Pediatric and Adolescent Shoulder Instability

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INTRODUCTION

Shoulder instability in young patients is a well-recognized spectrum of disease, from common traumatic anterior dislocations to recurrent multidirectional instability (MDI). In young adolescent or pediatric patients with open proximal humeral physes, shoulder instability was believed to be less common than physeal injury, but it may be more common than once believed.1,2 Both traumatic and nontraumatic shoulder instability in young patients have been found to have a high rate of recurrence, and appropriate treatment is paramount in reducing the risk of recurrence and facilitating young patients’ return to sports and other physical activities. The spectrum of shoulder instability seen in young athletes is discussed, including epidemiology, anatomy and biomechanical features, physical examination and imaging, and conservative and operative treatment strategies.

KEYWORDS

• Shoulder instability • Multidirectional instability • Arthroscopy • Pediatric • Adolescent

KEY POINTS

• There is a high rate of recurrence after first-time shoulder instability in a young active population.
• Given the high risk of recurrent instability, young, active patients who seek to return to competitive contact sports should consider surgical stabilization after a first-time instability event.
• Multidirectional instability should be initially treated with conservative treatment.
• Traditional surgical options for shoulder instability utilized open techniques. Newer arthroscopic techniques may now approach the success rates of the traditional treatments options.

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EPIDEMIOLOGY

Shoulder instability is common, with a rate of 11.2 per 100,000 person-years, as noted by Simonet and colleagues. These investigators found younger male patients to be most frequently affected. In young ice hockey players, an incidence as high as 7% has been reported. The classic study by Rowe in 1956 reviewing 500 shoulder dislocations found that 20% of these dislocations occurred in patients between the ages of 10 and 20 years, but only 8 patients who were younger than 10 years had dislocations. Wagner and Lyne found that 4.7% of the shoulder dislocations in their study occurred in children with open physes. More recent studies have estimated that up to 40% of shoulder instability events may occur in patients younger than 22 years.

Perhaps more striking than the high incidence of first-time traumatic anterior shoulder stability is the high rate of recurrence of shoulder instability in young active patients. The rate of recurrence has been estimated to be between 60% and 100% in these patients. Rowe found the rate of recurrence in patients younger than 10 years to be 100%, and 94% if between 10 and 20 years of age. Wagner and Lyne found an 80% rate of recurrence in 9 patients with open proximal humeral physes. Hovelius and colleagues found a 60% recurrence rate in 12-year-old to 16-year-old patients. Deitch and colleagues found a recurrence rate of 75% in 32 patients between the ages of 11 and 18 years. Lawton and colleagues reviewed a cohort of 70 shoulders with instability, of which 67% received conservative treatment with physical therapy initially. These investigators found that 40% required surgical stabilization. Hovelius and colleagues found 55% of patients younger than 22 years of age had 2 or more recurrences of instability at 5 year follow-up and 16% of these younger patients went on to have instability of the contralateral shoulder at 10 year follow-up. Postacchini and colleagues found a recurrence rate of 92% in patients between the ages of 14 and 17 years after traumatic instability and a lower recurrence rate of 33% in patients 13 years old or younger, but their series had only 3 patients in this youngest age group.

The incidence and prevalence of MDI are difficult to estimate, given the spectrum of hyperlaxity and disease that might be present. Emery and Mullaji examined 150 asymptomatic shoulders in patients between the ages of 13 and 18 years and found 57% of boys and 48% of girls had signs of shoulder instability using anterior drawer, posterior drawer, and sulcus tests. Although the incidence of MDI seems to be less than the incidence of traumatic anterior shoulder instability, MDI seems to have a higher incidence in overhead athletes, especially swimmers and gymnasts.

ANATOMY AND BIOMECHANICS OF TRAUMATIC AND NONTRAUMATIC INSTABILITY IN YOUNG PATIENTS

The shoulder joint begins to form during the sixth week of gestation through different growth rates, known as the interzone. At this early point, the glenoid lip is discernible and consists of dense fibrous and some elastic tissue, as opposed to fibrocartilaginous tissue of the knee meniscus. The shoulder capsule and the ligamentous thickenings are visible by the end of the eighth week, increasing in size only through development to adult proportions. Variations in the final maturation of the glenoid and the capsulolabral tissues do exist but the effects on shoulder function and instability are not fully appreciated.

The anatomy of the shoulder and specifically the labrum and glenohumeral ligaments are well studied and variable. Although anatomists have documented the presence of the anterior ligamentous structures, it is the surgeons and arthroscopists who
have refined these descriptions and allowed a better understanding in both the function and position of the capsular thickenings, which have led to modern concepts of treatment of shoulder instability. One such finding is the patulous inferior recess attached to the diminutive labrum seen in patients with significant joint laxity (Fig. 1). Although still present, the glenohumeral ligaments tighten only after significant rotation of the joint or translation of the humeral head has occurred. Often in these young, ligamentously lax patients, arthroscopic observation of the intra-articular space shows pristine, smooth articular cartilage, an endless-pool appearance of the labrum, and thin, almost translucent, shoulder capsules and the ability to sublux the humeral head over the anterior, inferior, and posterior labral edge. Addressing the diminutive labrum and the expansive capsule in these patients if multidirectional stability issues exist is visibly obvious and is discussed later. Although obvious, the need to create a labral bumper has not been established in the literature. The notion of creating a bumper to deepen the glenoid cavity and enhance the ability of glenohumeral compression to offer joint stability is mechanical founded. We believe from our experience that doing so is helpful and use this technique when treating patients with shoulder instability.

The presence of the inferior glenohumeral complex is also clearly shown arthroscopically. What is most apparent with regards to the inferior glenohumeral ligament (IGHL) is the reciprocal nature of the complex and its function as a hammock. The anterior portion fans out with external rotation and the posterior band of the IGHL becomes cordlike. When this appearance is lacking (or the opposite with internal rotation) during a diagnostic arthroscopy of patients with either unidirectional or multidirectional instability, addressing each of the aspects of a patient’s disease is necessary.

HISTORY

Because there is such a wide spectrum of disease with shoulder instability in younger patients, the history and physical examination are paramount in understanding a particular young patient’s disease and prognosis. Instability patterns are classically separated into either traumatic or atraumatic.

Traumatic dislocations occur after falls, altercations, motor or recreational vehicle accidents, or during sports events, particularly contact sports. Owens and colleagues found the highest rates of shoulder instability in football, wrestling, and

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Fig. 1. (A) Arthroscopic image of inferior labrum viewed from posterior portal of diminutive labrum and patulous capsule in a patient with MDI. (B) Arthroscopic image of posterior labrum viewed from posterior portal with fraying (arrow) at labral-articular cartilage junction in a patient with MDI.
hockey. In the initial evaluation of the patient with shoulder instability, it is important to understand whether an underlying joint laxity was present before the first instability event or whether the instability issue followed a traumatic event. Also, it is important to note whether they required a formal reduction effort or not and where that occurred (eg, on the field or in the emergency department). Especially in younger patients, it can be difficult to understand the instability event if there was not a witnessed dislocation or necessary reduction. These younger patients may describe only intense shoulder pain, a dead arm feeling, or occasionally parasthesias in the distal upper extremity associated with subluxation or dislocation events.

Although anterior shoulder instability comprises 90% to 95% of shoulder instability, posterior shoulder instability can also be present. Posterior instability has been found in approximately 4% of all traumatic shoulder dislocations. A good history can provide essential clues to the primary direction of instability. Pain in the abducted and externally rotated position, such as the overhead serving position for a racquet sport athlete or reaching overhead or with an outstretched arm for a pass in a basketball or football player, usually indicates anterior shoulder instability. Pain with internal rotation and pushing forward such as during a bench press maneuver, a football lineman in his blocking stance, or pushing open a heavy door may indicate posterior shoulder instability.

The symptoms of recurrent shoulder instability in the context of MDI in the young patient are even more vague. Atraumatic instability may occur during activities of daily living such as reaching overhead to get things from a shelf or during hair washing or grooming. Atraumatic instability can also occur during sporting events, particularly during noncontact sports such as overhead serving in racquet sports, during certain swimming strokes, or during weight-lifting activities. These patients describe occasional pain or mechanical symptoms, such as popping in the shoulder, which may be associated with particular overhead motions. A careful history for recurrent instability in other joints or in the family history may indicate a connective tissue disorder. History of connective tissue disorders such as Ehlers-Danlos syndrome changes the prognosis and potential treatment options for a young patient with recurrent shoulder instability.

Young patients with MDI usually do not require reduction maneuvers to reduce their shoulder dislocations. They may have pain with everyday activities, such as brushing their hair. Numbness in the hand while carrying heavier objects may indicate inferior shoulder subluxation. Even in the setting of MDI, it is important to know which direction of subluxation seems to dominate, because this can affect surgical and nonsurgical decision making. Previous investigators have attached a poorer prognosis to MDI with a voluntary component. These investigators have discussed poorer outcomes in patients with MDI secondary to seizure disorders, electrocution, and other psychological and medical conditions. Pediatric and adolescent patients have been included in these groups and collectively have been deemed to have poorer prognosis. However, the adolescent with MDI with or without a voluntary component should probably be viewed separately and, in our opinion, has a better prognosis.

PHYSICAL EXAMINATION

The physical examination for the younger patient with shoulder instability starts with an examination that is used in adults. This process includes an examination of the cervical spine and a scapular examination for signs of more central nerve causes of shoulder weakness and pain. Although cervical spine issues are less common in young healthy pediatric and adolescent patients, scapular winging is not uncommon in these
patients and is caused by nerve dysfunction or injury along with muscle weakness, imbalance, and dyskinesia. Similarly, a careful neurovascular examination of the brachial plexus and specially the axillary nerve is important, because injury to this nerve is reported in 5% to 35% of fractures and dislocations.25

All patients with traumatic shoulder pain with presumed open physes should be evaluated for proximal humeral physeal injuries. Deformity of the shoulder girdle in this age group is not universally a dislocation. We recommend radiographic evaluation before any reduction maneuvers for shoulder instability, especially in prepubescent patients. Range of motion and strength should be tested bilaterally in all patients with a suspected traumatic shoulder injury. This strategy should include testing sensory perceptions and strength in axillary, musculocutaneous, ulnar, radial, and median nerve distributions. Proximally, the cervical spine should be examined for tenderness and range of motion. Spurling sign should also be assessed in patients able to comply with the test.

There are a variety of provocative maneuvers to test shoulder instability. These maneuvers include the anterior apprehension test, Jobe relocation test, anterior and posterior load-and-shift tests, Kim posterior jerk test, hyperabduction test, and the sulcus sign.26 The anterior and posterior load-and-shift tests are generally performed with the patient supine to stabilize the scapula. The load-and-shift tests involve placing the arm in 20° of abduction and forward flexion, matching the plane of the scapular body and grading the amount of translation of the humeral head. Grade 1 translation is consistent with translation to the glenoid rim but not dislocating. Grade 2 translation is consistent with dislocation over the glenoid rim, but with spontaneous reduction when the force is removed. Grade 3 translation is consistent with dislocation either anteriorly or posteriorly without spontaneous reduction. The Kim posterior jerk test for posterior instability involves placing the affected arm at 90° of abduction, when the examiner holds the arm and elbow and applies an axial loading force. The arm is then elevated 45° while maintaining axial force that pushes the humeral head posteriorly and the result is considered positive if posterior pain or a palpable clunk is felt.27 Hyperlaxity and inferior instability can be tested with the sulcus sign. Downward traction is applied to the arm, and if a dimple is seen or palpated between the lateral acromion and the humeral head, the test is considered positive. Humeral head displacement greater than 2 cm or the presence of the sulcus sign with the arm in 90° of abduction is considered to indicate a higher degree of inferior capsular laxity (Figs. 2A, B and 3).26,28,29 Gagey and Gagey30 developed the hyperabduction test to evaluate for IGHL laxity. Passive glenohumeral abduction past 105° is considered to indicate inferior laxity.

All young patients with suspected glenohumeral instability should be evaluated for generalized hyperlaxity. The Beighton-Horan scale for joint hyperlaxity combines increased laxity at various joints, including the hand, elbow, knee, and trunk (Table 1). A score equal or greater than 4 on a 9-point scale is considered diagnostic for hyperlaxity. Borsa and colleagues31 found that women are more likely to have hyperlaxity and anterior glenohumeral joint laxity than men.

**IMAGING**

Evaluation of a young patient with suspected shoulder instability includes a standard trauma series of radiographs with orthogonal views. This strategy is particularly important in the young patient with open physes, because of the risk of proximal humeral physeal fractures mimicking an anteriorly dislocated proximal humerus. A nontraumatic shoulder radiographic series includes an anterioposterior, scapular Y, and
axillary view. If the young patient is too uncomfortable to comply with the arm positioning for a standard axillary view to confirm glenohumeral reduction, a Velpeau view may be performed. This view is typically performed with the arm at the side in a position of comfort with the patient leaning backwards over the radiograph plate and the beam angled straight downward. The West Point view is useful in suspected acute or recurrent shoulder instability, because it can best visualize the anterior glenoid rim.32

Fig. 3. Sulcus sign. (From Curtis RJ. Glenohumeral instability in the child. In: DeLee JC, Drez DJ, Miller MD, editors. Delee & Drez’s orthopedic sports medicine. vol. 1. Philadelphia: Saunders/Elsevier; 2010; with permission.)
Once a proximal humerus fracture is ruled out and glenohumeral reduction is confirmed, imaging of the young patient with suspected glenohumeral instability often includes magnetic resonance imaging (MRI). As in adults, the addition of intra-articular contrast is often recommended to improve the diagnostic ability of MRI in diagnosing labral disease. However, in the acute setting, intra-articular contrast is provided by the blood within the joint. Anterior instability in the young patient is often accompanied by a Bankart lesion or tear, an anterior labral periosteal sleeve avulsion lesion, or more infrequently, but important to identify on preoperative imaging, a humeral avulsion of the glenohumeral ligament (HAGL) lesion. Glenoid or humeral-sided bone loss or deformity (ie, bony Bankart lesions, glenoid fractures, inverted pear glenoid morphology, and Hill-Sachs deformities) can often be identified on radiographs or MRI but occasionally require evaluation by computed tomography (CT). Recent studies have shown that MRI can accurately assess glenoid bone loss when compared with CT scan with or without three-dimensional reconstructions.33,34

Imaging of the shoulder in patients with suspected MDI can be challenging to interpret, because the signs of instability that often accompany acute traumatic shoulder instability, such as labral, capsular, or ligamentous tears, are usually not present. Several imaging findings can be helpful in evaluating the patient with suspected MDI, although it is especially important in these patients to put the imaging findings in the appropriate clinical context with their history and physical examination findings. Dewing and colleagues35 found a patulous capsule, increased glenohumeral volume, and labral abnormalities on MR arthrography in patients with MDI. Kim and colleagues36 found increased rotator interval dimensions in patients with MDI. However, Provencher and colleagues37 found no significant differences in MRI findings of patients with MDI when compared with adult controls, showing the importance of making the diagnosis of MDI based on history and physical examination findings.

TREATMENT AND OUTCOMES

Acute Management of a Shoulder Dislocation in a Young Athlete

Many providers of sports medicine are faced with the issue of a young patient with a suspected shoulder dislocation seen on the field of play. Although in older, skeletally mature patients, it is reasonable to consider on-field reduction maneuvers if the provider is comfortable and trained in these techniques, in the young patient with open physes, we recommend that the provider at a minimum should consider appropriate radiographic imaging before reduction attempts to evaluate for a proximal humeral physeal fracture.38 Once a physeal fracture is ruled out or considered to be of low

**Table 1**

**Beighton-Horan joint hypermobility scoring system:** a score of greater or equal to 4 out of a possible 9 points usually indicates generalized hypermobility

<table>
<thead>
<tr>
<th>Joint</th>
<th>Movement Description</th>
<th>Points per Side</th>
</tr>
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<tbody>
<tr>
<td>Small finger</td>
<td>Dorsiflex the fifth metacarpophalangeal joint to at least 90°</td>
<td>1</td>
</tr>
<tr>
<td>Thumb</td>
<td>Oppose the thumb to volar aspect of the ipsilateral forearm</td>
<td>1</td>
</tr>
<tr>
<td>Elbow</td>
<td>Hyperextend the elbow to at least 10°</td>
<td>1</td>
</tr>
<tr>
<td>Knee</td>
<td>Hyperextend the knee to at least 10°</td>
<td>1</td>
</tr>
<tr>
<td>Trunk/hip</td>
<td>Place both hands flat on the floor with the knees fully extended</td>
<td>1</td>
</tr>
</tbody>
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probability, several reduction maneuvers are possible. These maneuvers include traction-countertraction, Stimson maneuver, and abduction maneuvers. Adequate sedation is recommended in the young patient both for patient comfort and also to reduce the amount of traction or force needed for reduction in this population in order to minimize further risk to the proximal humeral physis.

**Nonoperative Conservative Treatment of Pediatric/Adolescent Anterior Shoulder Instability**

Once glenohumeral reduction has been achieved, there are both conservative and operative treatment options for the management of the pediatric or adolescent patient with a first-time or recurrent traumatic anterior shoulder instability. Conservative treatment may include an initial period of sling or shoulder immobilizer use, followed by activity modification and physical therapy for range of motion and strengthening. Return to play is often allowed once painless full range of motion and normal, protective strength is achieved. Shoulder harness bracing is often used for young football players, or other contact athletes such as hockey and lacrosse players, who seek to return to play during the same season in which the instability has begun. The option to return to play with an unstable shoulder requires a full understanding by both the player and their parents; a player may also have to play in a position that can accommodate the restrictions of the brace (ie, limited overhead or abducted shoulder positioning). Physical therapy protocols designed for the rehabilitation of anterior shoulder instability treated nonoperatively focus primarily on scapular stabilization, with rotator cuff strengthening being added in the later stages of the process.

The main complication associated with conservative management of traumatic first-time anterior shoulder instability is the risk of recurrent instability. This risk is significant and although one study found this risk to be 21%, most reports document this risk to be 60% or greater. Cordischi and colleagues followed 14 patients between the ages of 10.9 and 13.1 years for an average of 3.4 years after a primary anterior shoulder dislocation and found 3 patients to have recurrent instability. Recurrent instability was associated with a HAGL lesion in all 3 cases and no patient had evidence of a discrete labral tear on MRI. Western Ontario Shoulder Instability Index scores were found to be better in the nonoperative group in this small series.

Other studies have found a higher rate of recurrent instability after conservative treatment of anterior shoulder instability in young patients. In 1956, Rowe found a 100% risk of recurrent instability in children younger than 10 years. The risk was 94% in adolescents between 10 and 20 years of age. Wagner and Lyne found an 80% recurrence rate in 10 adolescent shoulders between 12 and 16 years of age. Marans and colleagues found a 100% recurrence rate with an average of 5 recurrent instability events in 21 pediatric and adolescent patients between 4 and 16 years of age. Postacchini and colleagues found an 86% recurrence rate in adolescents between 12 and 17 years of age. The rate of recurrence was 92% for adolescents between 14 and 17 years of age but only 33% in patients younger than 13 years. Deitch and colleagues found a 75% recurrence rate in 32 adolescents between the ages of 11 and 18 years. Echoing the findings of Postacchini and colleagues, 8 of 15 patients (53%) with open humeral physes had recurrent instability, whereas 15 of 17 patients (88%) with closed humeral physes had recurrent instability. The high rate of recurrence in adolescents with shoulder instability is similar to the rates observed in late adolescents/collegiate-age athletes/military recruits seen in other studies. It is still unclear whether the rate of recurrence is as high in younger adolescent and prepubescent children. If the rate of recurrence in this younger population is lower, as some
investigators have suggested, it might be hypothesized that younger children and their families might be more willing to modify activities, especially avoiding contact sports. This hypothesis is similar to the findings by Postacchini and colleagues\textsuperscript{13} that children younger than 13 years had a lower dislocation rate. However, that study had a small cohort of this youngest group of patients with traumatic dislocations. Further studies need to evaluate whether younger and older adolescents in larger cohorts have different rates of recurrence and seek to identify possible causes.

**Nonoperative Conservative Treatment of Pediatric/Adolescent Multidirectional Shoulder Instability**

One of the classic tenants of shoulder instability treatment is AMBRI, which refers to atraumatic, MDI, which is often bilateral, with treatment beginning with rehabilitation and if that fails, consideration for inferior capsular shift. Most sports medicine providers consider physical therapy and rehabilitation the first-line treatment of MDI. Burkhead and Rockwood\textsuperscript{42} classically described good or excellent results with rehabilitation for 80% of patients with atraumatic instability. Takwale and colleagues\textsuperscript{43} described 90% good results with specialized physical therapy for involuntary positional instability, which they described as “instability caused by an abnormal unbalanced muscle action which is involuntary and ingrained,” which usually involves adolescent patients with posterior instability. Kuroda and colleagues\textsuperscript{44} studied more than 300 patients with atraumatic shoulder instability and advocated following these patients for several years with conservative treatment. These investigators noted spontaneous recovery of stability in 50 of 450 shoulders (9%) and that spontaneous recovery was statistically more likely if patients were willing to switch to nonoverhead athletics. It is not clear if these patients still had symptoms but avoided frank instability because of activity modification. Misamore and colleagues\textsuperscript{45} followed 64 patients with MDI with an average age of 16 years and found at 2 years follow-up that 34% had elected for surgery. Approximately half of the remaining patients had pain relief and graded their shoulders as having good or excellent stability. At mean 8-year follow-up, 78% of patients who had not undergone surgery reported persistent problems with their shoulders, and only 22% were symptom free. Conservative treatment of MDI can improve a patient’s shoulder function and provide good or excellent results in many young patients. However, there are some patients for whom this treatment course may not fully restore stability or provide complete pain relief. In general, some investigators have recommended at least 6 months of physical therapy and conservative treatment of MDI of the shoulder in young athletes.

**Operative Treatment of Pediatric/Adolescent Anterior Shoulder Instability**

Operative intervention is advocated for recurrent instability after traumatic anterior shoulder dislocations in young patients. It has also been advocated for some young patients in high-risk sports or activities as the primary treatment after a first-time shoulder instability event. The classic studies by DeBernadino and colleagues\textsuperscript{46} and Owens and colleagues\textsuperscript{47} showed excellent subjective function and return to sport, with a redislocation rate of 14.3% at longest follow-up after arthroscopic Bankart repair after first-time traumatic instability in young active patients. However, these patients were collegiate-aged military academy students, and this patient population might be different than a younger adolescent population. A few studies have specifically examined the results of surgical stabilization for traumatic anterior shoulder instability in pediatric and adolescent patients.\textsuperscript{5,7,11–13,48–51} Wagner and Lyne\textsuperscript{8} reported on 7 shoulders in patients between 12 and 16 years of age who required surgical stabilization using open techniques between 1965 and 1979. These investigators
reported no recurrence after surgery using older techniques such as Magnuson-Stack or Bristow procedures, which have since fallen out of favor for the treatment of primary shoulder instability. In 1992, Marans and colleagues reported on 13 patients who were an average of 13 years old who underwent open anterior stabilization procedures, including Bankart repair, Putti-Platt procedure, capsular shift, and Bristow procedure. One recurrent instability event (8% recurrence) was reported after surgery in a patient who had a Bristow procedure, and this patient underwent a revision with a Putti-Platt procedure. Postacchini and colleagues and Lawton and colleagues reported on pediatric and adolescents treated with open surgical stabilization, and only 1 patient had recurrent instability after surgical stabilization. Deitch and colleagues reported a higher rate (31%) of recurrence of instability after surgical stabilization but did not report on the specific surgical procedures performed in this cohort.

Newer studies have examined arthroscopic treatment of traumatic shoulder instability in pediatric and adolescent populations. Mazzocca and colleagues examined a late adolescent population between 14 and 20 years of age who were contact and collision athletes and treated with arthroscopic anterior shoulder stabilization. These investigators reported a low recurrence rate of 11%, and all of their athletes were able to return to organized high-school or collegiate sports. Kraus and colleagues reported on a series of 6 patients with an average age of 12 years old, in whom 5 of 6 cases were treated with arthroscopic stabilization. There were no recurrences at average 26-month follow-up and excellent Constant and Rowe scores. Jones and colleagues reported on 32 anterior arthroscopic Bankart repairs in 30 patients treated at Children’s Hospital of Philadelphia. Half of the patients had failed initial nonoperative management and half had primary surgical stabilization. The average age of the patients was 15 years, ranged between 11 and 18 years. Overall, there was a 15.6% rate of recurrence after surgery. Single Assessment Numeric Evaluation (SANE) scores were similar between groups treated with initial conservative treatment and initial surgical treatment at follow-up. Castagna and colleagues reviewed their results of arthroscopic stabilization in adolescent athletes aged 13 to 18 years who played overhead or contact sports. These investigators found that 81% of their patients were able to return to their preinjury sport, and the remaining 19% were able to return to sport but at a lower level secondary to their shoulder. A recurrence rate of 21% was found overall, but this was significantly higher in athletes participating in water polo (40%) and rugby (33.3%).

Overall, arthroscopic stabilization for traumatic anterior shoulder instability seems to be an effective treatment in younger populations, with recurrence rates that approach the rates seen in collegiate-age populations. Primary surgical treatment after first-time traumatic anterior shoulder instability may be considered in adolescent patients, given the risk of recurrence in these younger populations, and if patients and their families are unable or unwilling to modify the child’s activities and sports.

**Operative Treatment of Pediatric/Adolescent Multidirectional Shoulder Instability**

Operative treatment of MDI can be considered in young patients who have failed conservative treatment, including activity modification, physical therapy for strengthening, and scapular stabilization, and who continue to have pain and instability in their shoulders that interferes with their daily living or sports. Activity modification should be encouraged in this population as part of the initial conservative management. Operative intervention historically was considered a contraindication in patients with voluntary instability. We agree that these individuals require more intensive preoperative discussions and explanations as well as more structured postoperative management. However, we do not believe that this group should be viewed differently from other
young patients with shoulder instability, apart from the issues mentioned. These issues are also important to consider before surgery in patients with connective tissue disorders and global ligamentous laxity.52

Traditional operative treatment of MDI of the shoulder involved open inferior capsular shift, as described by Neer and Foster.28 These investigators reported satisfactory results in 39 of 40 patients. Other investigators have described good results with open inferior capsular shift for the treatment of MDI.53–58 The rate of recurrent instability postoperatively varies from 4% to 26%. In Hamada and colleagues’ series,55 which had the highest recurrence rate of 26%, two-thirds of their recurrences occurred in patients with voluntary subluxation (50% of patients with voluntary subluxation recurred), and eliminating these patients brought their recurrence down to 14%.

Patients were able to return to sport postoperatively between 75% and 100% of the time, but Choi and Ogilvie-Harris57 did note that only 17% of patients who underwent bilateral inferior capsular shifts were able to return to sport, and Altchek and colleagues53 stated that throwing athletes noted decreased velocity postoperatively.

As improvements and closer examination of the success of older stabilization procedures occur, technique modifications to Neer and Foster’s original description have been described. A subscapularis splitting technique has been described to eliminate the need to detach and reattach the subscapularis tendon.58 In addition, a glenoid-based T-plasty modification has also been described by Altchek and colleagues.53 Reduction in capsular volume has been considered crucial to the success of the procedure and is proportional to the amount of capsular shift.59

As the treatment of traumatic shoulder instability has gravitated toward arthroscopic techniques, so has the operative treatment of MDI. Advantages of arthroscopic treatment include the ability to address anterior, inferior, and particularly posterior disease at the same time and close the rotator interval if deemed necessary.60,61 Initial investigations into arthroscopic treatment of MDI used thermal capsulorrhaphy and showed good results.62,63 However, this technique has fallen out of favor and is no longer recommended given the concerns over thermal-induced chondrolysis.64–66

Multiple series have shown good results with arthroscopic treatment of MDI of the shoulder.61,67–70 Recurrence rates are reported to be between 2% and 12%, and subjective outcome scores report satisfactory results after 88% to 97% of procedures. Baker and colleagues70 reported that 86% of their patients were able to return to sports, with 65% returning to the same level as previously. The ability to tighten the capsule and attach it to a solid labrum or to fix the redundant capsular tissue to the glenoid rim via a suture anchor technique with newer techniques and equipment have greatly improved the ability to address all aspects of capsular laxity of patients with MDI. This improvement, as mentioned, allows the surgeon to not only reduce capsular volume but to do so selectively to reflect variations in that laxity.

One of the specific improvements in surgical technique that has occurred with the change to arthroscopic techniques is the ability to address the rotator cuff interval. Although the closure of the rotator interval remains a controversial portion of arthroscopic management of glenohumeral instability, the addition of a closure in selected patients is important and can improve outcomes. Harryman and colleagues71 initially showed that in vitro imbrication to the rotator interval capsule resisted inferior and posterior translation. Others72,73 have shown that rotator interval closure may not affect posterior stability but can affect anterior stability. However, not all unstable shoulders (traumatic or atraumatic) should have the rotator cuff interval closed routinely, because that closure may restrict external rotation.72,74–76

Outcomes after arthroscopic treatment of MDI seem to show equivalent results with open procedures in adolescent populations. In addition, although many series
examining MDI operative treatment include adolescent patients, there are no series to our knowledge studying an exclusively pediatric or adolescent patient population treated with surgical intervention for MDI. As surgical techniques evolve to treat this complicated spectrum of shoulder disease, our subjective and objective outcomes measures also need to evolve. Although judging success based on recurrence rate is certainly an important component to the outcome after these procedures, further refinement of subjective outcomes aimed especially at pediatric or adolescent populations is needed.

**OUR PREFERRED TECHNIQUES**

Our preferred treatment of pediatric or adolescent patients who have failed conservative treatment of traumatic or MDI is arthroscopic labral repair and capsulorrhaphy using suture anchor fixation. We use lateral decubitus positioning with an adjustable arm holder (Spider arm positioner, Smith & Nephew, Memphis, TN) for arthroscopic shoulder instability surgery (Figs. 4 and 5). After examination under anesthesia and diagnostic arthroscopy to document the extent and directions of instability and labral/capsular disease, 4 portals are established (standard posterior viewing, posteroinferior, anterosuperior, and anteroinferior portals). The proper placement of these portals cannot be overemphasized. During the placement of each portal, the ability to maneuver within the joint to access all aspects of the joint is imperative and should be checked. Moving or creating additional portals is not common but should be performed if better accessibility is needed. We have found that slight modifications of the portal placement, especially posteriorly, make the procedure technically easier. The first of these changes is moving the posterosuperior portal more lateral. Traditionally, this portal has been placed inferior and medial to the posterolateral corner of the acromion. We believe that this is an appropriate portal for rotator cuff surgery and other procedures when performing surgery in the beach chair position. However, in the lateral decubitus position, this portal needs to be slightly inferior and as lateral
as possible when referenced to the posterolateral corner of the acromion. This strategy allows us to gain an angle down onto the posterosuperior labrum, making this a working portal as well as a viewing portal.

The next 3 portals are made under direct visualization with the use of an 18-gauge spinal locator needle. The anterosuperior portal is placed above the biceps initially. During the case, it is slipped below the biceps. This procedure gives us the greatest possible separation between the 2 anterior portals and allows more ease of functioning. The anteroinferior portal is placed just superior to the subscapularis tendon and is angled inferiorly. To be sure that this placement is achieved, when using the locator needle, after the needle is in place, we let go of the needle. If it remains directed inferior, then we believe that it is appropriately placed. However, if the needle direction shifts superiorly after we let go, we re-establish the skin surface position to allow a better untethered angle. The posteroinferior portal is placed as inferiorly as we can. This strategy establishes the greatest separation between the posterior portals, as performed anteriorly, and allows us to use this inferior portal for inferior suture anchor placement and inferior capsular plication (Fig. 6).

Adequate mobilization of labral and capsular tissue from the glenoid rim is necessary for appropriate tensioning and providing a bleeding base to allow for healing. For both anterior and posterior lesions or combined lesions, capsulorrhaphy, suture, and suture anchors are placed inferiorly first and capsulolabral tissue is advanced to the glenoid rim using a suture passer (Accu-Pass suture shuttles, Smith & Nephew, Memphis, TN) (Fig. 7). This step is repeated as the repair and capsulorrhaphy is

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Fig. 5. Lateral decubitus positioning for right shoulder arthroscopy (overhead view). Note the use of Spider arm positioner (Smith & Nephew, Memphis, TN).
advanced superiorly either anteriorly or posteriorly as the labral bumper is restored. The arm should be taken out of traction at the conclusion of the repair to test stability in all directions.

**REHABILITATION**

Rehabilitation after arthroscopic anterior stabilization for anterior shoulder instability or pancapsular capsulorrhaphy for MDI generally begins with a period of immobilization. We generally use an Ultra-sling (DonJoy, Vista, CA) for 6 weeks postoperatively or until normal range of motion is achieved, whichever comes last. Initial rehabilitation centers around maintaining finger, wrist, and elbow motion. Isometric periscapular muscle activation is also begun in the first weeks to assist the early discomfort and smoother transition to advancing stages of rehabilitation. Range of motion activities begins with physical therapy and home exercise programs, including pendulum exercises, table slides, and wall pulleys. Isometric shoulder exercises are begun in weeks 2 to 4 and are advanced to isotonic exercises in weeks 4 to 8. Rotator cuff and scapular strengthening is begun once the sling has been discontinued and range of motion has been restored. Stationary bicycle and elliptical use without use of the arms are allowed.
before sling discontinuation. After the sling has been discontinued, jogging and running are allowed. At this point, rehabilitation shifts to more strengthening and plyometric exercises. After 3 months and once full range of motion as well as near normal strength have been achieved, we initiate sport-specific training. Isokinetic strength testing of shoulder internal and external rotators, along with endurance and power testing of the upper extremity is performed before return to sport, which is generally at the 4-month postoperative point. Return to sports is predicated by achieving these rehabilitative milestones as well as the specific sport that is being played. Noncontact, nonoverhead sports are possible often by the 4-month mark. Contact sports are generally not allowed before 6 months postoperatively. Overhead sports also are allowed at the 6-month mark, although we normally initiate a tossing or interval-throwing program at 4 months.

Rehabilitation after pancapsular procedures for MDI may be progressed more slowly given the extent of instability, amount of capsular shift needed, and often poor quality of soft tissue in these cases.

**SUMMARY**

Instability of the shoulder is a common issue faced by sports medicine providers caring for pediatric and adolescent patients. A thorough history and physical examination can help distinguish traumatic instability from multidirectional or voluntary instability. A systematic understanding of the relevant imaging characteristics and individual patient disease and goals can help guide initial treatment. Given the high risk of recurrent instability, young, active patients who seek to return to competitive contact sports should consider arthroscopic stabilization after a first-time instability event. MDI should be treated initially with conservative rehabilitation. Patients who fail extensive conservative treatment may benefit from surgical stabilization. Arthroscopic techniques may now approach the results found from traditional open capsular shift procedures. Future studies should be designed to examine the outcomes in solely pediatric and adolescent populations after both conservative and operative treatment of shoulder instability.

**REFERENCES**


