Sport-Specific Shoulder Injuries

16

Ann Cools

Contents

Abstract

In this chapter, shoulder injuries, related to sports performance, are described. Shoulder injuries are multifactorial due to the presence of several synovial and functional joints (glenohumeral, sternoclavicular, acromioclavicular, scapulothoracic,

A. Cools, PT, PhD
Department of Rehabilitation Sciences and Physiotherapy, Faculty of Medicine and Health Sciences, Ghent University, De Pintelaan 185, 9000 Gent, Belgium
e-mail: ann.cools@ugent.be

A.W.J.M. Glaudemans et al. (eds.), *Nuclear Medicine and Radiologic Imaging in Sports Injuries*, DOI 10.1007/978-3-662-46491-5_16

and coracoacromial arch) that might be injured. Acute shoulder injuries can occur as a result of a traumatic event in any sport, whereas chronic shoulder pain is often attributed to the high demands of the overhead throwing movement. Functional impingement and pain during throwing activities is the most frequent clinical finding in overhead athletes. During the clinical examination of the athlete, the clinician aims to identify the specific location and cause of impingement, the presence of rotator cuff pathology, biceps-related pathology, labral tears, instability, range of motion deficits, and scapular dysfunction.

16.1 Introduction

Most athletic shoulder injuries are the result of one of two mechanisms: (1) an acute external force applied on the shoulder complex (macrotrauma) or (2) repetitive overhead activity and overuse (microtraumata). The shoulder is susceptible to traumatic injuries such as dislocations, subluxations, acromioclavicular joint sprains, and soft tissue injuries, in particular in collision and contact sports. However, most of the injuries result from repetitive overuse mechanisms, due to overload, aberrant overhead throwing biomechanics, and dysfunctional adaptations to the sport, leading to chronic symptoms like impingement and bursitis (Ellenbecker and Cools 2010). Moreover the shoulder is predisposed to athletic injury because of the large amount of mobility of the glenohumeral joint, allowing powerful throwing and smashing but putting the shoulder at risk for injury due to the inherently poor glenohumeral instability. Incidence rates of shoulder injuries vary depending on the specific sports, with up to 20 % of acute shoulder injuries in ice hockey (Bahr et al. 2012). Chronic shoulder pain conditions caused by overuse and instability are the predominant injuries in sports demanding high loads on the shoulder such as baseball, tennis, and swimming, with an incidence of between 17 and 26 % (Bahr et al. 2012). The purpose of this chapter is to give an overview of functional shoulder anatomy and biomechanics and discuss common injuries of the shoulder complex in the overhead athlete.

16.2 Functional Anatomy and Biomechanics

The shoulder complex is composed of three synovial joints (sternoclavicular, acromioclavicular, and glenohumeral) and one physiologic articulation (scapulothoracic joint). These four articulations, together with the ligaments, the rotator cuff muscles, and the prime movers (deltoid, pectoralis major, and latissimus dorsi) of the shoulder, provide the necessary stability and power during various shoulder movements, in particular the overhead throwing movement. Dysfunction in any of these structures can result in limited performance of the entire upper limb.

16.2.1 Sternoclavicular Joint

The sternoclavicular joint provides the only real articular connection (synovial joint) between the shoulder complex and the axial skeleton. It is by nature a very stable saddle joint, stabilized by several ligaments, of which the most important one is the costoclavicular ligament. This ligament mainly controls anterior and posterior translations of the clavicular head on the sternum (Wilk et al. 2009b). The sternoclavicular joint is reinforced by the intra-articular disk, absorbing centrally directed forces and improving the congruence of the articular surfaces, thus avoiding dislocations of the clavicula. During arm elevation, the clavicula moves into elevation, long-axis rotation, and depending on the plane of the movement retraction or protraction (Ludewig et al. 2009).

16.2.2 Acromioclavicular Joint

The acromioclavicular (AC) joint is a synovial plane joint, allowing limited motion, and protected by two major ligament complexes. Some variations in size and shape of the articular surfaces need to be noted. In some cases they are separated by a meniscus attached to the superior acromioclavicular ligament. This meniscus may be a blade of fibrocartilage that extends nearly halfway into the joint, or it may form a complete disk that divides the joint into two parts. In other joints no synovial joint is present with the joint being made by a pad of fibrous tissue attached to the outer end of the clavicle, and no articular cavity. The acromioclavicular joint fulfills an important role with respect to shoulder mobility maintaining an appropriate scapular position during the early phases of elevation and assisting acromial elevation during elevation of the arm above shoulder height (Ludewig and Reynolds 2009). Functionally, the two main movements at the AC joint are anteroposterior gliding movement during shoulder flexion and extension and elevation-depression during glenohumeral abduction.

16.2.3 Glenohumeral Joint

The glenohumeral (GH) joint is the most mobile joint of the human body. In particular, overhead athletes place tremendous stress on the soft tissue and osseous structures of the GH joint (Ellenbecker and Cools 2010). Because of the lack of congruency between the humeral head and the glenoid, the shoulder has to rely upon the structural quality and functional capacities of the ligaments, the labrum, and the stabilizing muscles. Anatomically, the labrum serves as the glenoid attachment for the GH ligaments and the long head of the biceps. Biomechanically the main function of the labrum is to deepen the glenoid fossa, thus increasing the surface area of contact with the humeral head and avoiding excessive translation of the humeral head relative to the glenoid fossa (Wilk et al. 2009b). The anterosuperior part of the labrum has poor blood supply, making it susceptible for overload injury

(Cooper et al. 1992). Moreover vascularity decreases with age, and mechanoreceptors seem to be absent in the labrum, possibly influencing proprioceptive quality of the GH joint. Free nerve endings, however, were found in the fibrocartilaginous tissue of the labrum, the biceps insertions, and the connecting tissue around the labrum (Vangsness et al. 1995).

The shoulder joint capsule and the GH ligaments are loose and redundant, allowing a large range of motion. In particular the inferior GH ligament protects the shoulder from uncontrolled translations inferiorly and anteriorly during the combined motion of abduction and external rotation (Wilk et al. 2009b). Normally the capsule of the GH joint is sealed airtight and contains a very small amount of fluid. This results in a negative intra-articular joint pressure, leading to joint cohesion, thus contributing to passive joint stability (Alexander et al. 2012).

Beside the static constraints, the shoulder relies upon its active stabilizers, mainly the rotator cuff, during daily activities and specifically during overhead movements, to maintain functional stability. The rotator cuff muscles reinforce the shoulder in several ways. By contracting as a balanced force couple, the humeral head is sucked into the glenoid; however, the rotator cuff also strengthens the capsule through blending of the cuff tendons into the shoulder capsule. Making the capsule "stiffer" increases the GH stability, tightening the GH ligaments and thereby centering the humeral head into the glenoid fossa (Ellenbecker and Cools 2010; Nimura et al. 2012).

16.2.4 Scapulothoracic Joint

The scapulothoracic joint comprises the physiologic joint of the scapula floating on the thoracic wall, with very little ligamentous constraints, and mainly depending upon the quality of optimal recruitment of the scapular muscles to maintain a functional position with respect of the thorax and the shoulder. The ultimate function of the scapula is to provide a stable base for the GH joint by orienting the glenoid fossa for optimal contact with the humeral head (Kibler 1998). Whereas the trapezius muscle and the serratus anterior muscle actively control scapular movement through dynamic contractions, the pectoralis minor, rhomboid, and levator scapulae muscles have a more passive role, providing postural control to the scapula and keeping the scapula steady on the trunk during dynamic arm movements (Cools et al. 2008b; Ellenbecker and Cools 2010; Ludewig and Reynolds 2009).

The trapezius and serratus anterior muscles work as a force couple on the scapula, resulting in the necessary rotations and translational movements to guarantee proper scapular positioning and movement. The primary condition for an optimally working force couple is muscle balance, meaning that all muscles must be activated in the right amount and at the appropriate time. Disturbances in any of these variables may lead to scapular dyskinesia and possibly to chronic overload shoulder pain.

16.2.5 Coracoacromial Arch

The coracoacromial arch of the subacromial space is often considered as a physiologic joint of the shoulder complex, in which the bursa has an important role based on good gliding capacity and its protective function against direct trauma. The roof of the subacromial space is composed by the acromion, the AC joint, the coracoacromial ligament, and the coracoid process. The space within the arch or the coracohumeral distance depends upon arm position and decreases with arm elevation (Maenhout et al. 2012; Seitz and Michener 2011). It has been shown that the acromiohumeral distance is reduced in overhead athletes with an internal rotation range of motion deficit, possibly increasing the risk for impingement symptoms in this population (Cools et al. 2008b; Maenhout et al. 2012).

16.3 Etiology and Injury Mechanism

16.3.1 The Overhead Throwing Motion

Of all phases of overhead throwing, the cocking (just prior to the acceleration phase) and deceleration (final stage of throwing) phases are considered to be the most stressful and demanding for the glenohumeral joint.

During the cocking phase, the shoulder is put into a position of maximal external rotation, maximal horizontal abduction, and depending upon the specific sport a certain amount of abduction. As an example, during baseball throwing, the shoulder is in approximately 90° of abduction, whereas during the tennis serve or the volleyball smash, the degree of abduction is between 140° and 180° (Elliott 2006; Escamilla and Andrews 2009; Reeser et al. 2012). In particular the anterior part of the GH joint is at risk for being "stretched" out and needs to be protected by optimal concentric and eccentric rotator cuff activity to stabilize the humeral head into the glenoid fossa. In addition the labrum is highly stressed in this extreme external rotation position (Ellenbecker and Cools 2010).

The scapula plays an important role in the cocking phase. In order to keep optimal GH stability, the scapula has to move into upward rotation, posterior tilting, and maximal retraction (Kibler 1998). This movement results in proper alignment of the scapula along the axis of the humeral shaft. If the scapula is not able to perform this movement because of a lack of muscle strength or flexibility, "hyperangulation" will occur, meaning there is an angle between the plane of the scapula and the plane of the moving humerus, possibly leading to internal impingement (see Sect. 16.5.1) (Wilk et al. 2009a).

During the deceleration phase, the ball is released and the arm and shoulder decelerated. The shoulder joint moves into internal rotation, and the elbow extends rapidly. The deceleration forces are approximately twice as high compared to the acceleration forces, but for a shorter period (Escamilla and Andrews 2009). Tremendous eccentric activity is needed from the biceps, posterior cuff muscles, and scapular retractors. This demanding muscular activation puts the shoulder at risk for overuse lesions of the rotator cuff and labral tears at the attachment of the long head of the biceps (superior labrum from anterior to posterior or SLAP lesions) (Burkhart et al. 2003b, c). As a result of repetitive overhead throwing, the posterior shoulder structures (capsule and rotator cuff) tend to functionally adapt, leading to posterior shoulder stiffness and reduced internal rotation range of motion. This reduced range of motion has been associated with scapular dyskinesis, reduced acromiohumeral distance, and symptoms of subacromial impingement (Borich et al. 2006; Maenhout et al. 2012; Tyler et al. 2010).

In summary, overhead throwing is a very demanding movement for the shoulder complex, in which optimal biomechanics, neuromuscular coordination, and strength of the surrounding muscles are needed. Anterior instability, subacromial and internal impingement, tensile overload of the rotator cuff, and labral tears are possible injuries that might occur in case of aberrant throwing technique or overload.

16.4 Injuries

16.4.1 Acute Shoulder Injuries

Most common acute shoulder injuries in overhead athletes are anterior shoulder dislocation, AC joint injury, and clavicular fractures (Bahr et al.2012). Rotator cuff ruptures, fractures, sternoclavicular joint dislocations, posterior shoulder dislocations, and plexus and vascular injuries are less common but should not be overlooked. For the scope of this chapter, only the most common acute injuries are further described.

Dislocations

Dislocations occur more in men than in women, with high recurrence rate in young patients after a first episode of acute dislocation (Boone and Arciero 2010). Due to the acute traumatic event, they are very frequently accompanied by structural damage at the glenohumeral joint. Most injuries are located at the anterior capsulolabral complex (Bankart lesion) and at the posterior aspect of the humeral head (Hill-Sachs lesion). It is important to determine the injury mechanism, the direction of the force, and the amount of force that caused the event. Shoulder dislocations may be the result of a direct fall on the outstretched arm but also of an excessive high force applied to the shoulder in the abduction – external rotation position, for instance, by falling during downhill skiing or by being tackled by the opponent in team handball when shooting a ball (Bahr et al. 2012). Changes in the contour of the shoulder under the deltoid and inability to move the arm are typical signs of an anterior dislocation.

Fractures of the Clavicula

Clavicular fractures are extremely common in children and adolescents who fall on their shoulder or on an outstretched arm (Pandya et al. 2012). In some sports, in which the risk of falling is larger, for instance, in cycling or mountain biking, the prevalence of clavicular fractures is very high (22 % of all traumatic injuries in top-level road cyclists) (Bahr et al. 2012; De Bernardo et al. 2012). It can however also occur as a result of a direct impact on the shoulder, for instance, in contact sports such as rugby. The injuries are divided into medial and lateral fractures, depending on the location of the fracture with respect to the coracoclavicular ligamentary complex. Clavicular fractures lead to local swelling and malalignment that can easily be detected on inspection.

AC Joint Injuries

AC joint injuries are the result of a fall on the shoulder or a direct blow on the lateral side of the shoulder. If the trauma comes directly from the lateral side, the AC joint is compressed, often leading to structural damage to the intra-articular disk. If the impact comes from the front or the back, this may lead to AC dislocation and rupture of the coracoclavicular and acromioclavicular ligaments. AC joint injuries are classified into 6 grades, depending on the degree and direction of the malalignment (Bahr et al. 2012; Reid et al. 2012). Grades I and II comprise injury to the AC joint without dislocation. Grade III is a total dislocation with rupture of the coracoclavicular ligament. Grades IV to VI are total dislocations of the AC joint in posterior (IV), cranial (V), or caudal (VI) direction (Fig. 16.1). Initial diagnosis is based on swelling, pain, and visible displacement of the distal portion of the clavicula with respect to the acromion.

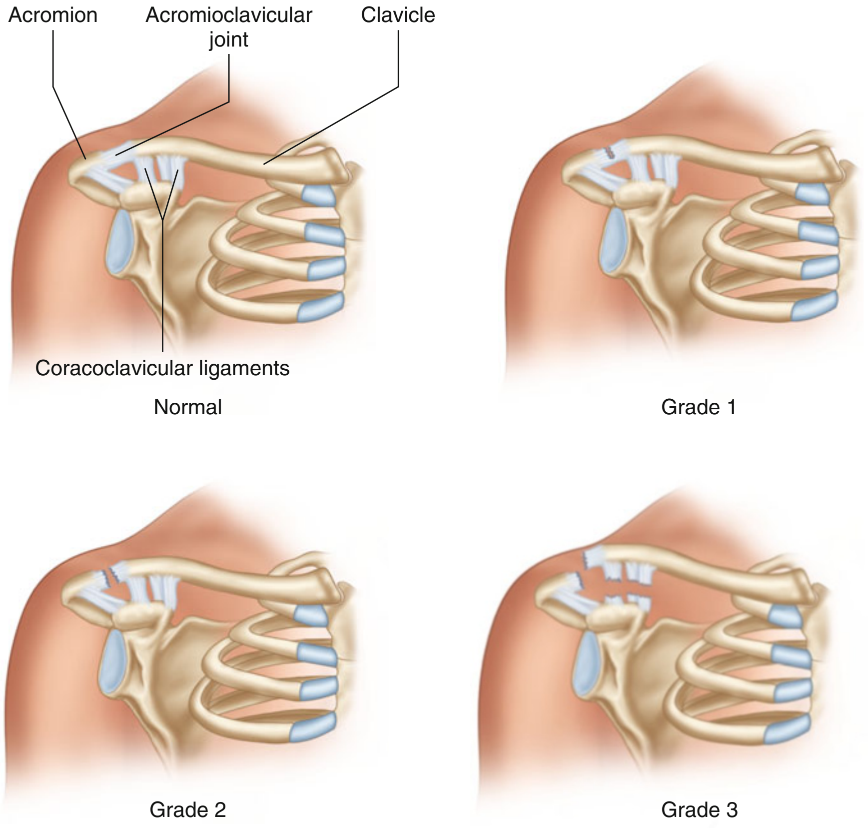

Fig. 16.1 Grading AC joint injuries *grade 1* to *3* (Bahr et al. 2012)

16.4.2 Chronic Shoulder Pain

Chronic shoulder pain is probably the most common arm problem in recreational and competitive overhead athletes. Throwing athletes need full, unrestricted arm function to optimally perform in their sport. Nontraumatic shoulder pain in the overhead athlete is a diagnostic challenge. The causes of chronic shoulder pain are numerous but often difficult to identify and diagnose. Research indicates that shoulder impingement is the most common cause of shoulder pain in overhead athletes (Cools et al. 2008b). In recent literature, impingement has been described as a group of symptoms rather than a specific diagnosis (Cools et al. 2008a). In this current opinion, it is thought that numerous underlying pathologies may cause impingement symptoms. Glenohumeral instability, rotator cuff or biceps pathology, scapular dyskinesis, and glenohumeral internal rotation deficit have been associated with impingement symptoms in clinical literature (Cools et al. 2008a; Kibler 1998). Various anatomical structures can be impinged internally or externally, probably depending on the motion and loading put on the shoulder during the pain-provoking activity. However, a possible instability in the shoulder is often "silent" and difficult to show by ordinary tests and has therefore by some been termed "functional instability" (Castagna et al. 2010; Jobe et al. 1989). It is now thought that functional instability in the shoulder may lead to a vicious circle involving microtrauma and secondary impingement and may eventually lead to chronic shoulder pain. Since the first paper, published by Walch et al. (1992), describing a new site of impingement between the humeral head and the posterosuperior rim of the glenoid, internal superior glenoid-type impingement has been suggested to be a common cause of chronic shoulder disorder in overhead athletes. This type of impingement occurs in the cocking position of throwing, with the glenohumeral joint in maximal external rotation, in maximum horizontal abduction, and, depending on the sport, in abduction or forward flexion (Cools et al. 2008b). In general, overhead athletes with internal impingement have posterior shoulder pain and tenderness of the infraspinatus tendon on palpation. Internal superior glenoid impingement particularly occurs when the humeral shaft goes beyond the plane of the body of the scapula during the cocking position of throwing (Wilk et al. 2009a). Under normal circumstances, the scapula goes into retraction simultaneously with the horizontal abduction movement of the humerus. When the body of the scapula and the humeral shaft fail to remain in the same plane of movement during the cocking phase of throwing, encroachment of the rotator cuff tendons between the humeral head and the glenoid rim may cause internal impingement symptoms. This phenomenon is called "hyperangulation." However, in spite of the documented structural pathology and cuff lesions (Walch et al. 1992), shown by several groups to be related to internal superior glenoid impingement symptoms, it is suggested that functional disturbances, such as subtle glenohumeral instability, glenohumeral range of motion (ROM) restrictions, scapular dysfunction, and muscle stiffness, are often associated with internal impingement symptoms, rather than structural deficits and pathologies (Cools et al. 2008b; Tyler et al. 2010). Another type of impingement, subcoracoid impingement, has been described related to anterior shoulder pain and subscapularis tendon tears.

However, the pathogenesis has still not been explained properly. Subcoracoid stenosis and anterosuperior translations of the humeral head, both resulting in narrowing of the coracohumeral space, may lead to anterosuperior tears of the cuff including the subscapularis tendon. Symptoms particularly occur during the deceleration and follow-through phases of throwing.

16.5 Examination

In view of the assumption that impingement symptoms may be the result of various underlying pathologies, it is important to understand the biomechanical relationship between these symptoms and shoulder diagnoses. Since functional deficits rather than structural pathology often are the underlying cause of chronic shoulder pain in the overhead athlete, the clinical examination of the patient is very important.

The physical examination of the overhead athlete consists initially of a thorough history (or subjective assessment); inspection; active, passive, and resistance tests; and pre- and post-examination palpation. During the physical examination of the athlete with shoulder pain, it is imperative that the investigator examines what kind of impingement the patient suffers from and what the underlying pathology might be. Several papers offer the clinician an approach to specific tests that can be used when screening the athlete's shoulder for impingement-related shoulder problems (Cools et al. 2008a; Hegedus et al. 2012). All the clinical tests described in the following paragraphs are summarized in Table 16.1.

16.5.1 Impingement Tests

Of the various provocative impingement tests, the most popular are the Jobe, Hawkins, and Neer tests. These tests show high sensitivity, however questionable specificity, and should therefore only be used as a first screening tool to confirm the presence of impingement-related shoulder pain. Besides these impingement tests, very often, instability tests (apprehension, relocation, release) are used as provocation tests for impingement, interpreting them with respect to pain rather than instability symptoms, to further define the cause of impingement. In general it is suggested that at least three tests should be positive to draw conclusions regarding impingement symptoms (Cools et al. 2008a; Hegedus et al. 2012; Meister et al. 2004).

16.5.2 Rotator Cuff Tests

To define the involvement of rotator cuff pathology in the impingement symptoms, a modified version of the Jobe test is a valuable tool (Tennent et al. 2003). Indeed originally the test was described to investigate the integrity of the rotator cuff muscles, particularly the supraspinatus. However, based on this test, one cannot define

Table 16.1 Summary of clinical tests of the shoulder (Cools et al. 2008a)

Impingement	Neer	Forced passive forward flexion with the arm internally rotated and caudal pressure on the acromion
	Hawkins	Passive internal rotation from a 90° forward flexed position
	Jobe	Resisted elevation in the scapular plane with the shoulder in maximal internal rotation
Rotator cuff	Full can	Resisted elevation in the scapular plane with the shoulder in external rotation (thumbs up)
	External rotation lag sign	Arm in slight elevation and external rotation: patient is asked to keep this position against gravity
	Hornblower's sign	An inability to externally rotate the elevated arm
	Lift-off test	Arm in full internal rotation on the back, patient is asked to lift off his/her hand from the back
	Belly-press test	Patient is asked to push his/her hand into his/her belly with the elbow aside, inability to keep the elbow steady
Scapular involvement	Scapular assistance test	Patient performs active elevation while examiner manually assists scapular upward rotation and posterior tilting
	Scapular retraction test	Patient performs Jobe test while examiner manually stabilizes the scapula into retraction against the thoracic wall
Instability	Apprehension	Patient exhibits apprehensive muscle tension during the position of 90° abduction-90° external rotation
	Relocation	Dorsal pressure on humeral head in the apprehension position gives symptom relief
	Release	Symptoms of instability when hand is released from the patient's shoulder after the relocation test
	Load and shift	Passive anterior translation of the humeral head with respect to the glenoid results in subluxation
	Sulcus	Examiner induces caudal translation on the humeral head by pulling on the elbow down; this results in a sulcus at the level of the glenohumeral joint
	Posterior subluxation test	Performing a dorsal pressure while the shoulder is in horizontal adduction results in posterior subluxation
	Hyperabduction test	Examiner performs abduction >90° while fixing the acromion and the clavicle caudally

(continued)

Table 16.1 (continued)

SLAP and biceps pathology	O'Brien test	Resisted elevation in two positions: 10° horizontal adduction thumb down (1) and thumb up (2), pain only during first position
	Biceps load II test	Resisted elbow flexion while shoulder is in 120° abduction, external rotation, elbow 90° flexed and full supination
	Yergason test	Resisted supination results in pain in bicipital groove
	Dynamic labral shear test	Examiner applies a shear load to the joint by maintaining external rotation and horizontal abduction and lowering the arm from 120° to 60° abduction
GIRD	ROM measurement	Left-right comparison of internal rotation with the arm 90° abducted in the frontal plane

whether a painful test is the result of functional impingement rather than rotator cuff muscle dysfunction. Therefore, the examiner can perform the full-can test, in which the rotation position is changed from internal (thumbs down) into external rotation (thumbs up). In addition, specific tests can be used to identify a rupture of the infraspinatus (external rotation lag sign, hornblower's sign) and subscapularis (lift-off test, belly-press test) (Cools et al. 2008a; Tennent et al. 2003).

16.5.3 Scapular Involvement Tests

Scapular involvement in impingement-related shoulder pain may be examined by the scapular assistance test (SAT) and the scapular retraction test (SRT) (Burkhart et al. 2003a; Cools et al. 2008a; Kibler et al. 2006). The SAT, in which scapular movement quality is examined, consists of manual assistance of correct scapular movement during elevation of the arm. In the SRT, in which scapular stability is examined, the empty-can test is performed while the examiner stabilizes the patient's scapula and shoulder in a position of retraction by placing the forearm along the medial border of the scapula. These tests are positive for scapular involvement if patients feel symptom relief compared to the original provocative test or movement.

16.5.4 Instability Tests

The clinical tests to examine shoulder instability can be divided in provocative tests and laxity tests. Commonly used provocative tests for instability are the apprehension and relocation tests. In case of instability, patients will exhibit instability symptoms, such as apprehensive muscle tension and subluxation, rather than pain. Distinct from the provocative tests, the laxity tests are assessing humeral translation with respect to the glenoid fossa. Commonly used laxity tests are the load and shift test (anterior laxity), sulcus sign (inferior laxity), posterior subluxation test (posterior laxity), and hyperabduction test (general laxity) (Cools et al. 2008a; Hegedus et al. 2012).

16.5.5 Biceps Pathology and SLAP Lesion Tests

Currently SLAP lesion tests are under debate (Hegedus et al. 2012). In general no test is found to be sensitive as well as specific. Therefore, it is suggested to use clusters of at least three SLAP lesion tests, in which apprehension test, O'Brien test, biceps load II test, Yergason test, and dynamic labral shear test may help in the evaluation of SLAP lesions.

16.5.6 Clinical Evaluation of GIRD

The assessment of GIRD is performed by measuring glenohumeral internal rotation range of motion, preferable in supine position with the shoulder abducted 90° and the scapula stabilized against the bench. A side difference of 20° is considered to be positive for GIRD ((Ellenbecker and Cools 2010; Borstad and Dashottar 2011).

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