrum during the late cocking phase of throwing and an anterior force occurs during follow-through

and arm deceleration. Regardless of the exact mechanism, a type II SLAP lesion, in which the biceps labral anchor is detached from the superior aspect of the glenoid, is most commonly encountered in throwers. The labral tear most often extends posterior to the biceps anchor or is a combined anterior and posterior detachment.²⁵

The consensus is that these lesions should be treated with arthroscopic surgical stabilization. Suture anchors are the most common type of fixation. Postoperative rehabilitation includes shoulder immobilization and wrist, hand, and elbow exercises for 4 weeks, after which shoulder range-of-motion and gentle strengthening exercises are begun. At 4 months, a gradual supervised throwing program begins. An athlete should not return to full competition until 6 to 12 months following surgery.

Instability

Shoulder instability in adolescent patients can be classified as atraumatic or traumatic, a distinction that is important in terms of treatment. Patients with traumatic instability usually have a single initiating event, consisting of a traumatic subluxation, a dislocation with spontaneous reduction, or a dislocation requiring a closed reduction. The shoulder is the most commonly dislocated joint in the body, with traumatic anterior dislocation accounting for most of these injuries. Traumatic shoulder dislocations are associated with a high incidence of pathologic changes. Structural damage can occur in both the osseous architecture and the soft tissues surrounding the shoulder joint. In studies involving arthroscopic examination, a Bankart lesion was demonstrated in 87% to 100% of shoulders of patients with a first-

time dislocation, and a Hill-Sachs defect was seen in 90% to 100%.²⁸⁻³⁰ SLAP tears have been found in 10% of patients with a traumatic shoulder dislocation.²⁸ Dislocations are of particular concern in the adolescent population because of the high risk of recurrence in these young, active patients. In one study, only 16% of patients with traumatic instability had a good or excellent result following nonsurgical treatment.³¹ In a retrospective chart review, Marans and associates³² found a 100% rate of redislocation in 21 skeletally immature patients treated with a sling for up to 6 weeks. Hovelius³³ reported a 76% rate of recurrence in Swedish hockey players; the recurrence rate was 90% when the initial dislocation had occurred when the player was younger than 20 years, but it was 50% when the initial dislocation had occurred when the player was older than 25 years. In a prospective cohort study of 252 patients, age 15 to 35 years, 55.7% were found to have instability by 2 years after treatment of an anterior shoulder dislocation with a sling, and the rate increased to 66.8% by 5 years.³⁴ Important risk factors for recurrence were age and male sex. Other studies have shown the recurrence rate in patients younger than 30 years to be as high as 75% to 96%.³⁵⁻³⁷

Atraumatic instability is multidirectional, and many patients cannot recall an inciting incident. This condition can be congenital (such as in patients with global ligamentous laxity) or acquired (as is often the case in young overhead throwing athletes whose shoulders are subjected to repetitive stress). The diagnosis necessitates documentation of instability in more than one direction, and it can be present bilaterally.³⁸ The mainstay of treatment of adolescents with

multidirectional instability is nonsurgical. Burkhead and Rockwood³¹ demonstrated good or excellent results in 80% of patients with atraumatic shoulder subluxation treated with an exercise program. Therefore, the importance of understanding the etiology of the patient's instability before one recommends conservative management with an exercise program was underscored in this study. Burkhead and Rockwood³¹ advocated a progressive-resistance program to strengthen the dynamic stabilizers of the shoulder. In addition, a key element is strengthening the scapular stabilizers, with a focus on the trapezius, serratus anterior, and rhomboids.

Shoulder instability is uncommon in adolescent throwers. However, there is agreement that instability should be assessed both clinically and arthroscopically in patients undergoing surgery. Burkhart and associates³⁹ suggested that excessive external rotation ($> 130^\circ$) on clinical examination may be an indication for anterior capsular plication to correct anterior capsular redundancy.

Both open and arthroscopic procedures are options for a patient who does not respond to nonsurgical measures. Studies of open capsular plication have shown 88% to 100% rates of good-to-excellent results, with a recurrence rate of up to 10%.⁴⁰⁻⁴² With improved techniques, similar rates of success have been achieved arthroscopically.⁴³

Thermal-assisted capsular shrinkage has been used to treat shoulder instability, but its role has been brought into question. In a retrospective study of 130 overhead-throwing athletes, Reinold and associates⁴⁴ reported that 87% returned to sports activity after undergoing thermal-assisted capsular shrinkage. However, 95% of the athletes in that study had ad-

ditional procedures performed at the time of the surgery. In most reports of success with thermal capsular shrinkage, the procedure was combined with other procedures, so it is difficult to determine the benefit of the thermal technique. The procedure is also not without complications, as capsular ablation, chondrolysis, and axillary nerve palsies all have been reported.⁴⁵⁻⁴⁷ We do not recommend thermal capsular shrinkage as either primary or adjunctive treatment of adolescents.

Less frequently encountered than its anterior counterpart, posterior instability accounts for only 2% to 5% of cases of shoulder instability. Classically, it has been observed in patients after a seizure and in victims of electrocution or high-energy trauma. Athletes who engage in collision sports, particularly football linemen, sustain these injuries as well. The mechanism is a posteriorly directed force applied to an arm in a forward flexed, internally rotated, and adducted position. A patient with posterior shoulder instability usually reports posterior shoulder pain or a sense of instability occurring when the arm is placed in this position.

A patient with posterior instability should be treated with an exercise program concentrated on strengthening the infraspinatus and teres minor muscles. Strengthening these shoulder external rotators increases posterior stability. Bottoni and associates⁴⁸ reported that, if this strategy is not successful, successful results can be obtained with either open or arthroscopic techniques. In their case series, 31 shoulders in 30 consecutive patients with an average age of 23 years (range, 15 to 39 years) underwent either an open or an arthroscopic posterior stabilization procedure. The mean time from the injury to the surgical treatment was

21 months, and the average duration of follow-up was 40 months. Twenty-nine of the 30 patients were men, and more than one half of the study population had sustained the injury during collision sports. Preoperative imaging and arthroscopy revealed a posterior labral tear or detachment and a reverse Hill-Sachs lesion in 28 of the 31 shoulders. Following surgery, 29 of the 31 shoulders were rated as good or excellent, and the conclusion was that both open and arthroscopic procedures lead to satisfactory results. Compared with the group treated with an open procedure, those treated with arthroscopic surgery had significantly better Western Ontario Shoulder Instability Index ($P < 0.03$) and Rowe ($P < 0.04$) scores.

There is controversy regarding the management of adolescent athletes who have sustained a first-time traumatic dislocation, as conflicting results have been reported in the literature. Sachs and associates⁴⁹ studied the natural history after a traumatic shoulder dislocation. In their managed-care population, which included patients of all ages, 43 of 131 patients (33%) had a recurrent dislocation, but only 29 of these 43 patients had requested surgical treatment by an average of 4 years after the dislocation. Thirty-nine of the 43 patients with a recurrent dislocation were younger than 40 years, and 37 of these 39 patients either engaged in collision sports or required overhead use of the arm for their occupation. Eighteen of the 37 patients had surgical repair of a Bankart lesion. The authors concluded that, even in the group at the highest risk for a redislocation, only approximately 50% of those who had a redislocation requested surgery, and early surgery could not be justified.

A counterpoint to this argument is that other studies have demonstrated decreased recurrence rates and better outcomes after surgical stabilization. In one randomized trial, patients treated with an open Bankart repair were compared with those treated with a sling.⁵⁰ At 2-year follow-up, 21 of 39 patients in the immobilization group had a recurrence compared with only 1 of 37 in the surgically treated group. After 10 years of follow-up, 25 of the 36 patients in the surgical group had a good or excellent result, whereas 29 of 39 in the conservatively treated group had an unsatisfactory outcome resulting from recurrence, instability, pain, and stiffness. In another randomized clinical trial, the results of 4 weeks of immobilization and a supervised rehabilitation program were compared with those of an arthroscopic Bankart repair.³⁵ In that study, 75% of the patients in the nonsurgically treated group had recurrent instability and six of them required a subsequent Bankart repair. There was only one recurrence among nine patients in the surgical group.

In a randomized controlled trial, Kirkley and associates⁵¹ examined 40 patients, younger than 30 years, who had a first-time traumatic shoulder dislocation. The patients were randomly assigned to be treated either with immobilization for 3 weeks followed by rehabilitation or with an arthroscopic Bankart repair followed by an identical immobilization and rehabilitation protocol. The dislocation had occurred during sports activity in 70% of the patients. The surgically treated group had significantly fewer redislocations (3 of 19 compared with 9 of 19 in the nonsurgically treated group; $P = 0.03$) at a minimum of 24 months and an improved quality

of life as measured with the Western Ontario Shoulder Instability Index at 33 months ($P = 0.03$). A follow-up study, at an average of 75 months after the dislocation, revealed no additional recurrences in either group and no difference in shoulder function.⁵² Compared with the nonsurgically treated group, the surgical group had a small but clinically relevant improvement in the Western Ontario Shoulder Instability Index. The authors concluded that a small subset of patients who were younger than 30 years, were high-level athletes, and were involved in high-risk sports were candidates for immediate arthroscopic stabilization. On the basis of these studies and our experience, we recommend discussing with adolescents and their parents surgical repair as a treatment option after a first-time traumatic shoulder dislocation.

When nonsurgical management is selected for a patient with a first-time traumatic shoulder dislocation, placement of the arm in external rotation should be considered. Traditionally, nonsurgical management of a first-time shoulder dislocation has consisted of immobilization in a sling with the arm in internal rotation for 3 to 6 weeks. Recently, Itoi and associates⁵³⁻⁵⁵ presented studies that challenged this belief. Using MRI, they showed that, following reduction of an anterior shoulder dislocation, there is enhanced coaptation of the displaced anterior capsular labrum (the Bankart lesion) to the glenoid when the patient's arm is positioned in external rotation.⁵³ In their initial clinical study, they compared shoulders immobilized in internal rotation with those immobilized in external rotation.⁵⁴ The amount of external rotation averaged 35°. At a mean of 15.5 months,

there were no recurrent dislocations of the shoulders that had been immobilized in external rotation whereas the redislocation rate was 30% in the group treated with immobilization in internal rotation. Problems with this study included the older age of the sample group and the lack of randomization. In a more recent randomized controlled trial comparing the results of immobilization in internal rotation with those of immobilization in external rotation in patients followed for a minimum of 2 years, Itoi and associates⁵⁵ reported a relative risk reduction for recurrent dislocation of 38.2% in the group treated with external rotation. In a subgroup of patients younger than 30 years, the relative risk reduction was 46.1%.

Attempts to replicate the results in the above studies have been difficult because of patients' poor compliance with immobilization in external rotation and difficulty enrolling patients who will consent to this treatment. Therefore, immobilization in external rotation can be considered as a treatment option, but its application and efficacy in the adolescent population are unclear.

A team physician must determine when it is appropriate for a young athlete to return to sports activity after an acute traumatic anterior dislocation of the shoulder. Athletes want to return to competition quickly, especially if the injury occurs during the playing season. Buss and associates⁵⁶ examined the return to athletic activity by 30 competitive varsity athletes who had sustained an acute traumatic dislocation or subluxation during the playing season. The athletes were allowed to resume playing once they had demonstrated a functional range of motion and symmetric strength of the upper extremities. A period of immobilization was not

required, and rehabilitation was initiated immediately following the injury. Twenty-six of the 30 patients were able to return and complete the season with an average of 10.2 days of missed action. Nineteen of these 26 athletes used a brace to prevent hyperabduction and external rotation of the shoulder. One player attempted to return to play but was unable to finish the season, and three were unable to return. Overall, 11 of the 27 athletes who returned to sports activity had recurrent instability, and 10 of the 27 (37%) had at least one episode of sports-related instability. Most (59%) of the 27 athletes who returned to sports activity had no episodes of recurrence. Of the 26 athletes who completed the season, 12 (46%) underwent surgical stabilization after it. The authors concluded that nonsurgical treatment of anterior instability can be effective for athletes who desire to return to sports activity in-season.⁵⁶ Additional long-term prospective research is necessary to assess the short- and long-term effects when an adolescent athlete sustains an in-season dislocation, is treated nonsurgically, and returns to sports activity early.

Recurrent anterior shoulder instability can result from a traumatic dislocation and prevent the athlete from returning to athletic activity. The standard treatment of recurrent anterior instability has been an open Bankart repair; however, more recent data have suggested that arthroscopic repairs, with the use of newer surgical techniques such as the placement of suture anchors, can lead to results comparable with those of open repairs.

Arthroscopic stabilization was compared with open stabilization in a randomized controlled trial with a mean duration of follow-up of

32 months.⁵⁷ Surgical failure was defined as a second dislocation, recurrent subluxation, or symptoms precluding a return to previous work or active military duty. There were three failures, one in the arthroscopic group and two in the open treatment group. Both groups showed improvement compared with the preoperative state, and the results of subjective evaluations were equal in the two treatment arms. The mean loss of motion, as compared with that of the contralateral shoulder, was greater in the open-treatment group. Fabbriani and associates⁵⁸ compared open and arthroscopic repairs, both done with metallic suture anchors, for the treatment of isolated Bankart lesions in 60 patients. This randomized controlled trial demonstrated no recurrences in either group and no significant difference in the Constant and Rowe shoulder scores between the groups at 2 years. The authors concluded that arthroscopic repair of an isolated Bankart lesion was an effective surgical option.

Recommendations

Nonsurgical treatment remains an acceptable option for a first-time shoulder dislocation as long as the athlete is informed about the high prevalence of recurrence. Adolescent athletes who sustain a first-time dislocation can return to sports activity after proper rehabilitation has been performed to regain strength and the range of motion needed to perform their duties on the field. Immobilization of the shoulder in external rotation should be considered following an anterior shoulder dislocation, but it has not been proven to be effective or tolerated in an adolescent athletic population.

On the basis of the available literature, it is recommended that early

surgical stabilization be considered for an adolescent athlete after a first-time shoulder dislocation, especially if the athlete is involved in collision sports. When a patient desires to return quickly to the sport, surgery can be delayed until after the season if the rehabilitation is effective at restoring the range of motion and symmetry of strength.

Summary

Given the increased athletic participation by adolescents and the growing demands that they are placing on their extremities, injuries are being seen more frequently in this population. Skeletal immaturity warrants special consideration because of the greater capacity for healing and remodeling as well as the susceptibility of the open physis to injury. Both traumatic and overuse injury mechanisms are seen in adolescents. Problems related to throwing by young athletes are of particular concern. Although there is some debate regarding the etiology of shoulder dysfunction, pain has been shown to be associated with overuse. This has led to the development of pitching regulations in organized youth baseball. Shoulder conditioning programs and instruction in proper pitching mechanics have been recommended in an effort to curtail early overuse shoulder injuries. Instability also is seen in young athletes. Atraumatic instability is best treated nonsurgically, whereas patients with a first-time dislocation may benefit from early surgical stabilization in certain instances, given the high rates of recurrent dislocation in adolescents. In the absence of osseous deficiencies, the results of arthroscopic repair for the treatment of traumatic anterior shoulder instability appear to be similar to the results of open repair.

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