Cutting Edge Treatments for Anterior Shoulder Instability

A Senior Honors Thesis

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By

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Introduction

As medical professionals, athletic trainers are focused on the overall well-being of their patients. When an injury occurs, the entire extent of the impact the injury has on a patient's life and daily activities needs to be taken into consideration. Like other medical professionals, we have adopted the use of the World Health Organization's ICF model. This disablement model is used to organize clinical decisions in order to best provide evidence-based care. It provides a framework for documenting a patient's ability to function and the disability. One major key of the ICF model is the use of common language to communicate between medical professionals of different backgrounds. The documentation from the disablement model can provide information for research on the effectiveness of therapeutic interventions, thus demonstrating the true value of athletic training services. ("ICF Model: A Framework for Athletic Training Practice", 2016)

The ICF model addresses the injury or illness of a patient holistically, including not only the health condition but also body function and structures impaired, activity limitations, participation restrictions, environmental factors, and personal factors. ("ICF Model: A Framework for Athletic Training Practice", 2016) It is important for every injury or illness to be addressed on an individual basis. Certain injuries highlight the importance of the use of the ICF model in clinical practice, including anterior shoulder instability. Because of many underlying factors, difference in patient populations, and post-injury goals, the entire rehabilitation process must be individualized to the patient.

Anterior shoulder instability is most commonly the result of chronic or acute injury to the glenohumeral joint, typically a glenohumeral joint dislocation or subluxation. This condition can quickly become debilitating if it is not treated properly soon after the initial onset of injury. The first anterior shoulder dislocation often has a traumatic origin, and is often followed by disabling and recurrent luxations. The rate of recurrence is approximately 94%, occurring most in the adolescent and athletic populations. Chronic anterior instability can range from minor symptoms to repeated subluxations and dislocations. The goal of any treatment of anterior shoulder instability is to reduce the rate of recurrence in younger, more active patients and decrease symptoms for older patients. (Willemsen, Berendes, Geurkink, & Bleys, 2019)

Injury to the anterior shoulder causing instability is most frequently seen in contact sports, such as football, or overhead athletes, like basketball. This is not to say this injury does not occur in other sports, as anterior shoulder dislocation is one of the most common shoulder injuries in athletics and in the general population. These specific populations tend to require more medical attention addressing the anterior shoulder instability long-term than other populations. (Willemsen, Berendes, Geurkink, & Bleys, 2019)

Athletic trainers are typically the first line of defense, responding to emergencies and acute injuries, preventing injuries and rehabilitation of patients. In certain states, athletic trainer's are knowledgeable and able to practice relocation techniques under the standing orders of a supervising physician. Relocation is typically done to reduce patient discomfort or to restore blood flow and neurological function to the extremity, and is contraindicated in the presence of symptoms of concomitant fracture. (Rossi, Anderson, & Doberstein, 2018) It is important that we, as a profession, thoroughly understand anterior shoulder instability and the current and developing treatments being used for our patients. We also must stay current on best practices for emergency care, rehabilitation, and criteria to return to play, so as to prevent reinjury for our patients.

Many times when a shoulder is acutely injured, the injury becomes chronic despite proper orthopedic intervention. Our current methods (bracing, arthroscopic surgery, and rehabilitation) have fallen short, as the rate of chronic anterior instability at the shoulder causing prolonged symptoms, recurrent episodes of instability, and redislocation is approximately 50%. This can be attributed to the complexities present exclusively in the shoulder joint, including unstable bony anatomy and complex ligamentous relationships. (Starkey & Brown, 2015) While current bracing, arthroscopy, and rehabilitation techniques have a place in the healing process, they also need to be improved upon to reduce complications. Small details can make a difference in rehabilitation and prevention, and require more research to further develop a more effective plan for management of anterior instability of the shoulder.

Relevant Anatomy

The shoulder is a complex structure that involves multiple joints to optimize functionality. The arm articulates with the trunk through the glenohumeral joint, the acromioclavicular joint, the coracoclavicular joint, the scapulothoracic joint, and the sternoclavicular joint. (Anderson, Hall, & Parr, 2013) While the glenohumeral joint is seen as the "true shoulder joint", the acromioclavicular and sternoclavicular joints act to increase range of motion, while the scapulothoracic joint acts as a lever and a pulley to increase muscular efficiency of the rotator cuff group. Anterior

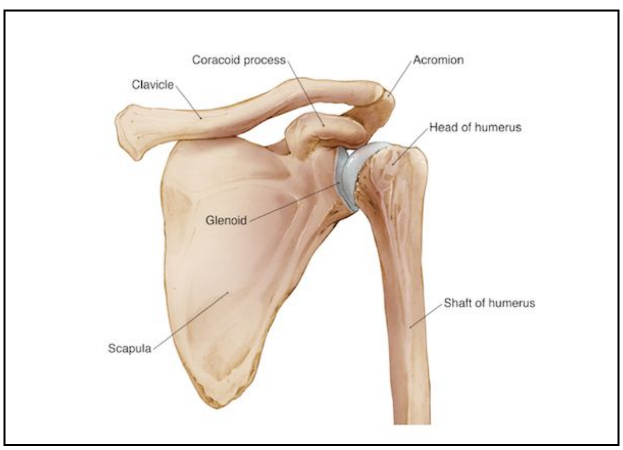

Figure 1

instability of the shoulder is directly related to injury of structures at and around the glenohumeral joint. (Anderson, Hall, & Parr, 2013)

The articulation between the glenoid fossa of the scapula and the head of the humerus is an inherently unstable joint. As a ball and socket joint, the shoulder has three degrees of freedom and approximately 16,000 different possible positions. The hemispheric head of the humerus is three to four times the surface area of the less-curved articulating surface of the glenoid fossa. The humeral head not only rotates but translates linearly across the glenoid fossa. This movement is limited by muscle tension and the fibrocartilage rim called the glenoid labrum. The glenoid labrum acts to deepen and stabilize the shoulder joint. It also serves as the attachment site of the long head of the biceps brachii along the superior portion. The labrum is commonly injured during any shoulder injury, and damage to the labrum is closely associated with the development of anterior shoulder instability. (Anderson, Hall, & Parr, 2013)

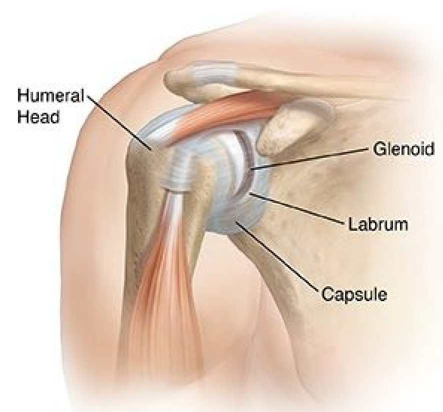

Figure 2

The joint capsule surrounding the glenohumeral joint is reinforced by the superior, inferior and middle glenohumeral ligaments on the anterior aspect of the joint, and the coracohumeral ligament on the superior aspect of the joint. The glenohumeral ligaments are not separate from the capsule, rather they are thickenings in the joint capsule itself. The middle ligament is a singular band that prevents abduction and external rotation at 0 degrees of abduction. The superior ligament is a singular band that helps to prevent inferior humeral translation. Between the superior and middle ligaments lies the Foramen of Weitbrecht, a weak site in the joint capsule that is most important for glenohumeral function and also the most often injured. The inferior glenohumeral ligament function is more complicated than the other glenohumeral ligaments. The complex moves in response to glenohumeral movement. During external rotation, the anterior band shifts superiorly and tightens the hammock to support the anteroinferior portion of the glenohumeral joint. During internal rotation, the posterior band moves superiorly and the hammock tightens to support the posteroinferior portion of the glenohumeral joint. The capsule itself forms a "vacuum" with negative intra-articular pressure, keeping the head of the humerus against the glenoid fossa. The coracohumeral ligament extends from the coracoid process to the greater tuberosity of the humerus, and acts to protect against external rotation and abduction. It also provides space for the rotator cuff tendon through the coracoacromial arch.(Starkey & Brown, 2015)

The rotator cuff muscle group provides dynamic stabilization and humeral control through force couples. Force couples are two opposing muscles that, when contracted, balance each other out. The subscapularis and infraspinatus or teres minor provide stabilization in the anterior and posterior directions, while the deltoid or supraspinatus and the infraspinatus or teres minor stabilize superior and inferiorly. The tendons of the rotator cuff blend into the joint capsule, and cause dynamic tensioning, whereas the rotator cuff muscles contract the joint capsule is tightened. These features of the rotator cuff group positively influence stability of the glenohumeral joint.The deltoid also contributes to shoulder stability through force couples by elevating the head of the humerus and keeping the articulating head of the humerus in the glenoid fossa. (Starkey & Brown, 2015)

There are several nerves and arteries or veins that can be affected by injury to the shoulder area. Large nerves that pass through and innervate this region are the axillary nerve, the intercostal-brachial nerve and the brachial plexus. Depending on the nature of the injury, neurological involvement can be a major concern or an indication of further damage to the tissues in the shoulder. (Starkey & Brown, 2015) The main blood supply to the arm that we are concerned about following injury to the shoulder is the axillary artery. This can be compromised during a glenohumeral joint dislocation, but often is overlooked because of the extensive blood flow to the arm that signs and symptoms of disruption to the axillary nerve are masked until it is too late. Any signs and symptoms of injury to the axillary artery should result in immediate referral to emergency medical services. (Starkey & Brown, 2015)

Etiology

While the glenohumeral joint is the most commonly dislocated joint in the human body, it is also considered a medical emergency. The joint needs to be relocated as soon as possible as to not compromise joint function. (Cutts, Prempeh, & Drew, 2009) Over 95% of glenohumeral joint dislocations are anterior. This is typically caused by an acute trauma, abduction and external rotation at the shoulder joint. After an initial dislocation, a following subluxation or dislocation is up to 50% more likely to occur. (Cutts, Prempeh, & Drew, 2009) This recurrence can happen with simple overhead motions, such as reaching to grab something from a shelf or brushing one's hair. At that point, the patient would be diagnosed with chronic anterior instability of the shoulder.

Younger populations tend to have capsuloligamentous damage primarily associated with anterior instability. Both anterior and posterior structures of the glenohumeral joint can be disrupted following an occurence of instability. ("Anterior Shoulder Instability", 2019)

Pathology

There are many underlying causes to anterior shoulder instability. The two most prevalent causes in the general population are a genetic predisposition and acute trauma to the glenohumeral joint. The long-term outcome of an initial shoulder dislocation is dependent on many factors, such as age of the patient at the time of the initial dislocation, concomitant injuries to the affected shoulder, and treatment of the initial injury. ("Anterior Shoulder Instability", 2019)

Shoulder instability is initially classified by the cause and voluntary reproduction, specifically was the incident atraumatic or traumatic and can the patient reproduce the instability voluntarily or not. Types of shoulder instability are further classified by the direction of the instability and the duration of the injury. Shoulder instability may occur in the anterior or posterior direction, or be multidirectional. (Rolfes, 2015) Instability occurs in the anterior direction most commonly, followed by multidirectional instability. (Cutts, Prempeh, & Drew, 2009) Instability may be acute, chronic or recurrent. (Rolfes, 2015)

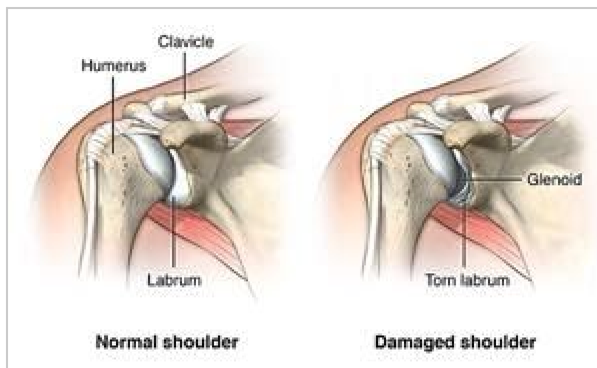

Figure 3

There is a bimodal age distribution for the frequency of anterior shoulder instability. On one side, there are young adults -typically male- who have sustained acute, high-force injury directly to the shoulder. The risk of recurrence in this age group has a strong correlation to the intensity of the force that caused the initial injury and the age of the patient at the time of injury, ages 16 to 30 being at the most risk. Management of instability in this patient is the subject of many debates, but typically surgery is highly recommended. On the other side of the distribution are the older patients who sustained the injury at a lower level of force during an isolated event. Considering the age of the patient, priorities for managing this condition in this population are early reduction and prompt mobilization of the joint to avoid the onset of long-term loss of range of motion. Failure to successfully reduce any dislocation within 24 hours in any patient would increase the likelihood of chronic instability. (Cutts, Prempeh, & Drew, 2009)

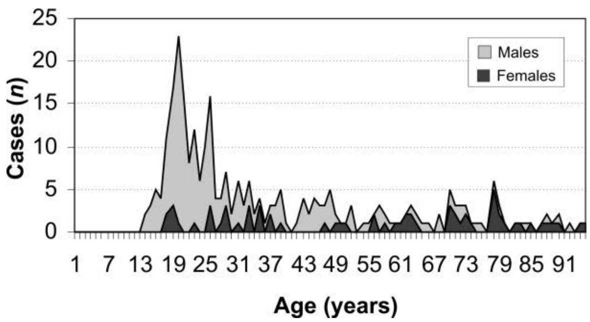

Figure 4

A genetic predisposition to anterior shoulder instability is multifactorial. The primary causes include increased ligamentous laxity and a decrease in muscular stiffness. (Olds, McNair, Nordez, & Cornu, 2011) Ligamentous laxity is associated with connective tissue disorders such as Marfan Syndrome, Ehlers-Danlos Syndrome, or Benign Joint Hypermobility Syndrome. The development of chronic anterior shoulder instability is much higher in younger patients, which can be attributed to a higher activity level. Damage associated with anterior glenohumeral instability differs from older to younger populations. In older populations, rotator cuff tears and neurovascular injuries occur more frequently concomitantly with anterior shoulder dislocation. This is attributed to degenerative weakening of the rotator cuff muscles.

Excessive external rotation of a thrower's shoulder is associated with the development of internal impingement syndrome, affecting the supraspinatus tendon. Impingement syndrome is a potential precursor to anterior instability. ("Anterior Shoulder Instability", 2019)

The existence of a Bankart lesion is considered the primary pathology in the development of anterior shoulder instability post-trauma.(Durban, Kim, Kim, & Oh, 2016) As the humerus is externally rotated during abduction, the humerus is levered out of the glenoid fossa and can avulse the anterior rim and labrum. (Cutts, Prempeh, & Drew, 2009) Bankart lesions are present in over 90% patients after a traumatic anterior shoulder dislocation. (Durban, Kim, Kim, & Oh, 2016) As the humerus moves out of the glenoid fossa, it typically tears the anterior labrum and can fracture the anterior lip of the glenoid fossa. As the shoulder is stabilized by the labrum, ligaments, and the shallow glenoid fossa, and a dislocation can disrupt all of these structures, a Bankart lesion can cause significant loss of function in the shoulder.

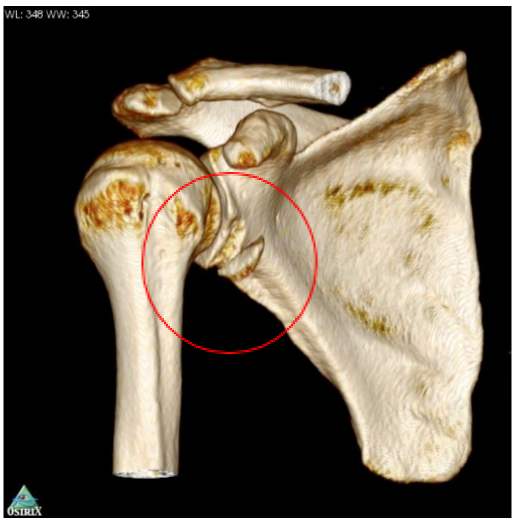

Figure 5

When the posterior surface of the humeral head moves over the anterior rim of the glenoid fossa during an episode of instability, the collision can create a bony indentation called a Hill Sachs lesion. (Cutts, Prempeh, & Drew, 2009) This alters the overall shape of the humeral head and changes the way the joint articulates. Because of

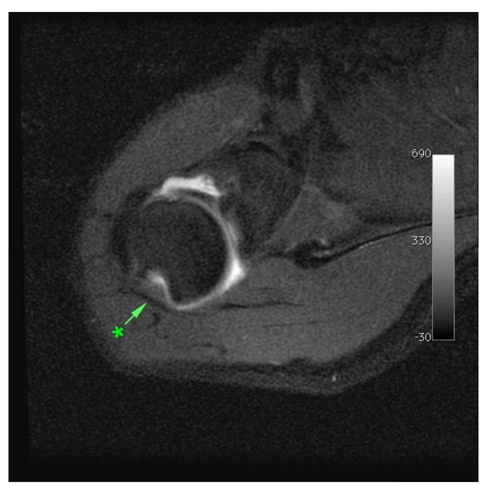

Figure 6

this change, the presence of the lesion greatly increases the risk of recurrent dislocation and instability in the affected shoulder. In a study of patients under 40 years old conducted by Hovelius *et al.,* 54% of anterior dislocations were associated with a Hill Sachs lesion. (Hovelius, et al., 1996)

In 22% of cases, a SLAP lesion can occur when the shoulder experiences an episode of anterior instability. Although anterior instability can be attributed to chronic injury, concomitant SLAP lesions are associated with high-energy, traumatic, single dislocations more than low-energy, repetitive trauma. The high-energy trauma can cause severe lesions and a great degree of anterior instability. Radiological evaluation of the affected shoulder in 39% of patients showed superior labral involvement after a single episode of instability. Instability is found to be worse in patients who incurred the injury at a younger age and who have delayed surgery after injury. These factors propagate and increase the severity of the present instability. (Durban, Kim, Kim, & Oh, 2016)

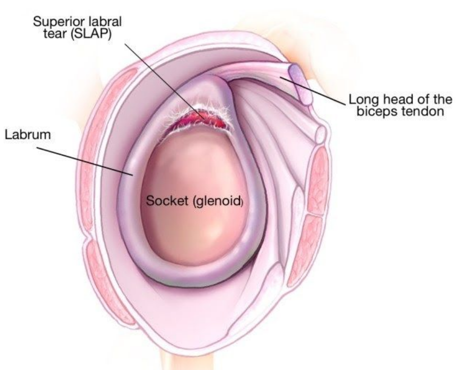

Figure 7

Diagnosis

Typically, diagnosing anterior dislocation is very straightforward. The deformity is noticeable and the signs and symptoms that follow are very indicative of the injury. The process to diagnose anterior instability without a singular traumatic event is much more difficult and requires ruling other conditions in or out. Just because an individual has positive indications for another injury does not rule them out of having anterior instability. These injuries are typically linked through mechanism of injury, shoulder anatomy, or muscular dysfunction from initial injury. Whatever the cause, it is still important to recognize anterior instability and treat the underlying cause as well as the symptoms.

Common signs and symptoms described by patients with instability include pain, weakness, and abnormal sensations in the affected shoulder. Pain is usually in the glenohumeral joint, although it can be diffuse throughout the shoulder region. Upon palpation, tenderness is usually found along the anterior joint line and the rotator cuff. Pain can worsen with reaching overhead or backwards, or when the arm is put into abduction and external rotation. Sleeping on the affected side may also increase discomfort to the joint. ("Anterior Shoulder Instability", 2019) The patient may describe stiffness in the shoulder in the morning or during their warm-up routine. They also may complain of popping, grinding or catching sensations within the shoulder joint. During special testing or performance of their sport, it may be noticed that the individual has marked weakness in their rotator cuff muscles. This weakness becomes more apparent in external rotation and during an “empty-can” test. Tingling or burning sensations may be felt in the distal arm or hand, or superficially over the deltoid muscle. The patient may describe a “dead-arm” sensation after throwing, complain of sharp pain in the anterior shoulder, tingling in the shoulder, or muscular weakness down the arm. ("Anterior Shoulder Instability", 2019)

As stated before, anterior instability is not a stand-alone diagnosis and is associated with almost any damage sustained in the shoulder. Some injuries are a cause of anterior instability, while others result from anterior instability. A Bankart lesion is the most common result of an incident of anterior instability. It is an avulsion of the anteroinferior labrum along the rim of the glenoid fossa and can also include a fracture of the rim itself. Avulsion of the glenohumeral ligaments can be caused by dislocation and subluxation of the glenohumeral joint, resulting in anterior shoulder instability. A SLAP lesion can occur after an anterior shoulder dislocation, where the superior, anterior and posterior labrum is torn where the bicep tendon attaches. Because this injury disrupts the labrum that deepens and stabilizes the joint, it can also lead to anterior shoulder instability. ("Anterior Shoulder Instability", 2019) The biggest culprit of recurrent anterior instability after initial anterior shoulder dislocation is a Hill-Sachs lesion. This occurs when the posterior surface of the humeral head collides with the anterior rim of the glenoid, resulting in a concave defect in the cartilage. A Hill-Sachs defect has been observed in approximately 80% of patients after an acute anterior dislocation and in 100% of patients diagnosed with recurrent anterior instability. ("Anterior Shoulder Instability", 2019) If the defect articulates with the anterior aspect of the glenoid surface while the arm is abducted to 90° and externally rotated, it is called an "engaging Hill-Sachs lesion" and associated with increasing the risk of an arthroscopic glenohumeral stabilization procedure failing. ("Anterior Shoulder Instability", 2019)

Prior to evaluation, it is important to come up with several differential diagnoses to rule in or out throughout the clinical evaluation. It is important to remember that just because anterior shoulder is suspected or apparent does not mean that it is exclusively the problem. Either injury to the soft tissue or deformity of the bony articulations caused the instability and will need to be addressed, or they happened as a result of the instability and will need to be addressed. Some differential diagnoses include adhesive capsulitis, dead arm syndrome, rotator cuff strain or tear, subacromial impingement, internal impingement, and bicep tendinopathy. ("Anterior Shoulder Instability", 2019) Any of these could be present alongside anterior instability, or may be lone injuries but the shoulder should be evaluated considering both.

At the time of injury, as well as days following the injury, special diagnostic tests can be performed to help rule in or out specific conditions. The most notable special tests that indicate anterior shoulder instability are the load and shift test, apprehension test, relocation and anterior release test, and the anterior drawer. These specific tests look for laxity in the joint. Other special tests for surrounding soft tissue, like the empty can test, O'briens, or Yergason's and Speeds may indicate other pathologies surrounding instability of the shoulder. ("Anterior Shoulder Instability", 2019)

In order to diagnose any lesions or soft tissue damage that may indicate anterior shoulder instability, imaging needs to be done on the glenohumeral joint. The most accessible and cost effective imaging performed is an x-ray. Many views are needed to visualize possible defects, including an anteroposterior view, axillary lateral view, a Velpeau view, an apical oblique view and many others depending on the physician's orders. Anteroposterior and axillary lateral views are typically initially ordered by a physician, followed by other positions if a better view is needed. A Velpeau view is taken while the patient is in a semi-reclined, seated position, while an apical oblique view is taken with the patient seated and rotated 45° and the beam directed 45° caudally to visualize posterior humeral defects. Hill-Sachs lesions are best visualized on anteroposterior with internal rotation or using a Stryker notch view where the patient is supine with the shoulder flexed to 100° while the x-ray is centered over the coracoid process. Bankart lesions are best seen in an axillary view and

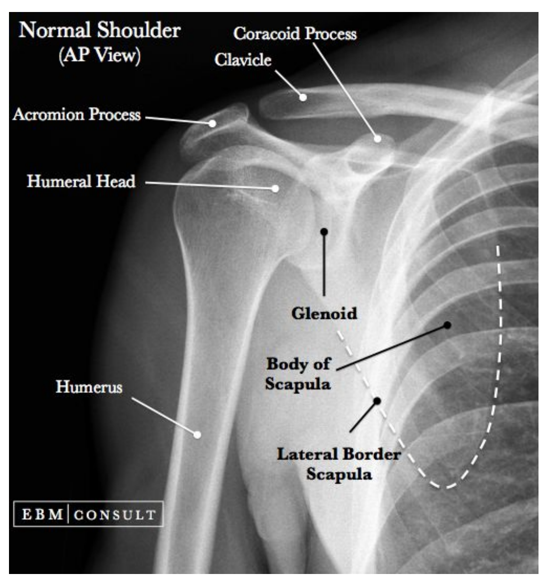

Figure 8

may be indicated on an anteroposterior view. ("Anterior Shoulder Instability", 2019)

An MRI is useful in visualizing and evaluating soft tissue, but does not provide clear enough pictures of bony deformities. Acutely, hemarthrosis from the dislocation serves as an intra-articular contrast medium, while gadolinium may be injected intra-articularly in chronic cases to visualize soft tissue pathology like labral tears and disrupted joint capsule. Anterior periosteal sleeve avulsion or humeral avulsion of glenohumeral ligament can occur with an anterior shoulder dislocation or instability, and associated with higher recurrence rates of instability. If missed during surgery, the defects can also lead to failure of the surgical intervention. These lesions are best visualized with the use of an MRI and MR arthrogram.

Traditionally, a CT is useful in demonstrating and quantifying bone abnormalities, especially glenoid bone loss, fracture, and humeral head abnormalities. The use of contrast can provide insight into soft tissue damage to the labrum, rotator cuff, and glenohumeral ligaments. ("Anterior Shoulder Instability", 2019) More recently, CTs are being used to evaluate the glenoid track and attempt to quantify the amount of instability. The glenoid track concept is important to assess overall risk of recurrent instability. The acknowledgement of bony abnormalities in the track can guide surgical decision-making to reduce the risk of recurrence. The existence of a Hill-Sachs lesion in the glenoid track is prevalent in 38-88% in shoulders that have anteriorly dislocated, and is associated with up to 100% of recurrent dislocations. (Radhan, Raj, Sivaraman, & Ramachandran, 2019) 3DCT is the most widely recommended preoperative

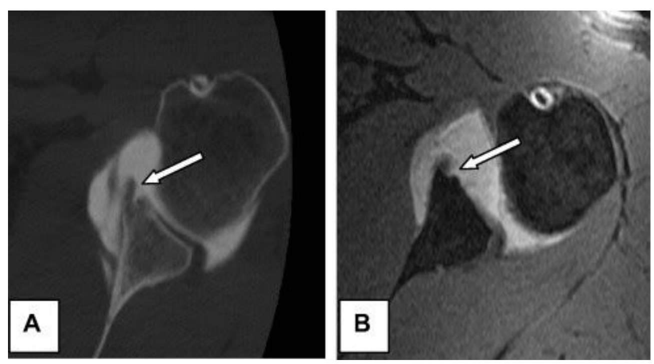

Figure 9

imaging study for bone tissue. The severity of bone loss is more easily visualized with the 3D interface. There many benefits to using CT over MRI in the shoulder. Using CT would reduce overall cost and radiation exposure. Engagement of the humerus to the glenoid has been well predicted using the glenoid track method, with follow-up intra-operatively. This practice should become routine in the preoperative evaluation of anterior shoulder instability. (Radhan, Raj, Sivaraman, & Ramachandran, 2019)

Unipolar bone loss is the partial loss of the glenoid or humeral head; bipolar bone loss is the association between both lesions. These lesions together significantly compromise the stability of the glenohumeral joint. Surgical decisions are made based upon the extent of osseous deficiency, location of the lesions, and patient-specific concerns. Minimal bone loss is classified as less than 20% , moderate bone loss falls between 20-30%, and significant bone loss is greater 30%. (Khattab & Tantawy, 2018) Assessing for defects using the 3DCT in the glenoid en face view, performed using the sagittal oblique view of both glenoid surfaces. The inferior ⅔ of the glenoid should be evaluated and measured, using the unaffected side as a "ruler". Circumference should also be measured and compared bilaterally. "There was no significant difference between MDCT 3D glenoid en face view and shoulder arthroscopy regarding percentage and degree of glenoid bone loss with good agreement between MDCT 3-D reconstruction imaging and arthroscope in detection of glenoid bone loss". (Khattab & Tantawy, 2018) While extremely accurate with the diagnosis and visualization of bony abnormalities, the MDCT 3D could only accurately diagnose 50% of patients who had Bankart lesions. Despite this shortcoming, preoperative CT imaging is a crucial tool to orthopedic surgeons. Ultimately, preventing surgical failures and recurrent instability is the goal of progressing conservative, non-invasive treatments and diagnostic imaging. (Khattab & Tantawy, 2018)

Using outcome measures can help gauge the patients perceived outcome and subjective improvement. One useful measure is the DASH questionnaire. The form consists of 30 subjective questions evaluating the ability of the patient to perform activities requiring the use of the upper extremity. The patient rates difficulty and interference on a 5 point Likert scale. This form should be filled out regularly throughout the course of treatment. A visual analog scale can help a patient-practitioner communicate about the effectiveness of the course of treatment. Ideally, pain will decrease throughout therapeutic intervention, but if we are pushing too hard or progressing too quickly, pain will increase. This increase should be communicated throughout each session, as well as prior to the beginning of the session. ("Anterior Shoulder Instability", 2019)

Reduction and Immediate Treatment

Anterior shoulder instability is not a life-threatening condition, but it can significantly impact a patient's quality of life if left untreated. For most optimal treatment, the damage caused by the instability should be addressed immediately, followed by personalized treatment of the underlying factors that led to instability. Immediate treatment of the condition could include reduction, imaging, a period of immobilization, rehabilitation, and surgery. Long-term management includes rehabilitation and possible modification to activities. (Rossi, Anderson, & Doberstein, 2018)

In order to have the best possible chance for a successful outcome immediately after dislocation, there are two priorities: avoid neurovascular complications and reduce the joint as atraumatically and as quickly as possible. Athletic trainers are qualified to handle emergency care of musculoskeletal injuries, including joint dislocations. As a Certified Athletic Trainer, this does not mean it is appropriate to attempt to reduce a dislocation in every situation. It is important to know the regulations within the state in which you practice, have proper consent documented from the individual and/or their parent or guardian, and have documented standing orders from an overseeing physician on the agreed upon protocol prior to any athletic season. An athletic trainer should also have proper education, experience and confidence in reducing a dislocation. If the individual is not comfortable in attempting an onsite reduction, the patient should be immobilized and transported to an emergency room. After any dislocation, the patient should follow up with an orthopedic doctor. (Rossi, Anderson, & Doberstein, 2018)

As with any injury, a proper history should be obtained from the patient to identify previous injuries, medical conditions, and details of the current injury. A quick, but documented comprehensive evaluation should be performed to rule out concomitant fractures, neurovascular damage, or other conditions before deciding to reduce a dislocated glenohumeral joint. After any attempt to reduce, successful or not, a neurovascular reassessment should be performed and documented. After the glenohumeral joint is reduced, the patient’s affected arm should be immobilized and they should be referred to an orthopedic physician for further evaluation and imaging. If there are any signs or symptoms present that would indicate a fracture, or pulse or sensation is altered on the affected side, a reduction should not be attempted and the patient should be immobilized and referred to the appropriate medical facility. (Smith & Hoogenboom, 2013) If after one attempt the glenohumeral joint will not reduce, the patient should be immobilized and referred to the appropriate medical facility. If a patient is suspected to still have open epiphyseal plates based on their age or gender, reduction of the joint should not be attempted as an associated fracture is highly likely. (Rossi, Anderson, & Doberstein, 2018)

On-site reduction should only be attempted for anterior glenohumeral dislocations, not posterior or inferior. The goal of reduction is to decrease pain without causing more damage to the glenohumeral joint. Onsite reduction can restore vascular flow to the extremity. (Rossi, Anderson, & Doberstein, 2018) If onsite reduction is going to be attempted, the initial evaluation should last no longer than three minutes. (Smith & Hoogenboom, 2013) The longer the reduction is delayed, the less likely that the joint will be able to be reduced without sedation because of the onset of muscle guarding and spasms. Sometimes soft tissue or bony alignment can impede reduction. A delay in reduction does not typically lead to further harm to the patient. Because of the nature of onsite reduction, there may be an undetected fracture, further damage to neurovascular structures could occur, and any attempt to reduce the dislocation may result in more pain to the patient. If the onsite medical practitioner has any doubts about reducing a dislocation, the patient should be splinted as-is and referred to the appropriate medical facility. Imaging should always be done after a reduction to ensure proper alignment and rule out fractures from the dislocation or reduction.(Rossi, Anderson, & Doberstein, 2018)

A common route for a practitioner to take when choosing to reduce a dislocation is instructing the patient through a self-reduction technique. This may be appropriate when forcible reduction is outside the scope of the health professional’s practice. A simple technique used for self-reduction has the athlete positioned in a long-sit, with the injured shoulder being stabilized by a medical professional. The athlete should flex the knee and hip on the same side as the affected shoulder, and place both hands over the knee. The affected side should be supported by

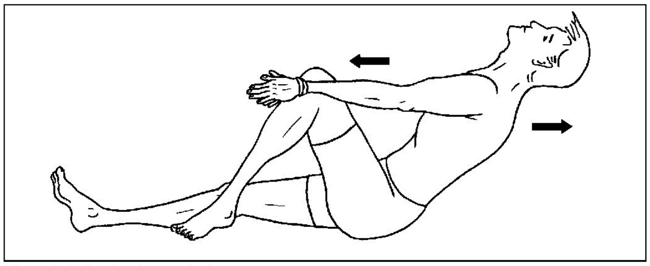
Figure 6. Self-reduction method.

Figure 10

the athlete's other hand as the medical professional positions themselves to support the athlete in case of loss of consciousness or balance. The athlete should then relax, leaning backwards while maintaining hand positioning at the knee. If the athlete is able to relax enough, the shoulder should reduce spontaneously. (Smith & Hoogenboom, 2013)

Immobilization of the affected shoulder should be in a relatively comfortable position for the patient. The amount of time the patient should be immobilized will depend on the physician and extent of injury. It has been found that immobilization for more than one week in patients without associated fractures did not improve recurrence rates. (Smith, Huxel Bliven, Morway, & Hurbanek, 2015) By using arthroscopic surgical intervention after the initial injury, results found that overall cost of care was much less expensive and more effective for younger patients. (Smith, Huxel Bliven, Morway, & Hurbanek, 2015) It is starting to be highly encouraged by orthopedic doctors to any patient under 30 years of age to consider arthroscopic intervention. (Smith, Huxel Bliven, Morway, & Hurbanek, 2015)

Conservative Treatments

Conservative management has three main priorities: pain management, regain normal range of motion, and equal strength bilaterally. With most injuries, conservative treatment is recommended first, followed by surgical intervention if there is a lack of improvement in the condition. While this is still common in the primary management of shoulder instability, it is beginning to be phased out when dealing with younger, more active populations because it simply does not work and results in much poorer long-term outcomes. Early surgical intervention prevents recurrence and further damage to the joint and surrounding soft tissue structures in higher risk individuals. Non-invasive management is still the most common route with patients who are older and less active, as the surgery itself can pose major risks to these populations. These patients are seen as “low-risk” and are less likely to have subsequent instability after the initial injury. (Ma, Brimmo, Li, & Colbert, 2017)

Pain management is the first priority in conservative treatment programs and is integrated throughout the rehabilitation process. Initially, nonsteroidal anti-inflammatories are recommended to decrease inflammation and thus decrease pain. ("Anterior Shoulder Instability", 2019) When this is unsuccessful, analgesics or corticosteroids may be used through intra-articular injections. Corticosteroid injections are used sparingly in young adult populations, as multiple injections can lead to the cartilage of the injected joint being broken down, leading to arthritis. The patient should be counseled on positions to sleep in comfortably, and about limitations to activities of daily living. ("Anterior Shoulder Instability", 2019)

The development of a rehabilitation plan should be based off the ICF model, and individualized to each patient based off several factors related to the injury itself: onset of pathology, degree of instability, frequency of dislocation or subluxation, direction of instability, concomitant pathologies, neuromuscular control, and activity level. ("Anterior Shoulder Instability", 2019) The glenohumeral joint allows for a significant amount of motion and is the most mobile diarthrodial joint. This makes the joint inherently unstable, as does the bony proportions of the small glenoid surface and the relatively large humeral head. Rehabilitation should appropriately balance the need to have a wide range of motion while simultaneously increasing dynamic stability. Dynamic stabilizers include musculotendinous structures, primarily the rotator cuff muscles, bicep brachii, and deltoid. Any muscular weakness or imbalance compromises the integrity of the dynamic stabilization performance, thus leading to recurrent anterior instability. Deficits in range of motion or strength through internal or external rotation at the glenohumeral joint has a strong correlation with recurrent anterior instability. Deficits in internal rotation has a greater correlation with long-term instability of the shoulder. Static stabilizers in the shoulder also work to stabilize the shoulder joint without movement or contraction. Static stabilizers include inert soft tissues like the labrum and glenohumeral ligament. (Ma, Brimmo, Li, & Colbert, 2017) Disruption of sensorimotor feedback has also been shown to increase with recurrent anterior instability. Proprioception and kinesthesia should also be included in shoulder rehabilitation for this reason. (Ma, Brimmo, Li, & Colbert, 2017)

The first phase after injury, or the acute phase, is characterized by pain, muscle spasm, and muscle guarding in an internally rotated position across the body. The patient typically will limit their own activity level because of this. Our goals as medical professionals in this phase are to reduce any pain, inflammation, and muscle guarding, protect the healing soft tissues and joint capsule, minimize negative effects of immobilization, and reestablish dynamic stability and proprioception of the glenohumeral joint. Immobilization is key in protecting the soft tissue structures and allowing the joint capsule to heal as much as possible, however the length of time for immobilization is not entirely clear in the literature, and can range from 2 days to two weeks. (Ma, Brimmo, Li, & Colbert, 2017) It has been found that immobilization past one week does not decrease the likelihood of recurrent instability. (Paterson, Throckmorton, Koester, Azar, Kuhn; 2010)

Early passive motion within a protected range may promote healing, enhance collagen organization, and decrease pain. This passive motion should be performed in the plane of the scapula and in a diagonal pattern to protect the healing joint capsule and engage proprioceptive and neuromuscular feedback to enhance the dynamic stability of the glenohumeral joint. Exercises to strengthen or regain internal or external rotation range of motion should be performed with little to no abduction. All exercises should be performed at no more than 90 degrees of abduction in the acute phase of healing. Ice and transcutaneous electrical nerve stimulation, or TENS, have been found to aid in pain management during this phase. (Ma, Brimmo, Li, & Colbert, 2017)

Restoring dynamic stability of the glenohumeral joint begins in the acute phase of healing and continues through the subacute phase. Isometric exercises are prescribed initially to minimize muscular atrophy in the shoulder. While restricting range of motion, the patient can progress to active-assisted motion, and then to resistive motion. Closed kinetic chain exercises can be initiated when there is no pain with resistive motion. Closed kinetic chain exercises are performed to increase joint congruency, decrease range of motion during exercise performance, decrease velocity of movement, and enhance proprioceptive feedback. All these factors help to regain dynamic stability while allowing the soft tissue damage in the shoulder to heal. Rhythmic stabilization to facilitate co-contractions in shoulder musculature in the scapular plane at less than 30° can also be initiated at this time. (Ma, Brimmo, Li, & Colbert, 2017)

Before initiating phase two, the patient should have reduced pain, static shoulder stability, and improved neuromuscular control. The goal of phase two is to regain at least 90% of passive and active motion except with external range at 90° of abduction. When indicated, flexion and internal or external rotation exercises can be initiated at 90° of abduction. External rotation at 90° abduction should be restricted to less than 50° until 4-8 weeks after injury. Stressing the healing anterior capsuloligamentous structures should still be avoided. Isotonic exercises are initiated in this phase, emphasizing internal and external rotators and scapular muscles to enhance dynamic stability. Exercises should start at 0° of abduction, and when a stable arc below 90° is achieved, rotator cuff exercises can be initiated above 90° abduction. Closed kinetic chain exercises can be progressed to hand-wall stabilization drills within the scapular planes, increasing height as tolerated individually. Scapular dyskinesis should be addressed during this phase, prior to initiating bilateral weight bearing in the shoulder. After that is addressed, we can include push-up exercises, increasing dynamic stability and core strength. Difficulty can be gradually adjusted, starting with hands on the wall or table, then the floor, and then to an unstable surface. This progression should continue onto phase three. (Ma, Brimmo, Li, & Colbert, 2017)

Phase three can begin when the patient is experiencing minimal to no pain in the shoulder, full shoulder motion and capsular mobility, good shoulder strength (⅘ on manual testing), endurance and dynamic stability of the scapulothoracic and upper extremity. Isotonic exercises are progressed to more functional and sport specific positions. Low resistance, high repetition exercises to increase muscular endurance at this phase. Exercises to focus on include bench press, seated row, and latissimus pull downs. Plyometric drills should be initiated to increase eccentric strength, starting with two-handed throwing drills and progressing to one-handed throwing drills against a trampoline. The progression of exercises should be gradual and without marked increases in pain. (Ma, Brimmo, Li, & Colbert, 2017)

In order to return to sport, a patient must complete certain criteria. Full functional range of motion, equal strength and endurance, adequate static and dynamic stability, and clinical examination without pain. It should be individualized to the patient's specific injury, sport, skill level, and goals. Commonly used criteria to progress into sport specific activity is an internal/external rotation ratio of 66-76% or higher at 180° per second, and an external rotation/abduction ratio of 67-75% or higher at 180° per second. This may not be adequate enough for return to activity. Contact athletes who do not require a great amount of abduction may consider a shoulder-stability brace during activity, but not in skilled positions or sports requiring overhead motion. (Ma, Brimmo, Li, & Colbert, 2017)

There is limited data available on the efficacy of rehabilitation protocols effectively reducing the risk of recurrence. There are so many variables that affect shoulder instability and rehabilitation and results, including age, number of dislocations, and amount of glenoid bone loss. These factors may even negate the purpose in engaging in conservative rehabilitation, lending to the idea of arthroscopic surgery as an optimal treatment of anterior shoulder instability. (Ma, Brimmo, Li, & Colbert, 2017)

Surgical Procedures

There are two primary options for the management of acute anterior instability: immobilization or arthroscopic stabilization. The decision to pursue surgical intervention is based on the patient's history, desired outcome, and risk of negative outcomes with or without surgical intervention. Patients under the age of 25 are at an increased risk of recurrent dislocation without any surgical intervention. Recurrent instability increases the risk of the development of osteoarthritis, elongation and loosening of the capsule, progressive labro-ligamentous damage, and glenoid bone loss. Because there are so many factors associated with the development of anterior instability, timing and technique of surgical intervention should be modified to the individual's age, occupation, and activity level. (Polyzois, Dattani, Gupta, Levy, & Narvani, 2016)

The prevalence of shoulder dislocations in the general population is estimated at about 2-8%. (Polyzois, Dattani, Gupta, Levy, & Narvani, 2016) Following acute anterior shoulder dislocation, recurrent instability rates range from 14% to 100%. (Polyzois, Dattani, Gupta, Levy, & Narvani, 2016) The biggest factor influencing the rate of recurrence seems to be the age at which the initial dislocation was experienced. The highest statistical rates occurred in patients under 20, and only a slight decrease in patients between 20-30. Even after arthroscopic repair, osteoarthritis can develop in certain patients. It is hypothesized that the development of osteoarthritis after anterior instability is directly related to the amount of time between the initial injury and surgical intervention. (Buscayret, Edwards, Szabo, Adeleine, Coudane, Walch, 2004)

With any type of surgery, there are risks. For arthroscopic anterior shoulder stabilization, the risks are minimal and usually resolve quickly. Post-operatively, patients may develop stiffness, reduced range of motion, decreased strength and function, persistent pain, arthritis, infection, and subscapularis dysfunction. Nerve damage is possible, and happens in less than 1% of cases that were treated arthroscopically. (Polyzois, Dattani, Gupta, Levy, & Narvani, 2016)

The Latarjet Procedure

There are many different techniques used to stabilize the anterior shoulder, and the technique used will depend on the cause of the instability, the desired outcome by the patient, as well as the surgeon performing the arthroscopy. The Latarjet procedure is one of the most commonly performed in the presence of glenoid bone deficiency. The surgeon uses a graft harvested from the coracoid process of the affected shoulder, along with the attached short head of the biceps brachii. (Polyzois, Dattani, Gupta, Levy, & Narvani, 2016) In the classic technique of the Latarjet procedure, the surgeon then cuts a slit through the subscapularis and attaches the bone graft to the anterior portion of the glenoid surface. In the congruent-arc technique, the coracoid is rotated 90° and transferred with the medial side against the glenoid. (Willemsen, Berendes, Geurkink, & Bleys, 2019) The graft acts as a bone block and widens the articulating

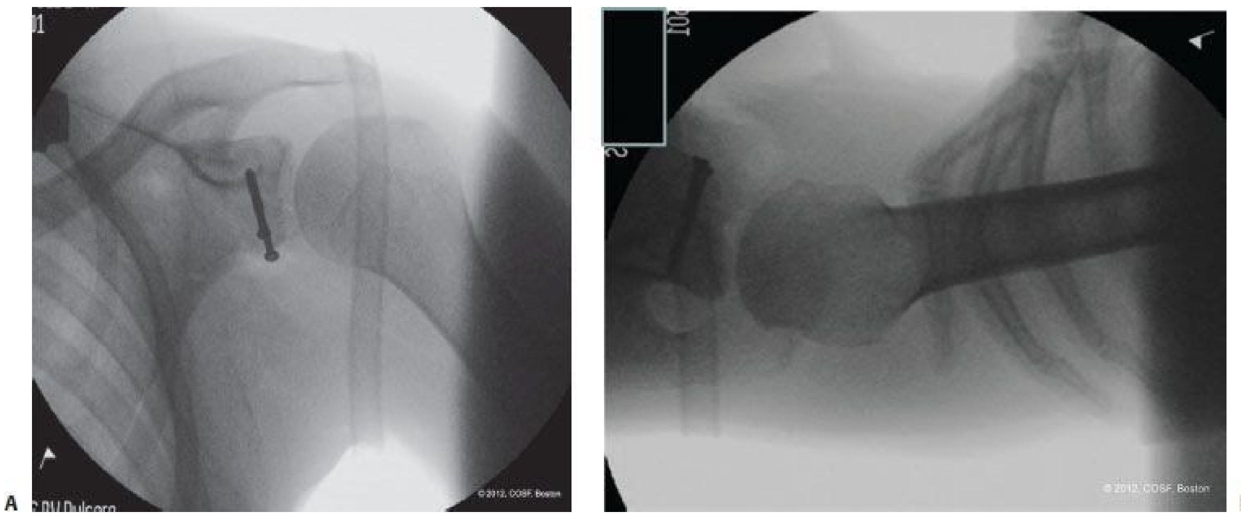

Figure 11

surface, stabilizing the anterior shoulder. There are low rates of recurrent instability, even after returning to high-energy activities. Severe complications arise in up to 30% of patients. (Willemsen, Berendes, Geurkink, & Bleys, 2019) The split subscapularis might provide some dynamic stability to the glenohumeral joint, but the bone block of the coracoid prevents normal function of the subscapular muscles. This technique can be performed arthroscopically or open. This technique will be used as a comparison to cutting edge techniques currently being researched and reviewed in this paper. (McHale, Sanchez, Lavery, Rossy, Sanchez, Ferrari, & Provencher, 2017)

The main goal of any arthroscopic anterior stabilization surgery is to prevent recurrent stabilization with a low complication rate. Bone loss is the primary factor in recurrent instability, and soft tissue repairs often fail when this bone loss is not addressed. (Huxel Bliven & Parr, 2018) One possible problem with the Latarjet procedure is that the coracoid bone graft is not accurately shaped to fit the area of bone loss. With new technology, there are possible substitutes that address this problem. 3D printing can circumvent issues found with the Latarjet procedure. The implant can be printed with titanium to fit flush with the remaining bone to fit the exact defect. It is placed outside the capsule to allow the capsule to function as an articulating surface. The proximal portion of the humerus is fastened to allow up to 30° of abduction and neutral rotation of the humerus in relation to the glenoid cavity. This increases the amount of stability provided by the bone structures. (Willemsen, Berendes, Geurkink, & Bleys, 2019)

The biggest drawback from the 3D-printed method is the absence of a dynamic muscle stabilizer. This is addressed in the Latarjet procedure and contributes 21% of the force needed to translate the humerus. (Willemsen, Berendes, Geurkink, & Bleys, 2019) The implant must be perfectly positioned to avoid widening or deepening the glenoid surface too much, and the capsule must be sutured into the proper position. The thickness of the capsule can also impact the outcome of the surgery, and is not predictable by preoperative CT scans. On the other hand, the Latarjet procedure has a high rate of complications including malpositioning, problems with the screw trajectory, loss of the range of motion, and eventually the development of osteoarthritis. The variability of the latarjet procedure compared to the titanium implant leads to similar long-term outcomes. More research needs to be completed on the comparison of these two techniques. (Willemsen, Berendes, Geurkink, & Bleys, 2019)

Subscapular Quadriceps Tendon-Bone Sling Procedure

Another technique in the process of being researched is the subscapular quadriceps tendon-bone sling method. This is a modification of the subscapular sling with a semitendinosus graft. The hypothesis is that by forming a sling structure with the tendon-bone graft, the surgeon can stabilize the joint much more than by performing the Latarjet procedure. The sling structure of the ligaments surrounding the joint is highly important to the integrity of the joints stability. The goal of this technique is to improve stability without losing external rotation of the shoulder, and decreasing the risk of damaging any nerves or vessels in the process. A sling is formed by wrapping the tendon graft around the subscapularis tendon, recreating a sling. (Klungsøyr, Vagstad, Ferle, Drogset, & Hoff, 2020)

The quadriceps tendon-bone graft is harvested from a cadaver, with a tendon no less than 8.5 cm and a bone graft at 2.5 cm long, 10mm x 10 mm. It is important to obtain a preoperative CT in order to accurately place the bone block. The bone graft must be put at an angle to prevent the reduction of the radius of the glenoid. The superior end of the bone block must be recessed to prevent damage to the subscapularis tendon. The labrum must be removed between 2 and 6 o'clock, while the anterior glenoid is resected between 6 and 12 o'clock. The bone block is placed and fixed with screws. (Klungsøyr, Vagstad, Ferle, Drogset, & Hoff, 2020)

No visible changes of the screws or displacement of the bone block was witnessed until a CT was performed, where three patients showed signs of changed position of screws and fractured bone block. Proximal tendon fixation was loosened during functional testing under arthroscopic observation. A new anchor was applied and fixated the graft appropriately. The inferior screw must be placed as close to the superior screw as possible to reduce the risk of fracture or tendon rupture. (Klungsøyr, Vagstad, Ferle, Drogset, & Hoff, 2020)

The QTB sling improved stability in all four testing positions post-operation. There were significantly decreased translations within the glenohumeral joint with the QTB sling. This technique may be a safe alternative to the Latarjet and other graft procedures. In the event the QTB procedure fails for any reason, the Latarjet procedure can be performed as a salvage procedure. A revision is difficult because of the distorted anatomy after the first attempt. An intact subscapularis tendon is key to achieving a stabilizing effect. The QTB procedure achieves a combination of the dynamic and static stabilization without tenodesis of the subscapularis tendon, preventing any blockage of normal function. (Klungsøyr, Vagstad, Ferle, Drogset, & Hoff, 2020)

Arthroscopic Iliac Bone Block Augmentation

This procedure is also based on the shortcomings of the Latarjet procedure. In order to provide stabilization in the presence of significant glenoid bone loss, a bone augmentation is required. Both the Latarjet procedure and the arthroscopic iliac bone block provide this crucial step. With the Latarjet procedure, resorption of the bone graft with the protrusion of the metal screws and the controversy of the dynamic sling effect are major concerns going into surgery. These complications can destroy normal joint kinematics resulting in scapular dyskinesia and graft osteolysis. The use of the iliac crest graft enables precise placement and fixation of the bone block using one suture anchor rather than a screw. Much more training is required to perform this method. (Jeong, Yoo, & Kim, 2020)

A three-dimensional model of the articular surface can be helpful in the preoperative planning to ensure the proper amount of iliac bone is harvested for the augmentation. The iliac crest graft is harvested from the anterosuperior iliac crest on the ipsilateral side. The size of the block should be 2 cm long × 1 cm high × 1 cm wide but can be adjusted to fit the size of the glenoid. A small hole is drilled parallel to the articular surface of the glenoid and the iliac graft, and a four-layer y-knot is passed through the hole. The soft knot is anchored to the cortical surface of the bone, and the iliac bone block is placed so the anterior bone defect is covered. (Jeong, Yoo, & Kim, 2020)

Figure 12

The suture must be tight enough so the graft is flush with the anterior surface, but not overtightened to where the suture may tear. The iliac bone block should have the hole drilled about ¾ of the length down from the superior edge, and should not be drilled through at its center. (Malahias, et al., 2020) The procedure allows a more precise anatomical reconstruction of the glenoid surface, while also being easier to execute and faster than the Latarjet procedure. It also does not injure the subscapularis muscle, which can lead to faster progression to rehabilitation exercises. The biggest potential downfall is the relatively weak fixation force by

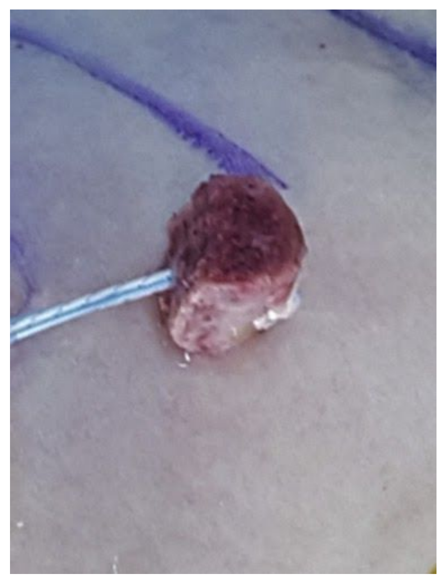

Figure 13

the suture knots. Harvest site morbidity is a concern, but this technique is actually the gold standard with the autologous iliac bone graft. (Jeong, Yoo, & Kim, 2020)

Rehabilitation from this procedure may be executed differently than your standard post-operative rehabilitation from stabilization surgery. Patients are immobilized in an abduction brace for six weeks following surgery, at which point passive range of motion exercises can be started. Before this point and until three months post-operation, only isometric muscle strengthening was permitted. Isokinetic exercises are initiated 3 months after full active range of motion is achieved. The patient is not permitted to return to contact sports until 12 months after surgery. (Jeong, Yoo, & Kim, 2020) The Iliac crest bone block technique in practice is safe and effective in the short-term follow-up for the management of anterior shoulder instability with substantial glenoid bone deficiency. (Malahias, et al., 2020)

Further Developments

3D Printing

A 3D patient-specific implant could decrease the failure rate among surgery techniques. Using an MDCT- 3D image, surgeons could print a titanium implant to precisely fill the osseous defect in the shoulder. The implant is placed extracapsularly to maintain a smooth articulating surface. With many cases of shoulder instability, there is a significant amount of osseous defects and glenoid bone loss. This decreases the functionality of the shoulder, increases the likelihood of recurrence, and decreases the likelihood of a satisfactory outcome after surgical intervention. By replacing the

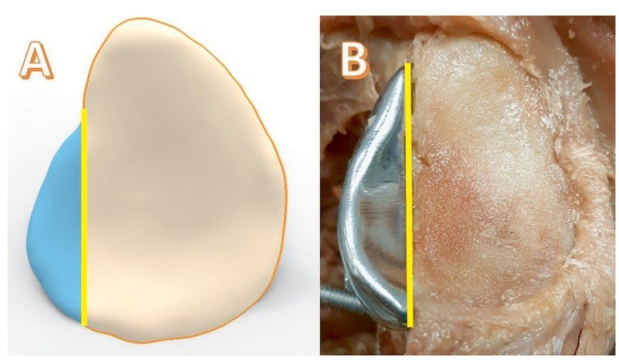

Figure 14

articulating surface of the glenoid that has been lost, more patients may be able to return to previous levels of activity sooner. Because the 3D-printed implant is not bone, we are not concerned about the implant and the glenoid surface healing together, just the scapular bone to heal around the screws. This could potentially decrease the amount of time needed for immobilization, and decrease overall recovery time. If this method worked, it would reduce the overall cost of the shoulder injury and prolong the individuals quality of life. More research should be done on best methods and long term outcomes of this surgical procedure. (Willemsen, Berendes, Geurkink, & Bleys, 2019)

Stiffness and Strength

A study found that 75% of patients were dissatisfied with the results of their conservative treatment of anterior shoulder instability, citing pain, instability and recurrence. (Olds, McNair, Nordez, & Cornu, 2011) Muscle stiffness may play a role in anterior shoulder stability, and it is hypothesized that by increasing muscle stiffness you can positively affect the outcome of conservative treatment. Muscle stiffness is defined as "the ratio of change in force to the change in muscle length". (Olds, McNair, Nordez, & Cornu, 2011) Specifically, active stiffness resisting horizontal extension need has not been thoroughly researched as a factor in reducing instability of the shoulder. Horizontal extension stretches the anterior musculature of the shoulder, and the muscles and tendons resist the stretch to protect the fibers. Despite the theory behind it, the study failed to produce a direct connection between muscle stiffness and quality of life, suggesting that more factors need to be considered. (Olds, McNair, Nordez, & Cornu, 2011)

One case study addressed glenohumeral laxity and stiffness in cheerleaders after partaking in a shoulder strengthening program. (Laudner, Metz, & Thomas, 2013) This was a six week strengthening program with two phases. Glenohumeral laxity and stiffness were tested

Phase I					Phase II		
	Week					Week	
Day/Exercises	1	2	3	4	Day/Exercises	5	6
Monday							
Seated dumbbell shoulder presses	4 × 10–12	4 × 10–12	4 × 8–10	4 × 8–10	Flat-bench dumbbell presses	3 × 10–12	3 × 10–12
Lateral pull-downs (overhand grip)	4 × 10–12	4 × 10–12	4 × 8–10	4 × 8–10	Plate rows	3 × 10–12	3 × 10–12
Dips (body weight or assisted)	3 × maximum	3 × maximum	3 × maximum	3 × maximum	Seated single-arm presses	3 × 10–12	3 × 10–12
Wednesday							
Incline barbell presses	4 × 10–12	4 × 10–12	4 × 8–10	4 × 8–10	Incline dumbbell presses	3 × 10–12	3 × 10–12
Seated rows	4 × 10–12	4 × 10–12	4 × 8–10	4 × 8–10	Single-arm rows	3 × 10–12	3 × 10–12
Standing cable reverse flies	3 × 15–20	3 × 15–20	3 × 12–15	3 × 12–15	Standing upright rows	3 × 10–12	3 × 10–12
Friday							
Standing barbell military press	4 × 10–12	4 × 10–12	4 × 8–10	4 × 8–10	Seated dumbbell presses	3 × 10–12	3 × 10–12
Incline dumbbell reverse flies	4 × 12–15	4 × 12–15	4 × 10–12	4 × 10–12	Lateral pull-downs	3 × 10–12	3 × 10–12
Push-ups	3 × max	3 × max	3 × max	3 × max	Swiss ball dumbbell presses	3 × 10–12	3 × 10–12

Figure 15

before and after the program for both the control group, who did not partake in a strength and conditioning program, and the participating group. The control group had more glenohumeral laxity and less stiffness than the participating group. The data concluded that the difference was clinically significant. It was also documented that the participating group had fewer shoulder related injuries throughout the season than the control group. Although more research is needed to make any correlation between muscular stiffness and the prevalence of shoulder instability, it has been recommended all that athletes take part in a preventative strength and conditioning program. (Laudner, Metz, & Thomas, 2013)

Capsular Plication and Thermal Capsulorrhaphy

Capsular plication and thermal capsulorrhaphy are two minimally invasive techniques being researched as methods to increase shoulder stability without any osseous deficiency. Both methods involve tightening the joint capsule of the shoulder in order to better keep the humeral head against the glenoid fossa, and both are suitable for treating anterior or multidirectional instability. These procedures are favored over more invasive procedures as this method is less invasive and heals faster than other methods. (Rolfes, 2015)

Capsular plication, or capsular shift, takes up slack in the joint capsule. This is done by suturing the capsule.There are a variety techniques such as suture or tack, plication and pleating variations, humerus- or glenoid-based shifts, direction of approach, and posterior "pinch-tuck" methods. The technique best suited to each patient is dependent upon surrounding tissue damage. This method has a high success rate, at around 91%. (Rolfes, 2015) Approximately 98.6% of patients reported being "mostly" to "extremely" satisfied post-surgery and rehabilitation. (Rolfes, 2015) About 87.7% of patients intended on returning to sport at their previous level, while only 74% were able to. (Miniaci & Codsi, 2006) Overall, the surgery is seen as highly successful.

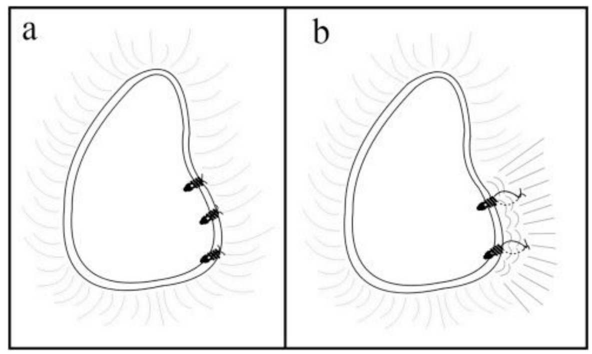

Figure 16

Thermal capsular-shift, or thermal capsulorrhaphy, is a surgical technique that either imitates a "painting-style" that leaves no remaining tissue between treated areas, or a striping technique that leaves minimal tissue between treated areas. More often, the striping technique is performed as the paintng technique can lead to excessive damage to the capsule. The techniques use a thermal laser that damages the tissue of the capsule, which is then repaired by fibroblasts and collagen formation, ultimately strengthening the capsule. The immobilization period after the procedure is performed varied between one to three weeks with a four to six month recovery. The overall success rate reported by physicians in the study was 76.5%. (Rolfes, 2015)

Thermal capsulorrhaphy is not indicated for patients who present with voluntary dislocations or moderate instability. This method is mostly recommended to patients exhibiting mild instability. When labral repairs were performed in conjunction with thermal capsulorrhaphy, the failure rates were significantly lower.Overall, the capsular plication procedure offers greater patient satisfaction and a higher success rate than the thermal capsulorrhaphy and is more applicable to a greater population of patients. Contraindications to both surgical interventions include osseous deficiency, hypermobility disorders, and excessive instability. These techniques can be performed alongside other surgical techniques that address contraindications. (Rolfes, 2015)

Rate of Force Production

Strength testing is already a component of return to play testing after shoulder instability. While strength is important to optimal shoulder function, what prevents reinjury to the shoulder once the patient is in a less controlled environment? Their ability to react and generate enough force to protect and stabilize the joint before it is forced past its normal range. Currently, we do try to ease the athlete back into activity in a controlled environment before allowing them to participate in an uncontrolled environment, but testing the rate of force production is not yet widely available.

Testing protocols must be appropriately challenging and sensitive enough to inform the practitioner on return to play decisions. The clinical tests themselves must have validity, reliability, and sensitivity in order to be widely used. Evidence-based practice is extremely important in all fields of medicine, athletic training included. A testing protocol also must outline criteria to progress, as well as the actual progression. There are three elements of returning to sport: return to participation, return to sport, and return to performance. (Ashworth & Cohen,

2019) In order to return to performance, the patient must be able to produce the same rate of force development bilaterally.

A force platform can be used to measure the rate of force development. They require a higher level of shoulder function and the rate and strategy of force development. These can

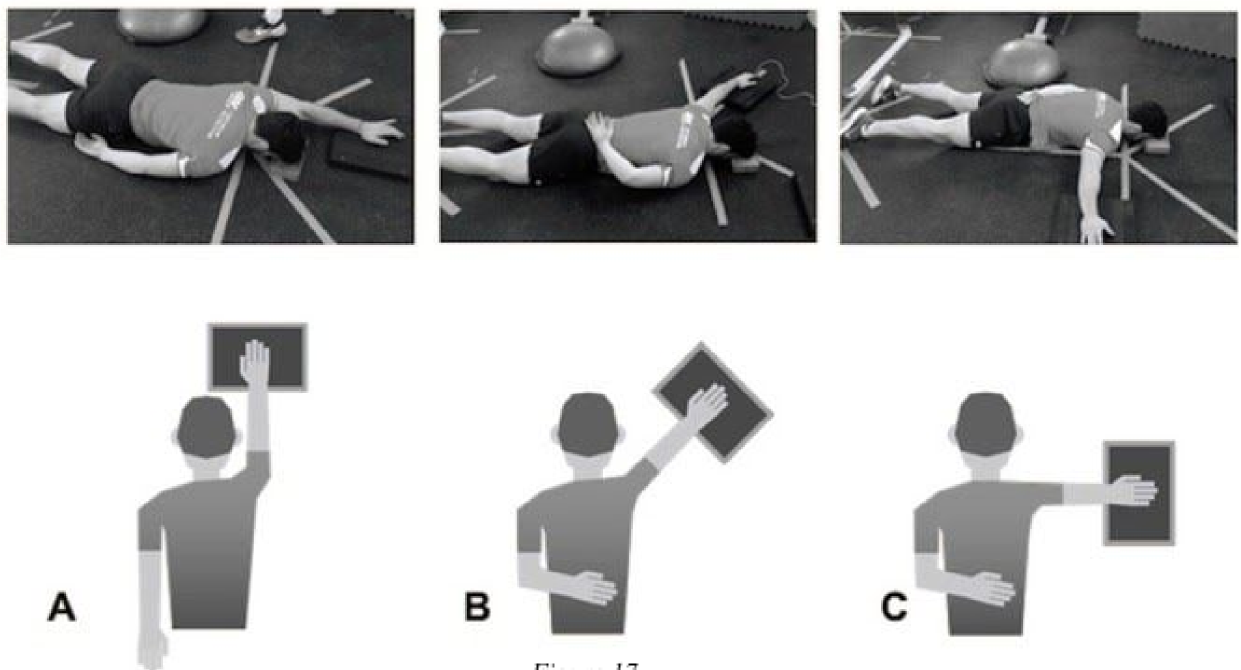

Figure 17

identify key components of optimal performance and promote injury prevention. If the tests were widely used, deficiencies could be identified and addressed before significant injury occurs. The "ASH" test was developed to test long-lever stress and the ability to transfer force across the shoulder complex during an arm tackle. The test is a maximal isometric contraction produced by the patient as fast and with as much force as possible. Although the test can indicate precisely what the dysfunction is, it will indicate when any dysfunction is present. Preliminary data from the study indicates excellent reliability for this test. (Ashworth & Cohen, 2019)

Innovative tests should follow a structured process to establish reputability and trust in the data collected. Tests must be able to stand up to the necessary scientific rigor to be considered valid, reliable and repeatable. Further tests should be designed to further identify deficits in the shoulder. The identification of deficits in athletes who compete in upper extremity dominant sports, such as baseball and swimming, can help to create a better injury prevention program and specific strength training programs individual to the athlete. (Ashworth & Cohen, 2019)

Shoulder Taping- Leukotape

A study using surface electromyography was used to identify the magnitude and onset of contraction in the upper trapezius, lower trapezius and serratus anterior in comparison to the middle deltoid and find the excitability of the muscle at rest as well as during maximal isometric contraction. (Snodgrass, Farrell, & Tsao, 2018) Active range of motion in shoulder flexion and shoulder abduction were also evaluated. Measurements during this study were made before taping, immediately after applying the tape, 24 hours after taping with the original tape on, and 24 hours after the original tape was applied with the tape removed. (Snodgrass, Farrell, & Tsao, 2018) The tape used for the study was a rigid athletic tape (Leukotape). (Snodgrass, Farrell, & Tsao, 2018)

Results showed that the onset of contractions occurred earlier immediately after applying the tape than in measurements taken before taping during abduction and flexion. The earlier onset during abduction occurred in the upper trapezius while in flexion it occurred in the lower trapezius. Range of motion was slightly increased in shoulder flexion and shoulder abduction. This change was short-lived, as the results showed there was no difference before applying the tape compared to 24 hours after the tape was applied. (Snodgrass, Farrell, & Tsao, 2018)

No difference was noted in the contraction of the scapular muscles before or after taping. (Snodgrass, Farrell, & Tsao, 2018)

The results from the study indicate a relation to the neuromuscular activity or neurological processes rather than any alterations to corticomotor activity. Increased range of motion in shoulder abduction immediately after taping may have been associated with the earlier contraction of the upper trapezius through the upward rotation of the scapula. The findings of this study suggest that the optimal time to initiate rehabilitation exercises focusing on engaging the trapezius should be immediately after the application of the tape. Given the short time period of the positive results after tape application, scapular taping should be used in conjunction with other rehabilitative interventions to manage shoulder pain and instability. (Snodgrass, Farrell, & Tsao, 2018)

Shoulder Taping- Kinesio Tape

Kinesio tape is hypothesized to work through the constant shear forces produced by the application of the tape to the skin, stimulating cutaneous mechanoreceptors. This increase in stimulation would result in better joint position sense. When applied to the shoulder during a study (Aarsath, Suprak, & Chalmers, 2015) it was hypothesized that Kinesio Tape would enhance shoulder joint position sense at all angles. Throughout testing, this hypothesis was proven wrong. Short term effects were observed, but there were no apparent long term benefits. Only collegiate athletes participating in overhead sports with no previous injuries were included in the study, which may skew the results. There was not enough evidence provided to recommend kinesio tape as a treatment, alone or in conjunction with rehabilitation, for shoulder pain or instability. (Aarsath, Suprak, & Chalmers, 2015)

Final Thoughts

Undergoing surgical intervention for anterior shoulder instability is an aggressive approach to treating a potentially debilitating, long-term condition. Although parents and young athletes typically try to avoid surgery, this is a surgery that should happen sooner rather than later. These patients want to return to high levels of activity, and rehabilitation will not fix the ligamentous and osseous damage needed to perform at high intensities. That being said, the surgery should cater to the patient, identifying potential risk factors, underlying conditions, ultimately promoting quality of life. Current literature does not address the needs of young patients, and they are often left to the same principles used for adults. The surgeon also needs to consider the ability to perform surgical revision for this younger population if problems arise as the patient becomes older. (Bonazza & Riboh, 2020)

The current research in non-operative and rehabilitative measures is promising, but we cannot change the nature of the shoulder. The fact is, damage to tissue surrounding the shoulder decreases the structural integrity of the shoulder. This tissue damage will not heal on its own, and it is up to the discretion of the physician and patient on further treatment. Not only should we be researching effective return to play criteria and testing, but also creating the most minimally invasive, long-lasting, and effective surgical techniques to decrease poor outcomes. By decreasing recurrence, we can promote activity and physical well-being over the entire lifespan of a patient.

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Pictures:

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Figure 2:https://www.mountnittany.org/articles/healthsheets/494
Figure 3:
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Figure 5: Case courtesy of Dr David Cuete, Radiopaedia.org, rID: 27860 https://radiopaedia.org/articles/bankart-lesion?lang=us
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