American Football

1

Jonathan D. Hughes, Christopher M. Gibbs, Neel K. Patel, Dale G. Thornton, Aaron V. Mares, and Volker Musahl

1.1 Introduction

American football is popular among all age groups in the United States and is played at various levels, including Pop Warner league, junior high school, high school, collegiate, and professional. Athletes that play this high-speed, high-impact collision sport are susceptible to various injuries ranging from muscle strains to career-ending fractures and ligamentous injuries. Common injuries sustained in American football include concussions, anterior cruciate ligament and medial collateral ligament tears, glenohumeral shoulder instability, acromioclavicular joint injuries and clavicle fractures, and ankle sprains and syndesmotic injuries. This chapter will review the epidemiology of injuries incurred during American football, as well as diagnosis, on-field and in-season management, and prevention of the most common injuries seen in American football.

J. D. Hughes · C. M. Gibbs · N. K. Patel · A. V. Mares
V. Musahl (✉)
UPMC Freddie Fu Sports Medicine Center, University of Pittsburgh, Pittsburgh, PA, USA
e-mail: hughesjd3@upmc.edu; gibbscm2@upmc.edu; patelnk@upmc.edu; maresav@upmc.edu; musahlv@upmc.edu

D. G. Thornton
Duratz Sports Complex, University of Pittsburgh, Pittsburgh, PA, USA
e-mail: dthornton@athletics.pitt.edu

1.2 Epidemiology

American football is one of the most popular sports in the United States with over 60,000 collegiate, over 1 million high school athletes, and over 225,000 sandlot and professional athletes participating each season [1, 2]. American football is a high-speed, high-impact collision sport that has potential for serious injury to participants. Athletes partake in drills throughout the week that include player-to-player contact and player-to-surface contact, which places the athlete at risk for career-ending fractures, joint dislocations, and ligamentous ruptures. These drills are frequently performed at full-speed, and therefore the athlete is susceptible to noncontact ligament tears and muscle strains, as well as overuse/repetitive injuries. The athletes are required to give full effort throughout the week, then expected to play full-contact games at the end of the week. As the season progresses, risk of injury increases due to continued collisions, fatigue, and repetitive nature of the sport. Offensive and defensive lineman are the most susceptible to injury, as they are involved in contact activities every play [3]. Additionally, the type of playing surface, including artificial turf and natural grass, can have an effect on injury risk. Prior studies have demonstrated artificial turf has an increased risk of injury compared to natural grass, as does poorly maintained playing surfaces [4–6].

S. Rocha Piedade et al. (eds.), *Specific Sports-Related Injuries*,
https://doi.org/10.1007/978-3-030-66321-6_1

Playing American football puts unique demands on the body, and as a result the injury rate is nearly twice that of other popular sports such as basketball. Among 15 collegiate sports, American football had the highest rate of injury during competition at 35.9 injuries per 1000 athlete-exposures (AE) [7]. All other sports except wrestling (26.4 injuries per 1000 AE) had less than 20 injuries per 1000 AEs [7]. An epidemiologic study found that approximately 500,000 high school American football-related injuries occurred annually. Additionally, the injury rate was much higher during actual competition compared to practice for middle school, high school, and collegiate athletes [2, 8]. However, the overall number of injuries was still higher during regular practice, accounting for nearly 56% of all injuries, than during competition (approximately 40%) in collegiate athletes due to the significantly higher athlete-exposure during practice [9]. One study evaluating the effect of age on American football-related injuries showed that fractures were the most common injury regardless of age, but the rate of fractures was lower in athletes 15–18 years of age compared to younger athletes [10]. Additionally, the rate of closed head injuries, including concussions, was highest in athletes younger than 8 years of age [10]. Epidemiological studies such as the ones discussed in this section are important as they highlight important patterns and potentially modifiable risk factors that can help injury prevention efforts that will be discussed later in this chapter.

1.3 Percentage of Injuries and Their Anatomic Locations

American football-related injuries can involve any part of the musculoskeletal system including the upper and lower extremities as well as the head and cervical spine. One study investigating the distribution of injuries by anatomic location found that 43.2% of injuries were upper extremity injuries and 32.6% of injuries were lower extremity injuries [10]. Other studies have cited that approximately 20% of American football-related injuries involve the knee and about 17% involve the foot and ankle.

The most common American football-related knee injuries are medial collateral ligament injury (MCL), meniscal injury, and anterior cruciate ligament (ACL) injury with 25% of knee injuries requiring surgical intervention [11]. The incidence of ACL injuries in the National Football League (NFL) is 0.7 per 1000 players resulting in approximately 53 ACL injuries annually in the NFL [12, 13]. Running backs and linebackers are at highest risk for ACL injuries with 9.7% and 8.9% of players, respectively, having a history of ACL injury at the NFL combine [14].

With regard to foot and ankle injuries, they occur at a rate of 15 per 10,000 AEs [15]. Lateral ankle ligament sprains, syndesmotic (high ankle) sprains, medial ankle ligament sprains, midfoot injuries, and first metatarsophalangeal joint injuries account for nearly 80% of all foot and ankle injuries related to playing American football [15]. In terms of median time loss from play, the most severe foot and ankle injury was an ankle dislocation, which resulted in a median time loss of 100 days, followed by metatarsal fractures (38 days) and isolated malleolus fracture (31 days) [15]. Additionally, foot injuries such as Lisfranc injuries, which are present in 1.8% of athletes at the NFL combine, can significantly affect draft position, performance, and longevity of an American football career [16].

Shoulder injuries are among the most common American football-related upper extremity injuries. One epidemiological study showed that nearly 50% of athletes at the NFL combine had a history of a shoulder injury with 36% of these injured athletes requiring surgical intervention [17]. The most common shoulder injuries were acromioclavicular (AC) injuries (41%), anterior instability (20%), and rotator cuff injury (12%) [17, 18]. The highest incidence of AC injury occurred in quarterbacks at a rate of 20.9 injuries per 100 players [19]. The most common surgeries performed for shoulder injuries were anterior instability reconstruction (48%), Mumford/Weaver-Dunn surgery (15%), posterior instability reconstruction (10%), and rotator cuff repair

(10%) [17]. Overall, these injuries can result in a significant loss of playing time even in cases of AC injuries, which typically do not require surgical intervention [19].

Cervical spine injuries are less common American football-related injuries, but are still important to highlight. The cervical spine injury rate is 2.91 per 10,000 AEs with stingers being the most common injury at a rate of 1.87 per 10,000 AEs [20]. Cervical spine injuries were most common in linebackers followed by defensive linemen. Overall, one study found that most athletes were able to return to play (RTP) within 24 h of their initial cervical spine injury (64.4%), while only 2.8% remained out of play for >21 days [20]. Once again, information regarding the positions affected and the relative time loss by particular injuries is important in order to implement appropriate and unique prevention measures, which will be discussed later in this chapter.

1.4 General Evaluation of Extremity Injuries

The team physician needs to perform a detailed history and physical on all the athletes before the season starts, and remember all aspects of the history and physical as the season progresses. Therefore, when it comes to on-field injuries, the team physician can obtain a detailed and focused history of injury mechanism and perform a specific evaluation for the suspected injury, followed by formulating a rapid plan of attack (Fig. 1.1).

Initial evaluation of a suspected extremity injury consists of a thorough history to elicit the specific nature and location of their complaint, mechanism or injury, severity of pain, whether they are able to bear weight or move an injured extremity, presence of functional deficits such as mechanical block to motion or neurologic deficit, and history of previous injury or surgery to the injured and contralateral extremities [21].

Fig. 1.1 A focused, detailed history and physical exam conducted on the field to formulate a quick treatment plan

Following this, an examination should be performed of the entire injured extremity and compared to the contralateral side. Examination should begin with inspection of the skin and soft tissue for gross deformity, ecchymosis, effusion, or open wounds. Range of motion of the surrounding joints should be attempted actively and/or passively as tolerated and compared with the contralateral extremity. Crepitus, pain, swelling, or deformity may be detected using palpation. Adjacent ligaments should be stressed and compared to the uninjured extremity. Strength should be evaluated if possible, however full effort may be limited due to pain. A careful neurovascular examination should be performed. Finally, special tests to evaluate for particular injuries based on the initial history and examination should be performed.

1.5 Five Common American Football-Related Injuries

The mechanism of injury, on-field management, and in-season treatment of five common injuries will be discussed. Based upon the senior author's experience and prior epidemiological studies, this chapter will discuss concussion, knee ligament injuries including injuries to the ACL and MCL, anterior and posterior labral tears associated with glenohumeral instability, acromioclavicular (AC) injuries and clavicle fractures, and ankle sprains including syndesmotic injury.

1.5.1 Concussion

1.5.1.1 Mechanism of Injury

Concussion is defined as a transient, functional traumatic brain injury induced by biomechanical forces [22]. Among youth, high school, and college American football players, concussions are most commonly caused by player contact, accounting for 83% of concussions [23]. At the collegiate level, a larger proportion of concussions are caused by player contact (88% vs. 80% and 81% at the youth and high school levels, respectively), while youth athletes are nearly twice as likely to sustain a concussion due to surface contact than high school and college athletes. Youth athletes are more likely to sustain a concussion while being tackled (42% vs. 23% for both high school and college athletes), while college athletes are more likely to sustain a concussion while being blocked (16% vs. 10% and 6% for high school and youth athletes, respectively). At the professional level, the mechanism of sustaining a concussion was studied using video analysis of National Football League (NFL) games [24]. Concussions were found to occur most often during a passing play, accounting for 50% of cases. In 41% of cases, a concussion was sustained during tackling, most commonly from a helmet-to-body impact. The authors demonstrated the mechanism of injury varied by position: cornerbacks were found to be injured most commonly by a helmet-to-body impact while wide receivers and quarterbacks were found to be more commonly injured by a helmet-to-ground or helmet-to-helmet impact.

1.5.1.2 On-Field Management

An athlete suspected of having sustained a concussion after a forceful direct or indirect impact to the head with any symptoms, signs, or concern by any trained observer should be immediately removed from play and evaluated [25]. The athlete should not RTP until an appropriate evaluation has been completed by a qualified healthcare professional. The 2017 Berlin Concussion in Sport Group Consensus Statement described several mandatory and discretionary symptoms which require further evaluation [25]. Mandatory symptoms include loss of consciousness, lying motionless for more than 5 seconds, confusion, disorientation, amnesia, vacant look, motor incoordination, tonic posturing, impact seizure, and ataxia; the presence of one or more of these signs mandates removal from play according to NFL rules [25, 26]. Discretionary signs include clutching the head, being slow to get up, suspected facial fracture, possible ataxia, and behavior change; the presence of the discretionary signs require a dedicated concussion evaluation. Following resolution of the discretionary signs, the athlete may RTP if the diagnosis of concussion is excluded and the discretionary signs can be attributed to another cause.

Initial management of a player suspected to have sustained a concussion should include consideration of intracranial, maxillofacial, cervical spine, and airway injuries, with implementation of appropriate management such as cervical spine immobilization as indicated. If the on-field or sideline evaluation is suggestive of concussion, the athlete should be moved to a distraction-free environment for a more thorough evaluation. A concussion evaluation should include a history and physical exam to elicit symptoms of concussion including confusion, headache, loss of consciousness, post-traumatic amnesia, retrograde amnesia, balance problems, dizziness, visual problems, personality changes, fatigue, sensitivity to light or noise, tinnitus, numbness, and vomiting [22]. The presence of dizziness reported by the athlete on the field or sideline is especially important to identify as this symptom is associated with a six times likelihood of having a protracted recovery of more than 21 days [27]. A thorough neurologic exam including administration of Maddock's questions, evaluation of the cervical spine, speech, gait, and eyes as well as a balance assessment should be performed [22, 27]. Additional tests such as the Sports Concussion Assessment Tool (SCAT5) and King-Devick tests have also been described as aids for diagnosing concussion. The SCAT5 consists of evaluating for "red flag" symptoms and signs of concussion as described above, Maddock's questions, Glasgow coma scale scoring, and cervical spine assessment [28]. The King-Devick test consists of reading numbers from left to right on cards and takes less than 2 min to perform [26]. Finally, athletes diagnosed with concussion should be serially evaluated for 48 hours to detect delayed symptom onset [22, 25].

1.5.1.3 In-Season Treatment

For athletes with concussion, RTP is permitted after concussion-related symptom scores have returned to baseline levels at rest and with competition-intensity exercise, the neurologic examination is normal, and cognitive testing has returned to baseline or age-appropriate levels [25]. A graded RTP protocol is recommended, which typically takes 7 days. Elite athletes with early resolution of symptoms may return to play earlier than 7 days following intensive specialist-directed evaluation in an advanced care setting specializing in concussion management while younger athletes are typically managed more conservatively [25]. In the NFL, the team physician, in consultation with an independent consultant, is responsible for RTP decisions [22, 25]. At all levels, no athlete should RTP until cleared by a qualified healthcare professional.

1.5.1.4 Prevention of Injury

Concussion identification and prevention has gained international attention over the past few years and led to significant changes and improvements to sporting equipment and the game rules. The most important aspect of concussion prevention is educating players, trainers, coaches, and match officials on early recognition, immediate management, and appropriate RTP criteria for players of all ages [29, 30]. Although recent strides have been made, further education is warranted, especially regarding the misconceptions of concussions and less-commonly recognized symptoms [29].

Improvements and implementation of specific sporting equipment, including customized mouth guards and helmets, have led to a decrease in self-reported concussions and traumatic brain injuries [31–34]. Rule changes, including video review and in-arena spotters to identify signs of concussion, have improved diagnosis of in-game concussions [35–37]. Over the past few years, the NFL has made specific changes to kickoff and targeting rules to enhance player safety. However, there is a paucity of literature regarding the effectiveness of these kickoff and targeting rule changes.

1.5.2 ACL and MCL Injury

1.5.2.1 Mechanism of Injury

The typical mechanism of ACL injury during American football is a noncontact injury usually sustained during a lateral movement such as pivoting or cutting resulting in a dynamic valgus moment on the knee while the knee is positioned in near extension with the foot externally rotated [38]. MCL injuries typically occur when a valgus force is directly applied to the knee or results from cutting maneuvers with the foot planted [39–41]. Given the similar mechanism of injury, ACL and MCL injuries commonly occur simultaneously, with American football players sustaining a concomitant ACL and MCL injury at a rate 2.7 times higher than athletes in other sports [42].

1.5.2.2 On-Field Management

Evaluation for ACL injury consists of the anterior drawer and Lachman tests in which an anterior force is applied to the tibia with the knee at 90° and 30°, respectively, with excessive anterior translation indicative of ACL injury [43]. The pivot shift test is useful to assess for rotatory instability and is performed by applying a combined valgus moment to the knee and internal rotation force on the tibia with the knee initially extended followed by flexion of the knee and observation of spontaneous posterior reduction of the tibia [43]. Diagnosis of MCL injury is typically facilitated by palpation over the ligament to elicit tenderness as well as assessment of knee laxity upon application of a valgus load. Evaluation of the MCL to test for ligamentous laxity is performed by applying a valgus force to the knee flexed to 30° [39]. Medial compartment opening of 0–5 mm corresponds to a grade I injury in which the ligament is stretched without ligamentous disruption, 5–10 mm corresponds to a grade II injury with partial ligament tearing, and >10 mm opening corresponds to a grade III injury with complete tear of all MCL fibers [39, 40].

Following initial on-field evaluation, a standard radiographic evaluation should be performed to assess for dislocation or osseous injury followed by magnetic resonance imaging (MRI) to evaluate for ACL or MCL injury and concomitant injuries to the meniscus, articular cartilage, and cruciate or collateral ligaments (Fig. 1.2) [26, 43].

1.5.2.3 In-Season Treatment

Although nonoperative management, consisting of physical therapy, anti-inflammatory medications, increasing range of motion and strength, and progressive RTP, can be considered for recreational athletes, for the majority of American football players, ACL reconstruction is recommended within 5 months of injury to prevent the development of additional injuries such as menis-

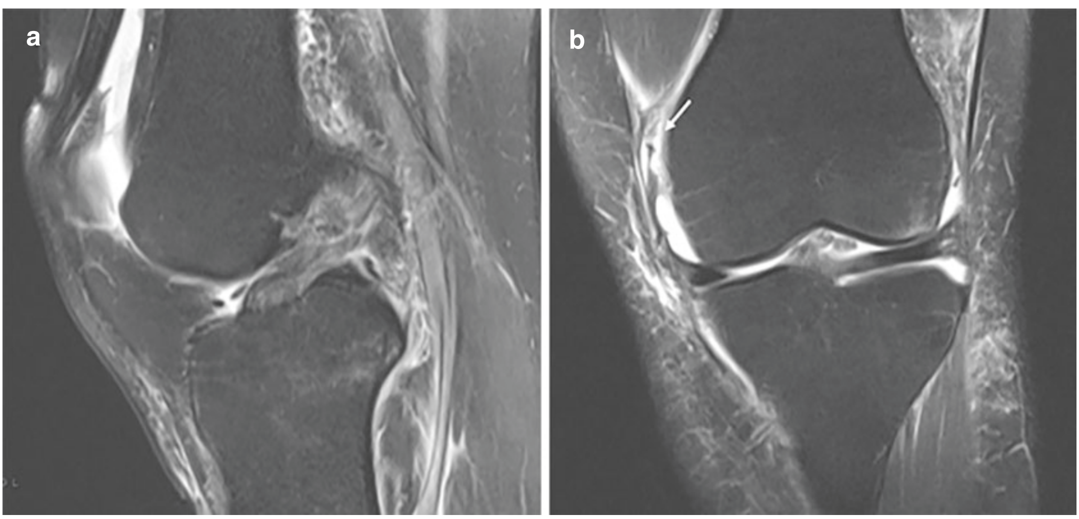

Fig. 1.2 Magnetic Resonance Imaging (MRI) of a left knee with anterior cruciate ligament (ACL) and medial collateral ligament (MCL) tears. Image (**a**) is a T2-weighted sagittal MRI demonstrating a complete midsubstance ACL tear. Image (**b**) is a T2-weighted coronal MRI demonstrating a full thickness MCL tear off its femoral origin (white arrow)

cal tears [43]. When performing an ACL reconstruction in an American football player, bone-patellar tendon-bone autograft is preferred by most surgeons due to high rates of failure with allograft and hamstring tendon autograft in young athletes [44–48].

In a 2016 case series of NFL players who had undergone an orthopedic procedure, 82% returned to play following ACL reconstruction; however, athletes played for an average of 1.6 years following ACL reconstruction, and for those who did return, decreased number of games played and performance can be expected until postoperative seasons 2 and 3 [49]. At the high school and college level, approximately 2/3 of athletes will RTP following an ACL injury [50]. At the professional level, athletes have been shown to RTP on average 10.8 months after primary ACL reconstruction while RTP occurred at 12.6 months following revision ACL reconstruction [51, 52]. In general, athletes should RTP at a minimum of 9 months postoperatively to allow for graft healing once the player is able to meet postoperative RTP protocols such as demonstration of symmetric quadriceps strength and performance in hop testing, as well as the ability to safely perform sport-specific movements [43]. Given the length required for RTP, an ACL injury can considered to be season-ending in most cases.

Treatment of isolated MCL injuries is dictated by the grade of injury. Nonoperative management consisting of initial rest, ice, compression, and elevation of the injured extremity followed by weight-bearing in a hinged knee brace and strengthening exercises, is recommended for isolated grade I–II injuries [39, 40]. Isolated grade III injuries may be treated nonoperatively or operatively, with operative intervention indicated in isolated grade III tears with severe valgus alignment, MCL entrapment of the pes anserinus, or avulsion injuries [41]. Concomitant ACL and grade I or II MCL injuries are typically managed with initial nonoperative management to allow MCL healing followed by reconstruction of the ACL [40]. Management of ACL injuries with concomitant grade III MCL injury is controversial. Nonoperative management of the MCL injury followed by delayed ACL reconstruction as well as early ACL reconstruction with nonoperative or operative management of the MCL tear have been proposed with no clear superiority of any approach [26].

Following nonoperative treatment, athletes with a grade I MCL injury can expect to RTP 11 days post-injury, while those with grade II injuries RTP 20 days post-injury on average [53]. Grade III injuries require longer rehabilitation times, particularly following surgical intervention. Athletes with nonoperatively treated grade III injuries may RTP as early as 5–7 weeks after injury while those treated with surgery may require 6–9 months of rehabilitation [54]. In-season management of MCL tears should be determined after discussion of the risks and benefits of each treatment modality including the average time until RTP with the athlete and his or her family.

1.5.2.4 Prevention of Injury

In order to help prevent ligamentous injury to American football athletes, prevention programs should be incorporated into training regimens. The prevention programs should incorporate neuromuscular training including proprioceptive and muscle-activation exercises, single-leg training, game-time decision-making for unanticipated conditions, and proper foot positioning in dynamic movements [55].

Although bracing is common among American football athletes, there has been conflicting evidence on the efficacy of bracing in American football athletes. Prior studies have demonstrated a protective effect of bracing on MCL injury [56, 57], especially in the high-risk positions of offensive and defensive line, linebacker, and tight end [58]. However, other studies have questioned the effectiveness of bracing and no difference or an increased risk of knee injuries with bracing has been shown [58–60]. There is no conclusive evidence that bracing prevents ACL tears, or is protective of an ACL-reconstructed knee [61].

1.5.3 Anterior and Posterior Labral Tears Associated with Glenohumeral Instability

1.5.3.1 Mechanism of Injury

Anterior and posterior labral tears resulting from acute glenohumeral instability have distinct mechanisms of injury and presentation [62]. Glenohumeral instability events are typically described as either a subluxation, in which symptomatic instability occurs without separation of the articular surfaces requiring reduction, or dislocation, with complete disruption of the articular surfaces requiring reduction [18]. Anterior instability typically results from an acute anterior dislocation event with the arm in the abducted and externally rotated position, while posterior labral injuries typically present in a more insidious manner resulting from high-intensity, dynamic posterior loading to a forward flexed, internally rotated, and adducted arm causing a shearing force on the posterior labrum [62–65]. Anterior instability commonly causes avulsion of the anterior labrum and capsular attachments at the glenoid rim, known as a Bankart lesion [64]. In American football, skilled position players (i.e., running back, quarterback, defensive back, and linebackers) are more likely to sustain an anterior instability injury while linemen are at particular risk for posterior instability due to the nature of blocking and the propensity for bench pressing heavy weight [17, 63].

1.5.3.2 On-Field Management

An acute anterior shoulder dislocation is generally seen with the arm held in abduction and external rotation with a palpable prominence over the anterior shoulder accompanied by a defect or sulcus on the posterior shoulder. An acute posterior shoulder dislocation typically presents with the shoulder held in an adducted, internally rotated position [63]. Reduction may be attempted prior to the onset of muscle spasm, with successful reduction followed by a repeat neurovascular examination. If the glenohumeral joint cannot be reduced, transfer to a medical center for closed or open reduction is necessary.

For athletes presenting without frank dislocation events, physical examination for anterior instability consists of the apprehension sign, or feeling of apprehension induced with the arm in abduction and external rotation [64]. This can be combined with the Jobe relocation test which involves application of a posterior force on the anterior shoulder; this test is positive when this maneuver alleviates the feeling of apprehension. In addition, the anterior load-and-shift test can be used to evaluate the amount of anterior humeral translation present. A sulcus sign may be seen with inferior traction on the arm, particularly with inferior capsular laxity or multidirectional instability.

In cases of suspected posterior subluxation, patients may complain of pain or weakness rather than instability; these symptoms may be more prominent at the end of a game or workout when the surrounding musculature is fatigued and unable to compensate for loss of structural integrity [63]. Physical examination should evaluate for associated atrophy, scapular winging or dyskinesis, and generalized ligamentous laxity. The posterior load-and-shift, jerk, and posterior apprehension tests are also useful for detecting posterior instability [63]. The Kim test is particularly useful for evaluation of posteroinferior labral tears. This test is performed by applying an axial load with the arm abducted to 90° and forward flexed 45° in the sagittal plane [18]. The test is positive if this maneuver recreates the patient's pain.

Radiographic analysis should be performed to assess for associated osseous abnormalities such as fracture and evaluate for possible glenoid dysplasia or bone loss [63]. MRI, often with contrast (magnetic resonance arthrogram), is useful for evaluating the intra-articular structures including the anterior and posterior capsule and labrum (Fig. 1.3) [18, 63]. If there is concern for significant osseous deformity or bone loss, computed tomography scan with three-dimensional reconstruction is useful [63].

1.5.3.3 In-Season Treatment

Following first-time instability events without associated osseous defects, nonsurgical manage-

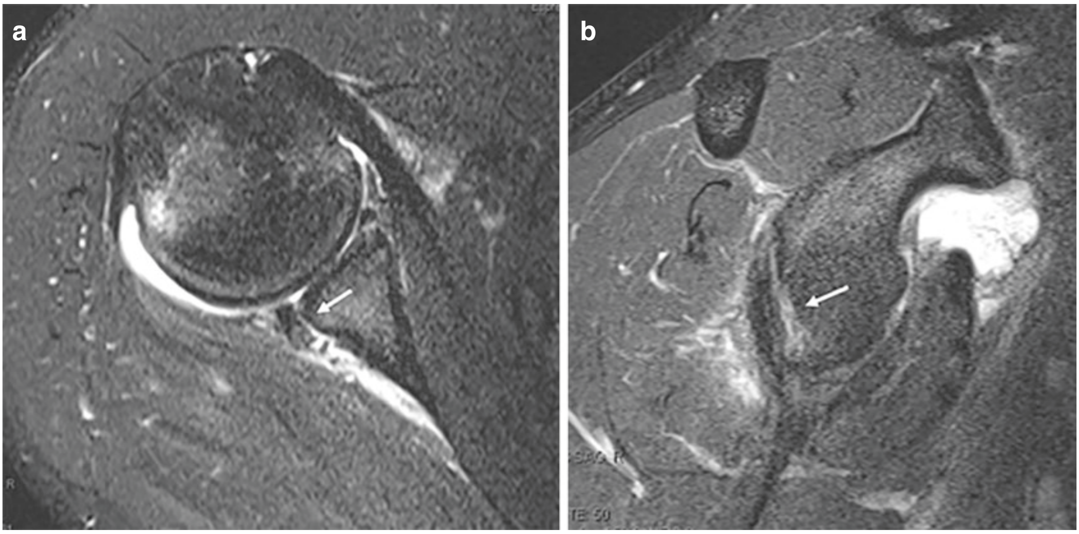

Fig. 1.3 Magnetic Resonance Imaging (MRI) of a left shoulder with a posterior labral tear. Image (**a**) is a T2-weighted axial MRI demonstrating a posterior labral tear (white arrow). Image (**b**) is a T2-weighted sagittal MRI demonstrating the posterior labral tear (white arrow)

ment is often the treatment of choice with surgical management reserved for those who fail initial nonoperative management [18]. Initial nonoperative management is especially attractive to many athletes as it allows earlier RTP than surgical intervention, which is often a season-ending event. Most athletes are able to return to sport after a brief period of immobilization followed by range of motion and strengthening exercises for 3 weeks, provided the athlete has symmetric pain-free range of motion and strength, is able to perform sport-specific skills, and there is no evidence of instability [66]. However, athletes should be counseled that 59–90% will experience a recurrent anterior instability event without surgical treatment [64, 66, 67]. With each instability event, the athlete is at risk of more severe injury, which may necessitate more complex surgical intervention with worse outcomes [66]. Following failed initial nonoperative management or multiple dislocations, concomitant injury such as a rotator cuff tear or periarticular fracture, or in the setting of significant osseous defects of the humeral head or glenoid, surgical intervention is recommended to reduce the likelihood of recurrent episodes of instability [64, 68].

The treatment outcomes for anterior and posterior labral tears as a result of glenohumeral instability are different. Significant improvements in clinical outcome scores have been demonstrated following both anterior and posterior labral repair; however, patients with anterior instability have been shown to have better postoperative clinical outcome scores than those with posterior instability [62]. Ultimately, the management of the in-season instability event requires a discussion with the athlete and his or her family regarding the risks and benefits of each treatment option, and a decision made based on their individual values, preferences, and goals.

1.5.3.4 Prevention of Injury

Periscapular and rotator cuff muscles assist with shoulder stabilization and glenohumeral joint kinematics. A periscapular and rotator cuff strengthening program should be incorporated into daily workouts to prevent glenohumeral joint dislocations.

Shoulder braces are routinely used by athletes with a history of shoulder subluxations or dislocations, as the brace has been shown to reduce shoulder range of motion and add stability to the glenohumeral joint [69, 70]. However, there is a paucity of evidence regarding the efficacy of shoulder bracing to reduce the incidence of shoulder injury in athletes.

1.5.4 AC Injury and Clavicle Fracture

1.5.4.1 Mechanism of Injury

Injuries to the AC joint and clavicle most commonly occur from a direct blow to the top of the shoulder, which may occur when tackling or diving or via an indirect injury such as a fall on an outstretched arm [18, 71–73]. AC joint injuries most frequently affect defensive backs, wide receivers, and special team players, but the incidence of injury is greatest in quarterbacks, special team players, and wide receivers [19].

1.5.4.2 On-Field Management

In the evaluation of an AC joint injury or clavicle fracture, a deformity may be seen and tenderness present at the site of injury. The athlete may report pain with movement of the arm, particularly with cross-body adduction.

Radiographic evaluation should be performed to evaluate for associated fractures in the setting of AC joint injury or to confirm the diagnosis of a clavicle fracture. The use of the Zanca view, or an antero-posterior (AP) radiograph with 15° cephalic tilt, can be particularly helpful in visualizing the AC joint [18]. MRI may be useful for more severe AC joint injuries to evaluate for the presence of concomitant injury; edema in the AC joint is a hallmark of AC joint injury [18, 72].

1.5.4.3 In-Season Treatment

AC joint injuries are typically treated according to the type of injury [72]. Type I and II injuries, which involve sprains of the AC and coracoclavicular (CC) ligaments, respectively, are typically treated nonoperatively in a sling with rest, pain control, cryotherapy, and physical therapy [18, 72, 74]. Type I or II injuries are often also treated with injection of local anesthetic to allow athletes to continue to play [75]. Treatment of type III injuries, with disruption of the AC and CC ligaments and a CC distance increased by 25–100% compared to the contralateral side, is controversial; however, 70% of NCAA team physicians preferred nonoperative management in a 2016 survey (Fig. 1.4) [75]. Type IV–VI, which involve significant displacement of the clavicle relative to the acromion, are typically managed operatively [72, 74].

The majority of AC joint injuries in American football players are Type I and II injuries and can be managed nonoperatively, with surgery required in only 1.4% of injuries [19]. The average loss of time for AC joint injuries was 10 days; however, AC joint dislocations and type III AC sprains had an average of 78 and 26 days lost to injury, respectively [19].

Nondisplaced midshaft clavicle fractures can typically be managed nonoperatively with rest

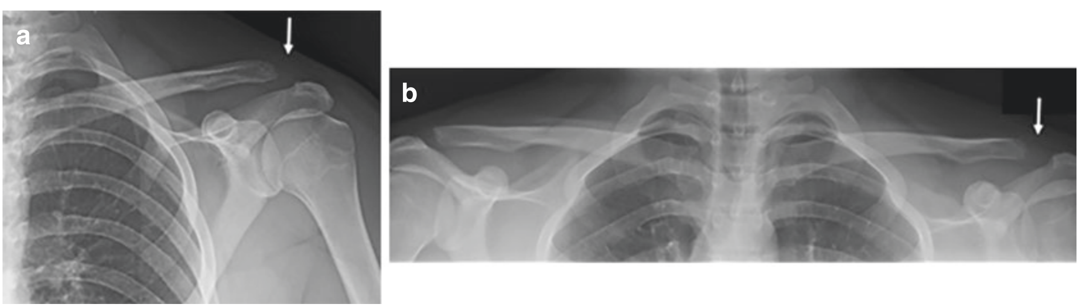

Fig. 1.4 Standing radiographs of a type III left shoulder acromioclavicular joint (AC) injury. Image (**a**) is a left shoulder antero-posterior radiograph demonstrating an AC joint injury (white arrow). Image (**b**) is a bilateral shoulder radiograph demonstrating asymmetric AC joint on the left shoulder (white arrow) as compared to the contralateral side

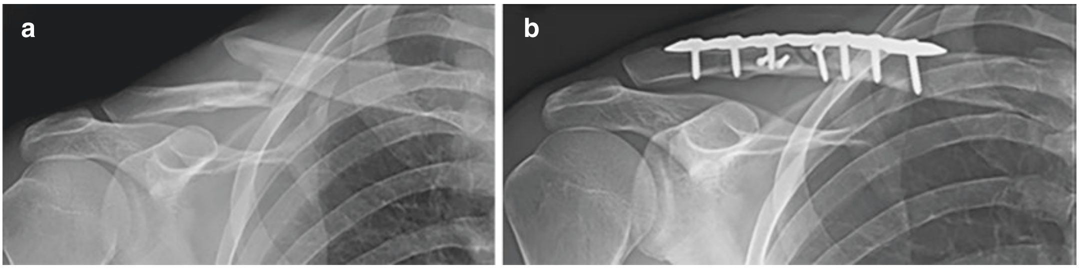

Fig. 1.5 Standing radiographs of a displaced right clavicle fracture. Image (**a**) is a right shoulder antero-posterior radiograph demonstrating a displaced clavicle fracture. Image (**b**) is a postoperative radiograph of the right shoulder after open reduction internal fixation of the fracture

and initial sling immobilization followed by increasing range of motion and strength [76]. Open reduction internal fixation (ORIF) is typically used for treatment of displaced fractures (Fig. 1.5). Distal clavicle fractures are managed based on the relationship of the fracture to the CC ligaments. Fractures distal to the CC ligaments are considered stable and can be managed nonoperatively while those that involve or are medial to the CC ligaments require ORIF [71]. Methods of fixation include hook pate fixation, plate fixation with ligament reconstruction, open suture fixation, arthroscopic Endobutton fixation, CC screw fixation, cerclage wire fixation, and tension band wiring [76].

Athletes can expect a recovery period of 10–12 weeks following midshaft clavicle fractures [76, 77]. Following a distal clavicle fracture, RTP typically occurs between 14 and 20 weeks post-injury [72, 76, 77].

1.5.4.4 Prevention of Injury

Over the past 20 years, the incidence of AC joint injuries have decreased, most notably due to changes in practice regimens and decreased physical contact in practice [19]. There is currently no protective equipment for the prevention of AC joint and clavicle fractures. American football athletes wear shoulder pads that decrease the risk of shoulder injury during routine plays, but a high-energy hit to the shoulder or contact with the playing surface may still lead to an AC joint or clavicle injury.

1.5.5 Ankle Sprains and Syndesmotic Injury

1.5.5.1 Mechanism of Injury

Lateral ligament sprains, or low ankle sprains, typically occur with inversion of the foot accompanied by external rotation of the ankle joint [78, 79]. Syndesmosis injury, also known as a high ankle sprain, typically occurs when the foot is dorsiflexed, everted, and externally rotated in relation to the tibia which typically occurs during a collision causing the athlete to fall forward while the foot is plantarflexed and externally rotated [80].

1.5.5.2 On-Field Management

Evaluation of an acute ankle sprain typically reveals pain, swelling, and ecchymosis located anterolaterally and posteromedially at the level of the ankle joint (Fig. 1.6) [19, 80]. The anterior drawer test, performed by applying an anterior force on the posterior hindfoot with the foot in neutral position, is useful for testing the integrity of the anterior tibiofibular ligament [79]. The calcaneofibular ligament can be tested by inverting the hindfoot with the ankle in neutral dorsiflexion [78, 79]. Several provocative tests are useful in evaluating for syndesmosis injuries. Pain when applying a compressive force between the proximal fibula and tibia with pain (squeeze test) or with external rotation of the foot and ankle relative to the tibia is suggestive of syndesmotic injury [80].

Fig. 1.6 On-field evaluation of a low ankle injury. This evaluation typically reveals pain and swelling about the anterolateral and posteromedial ankle

Radiographic evaluation of low ankle sprains should be dictated by the Ottawa ankle rules for evaluating for ankle fractures [79]. In cases of suspected high ankle sprain, weight-bearing and external rotation stress radiographs are useful to identify associated fractures or tibiofibular diastasis [78, 80, 81]. Full-length radiographs of the tibia and fibula should be obtained to evaluate for possible proximal fibular fracture, also known as a Maisonneuve injury [78]. MRI evaluation is also useful to show the extent of ligamentous injury as well as the presence of nondisplaced fractures.

1.5.5.3 In-Season Treatment

Treatment of low ankle sprains begins with nonoperative management with compression, ice, pain control with anti-inflammatory medications, and elevation. Injuries without complete tear of the lateral ligaments should be treated with immediate functional rehabilitation while those with complete ligamentous tears treated with a short period of immobilization followed by rehabilitation [78]. Functional rehabilitation consists of early mobilization with external support followed by range of motion, strengthening, and proprioceptive exercises, and return to sport-specific activity [79]. Surgical intervention, consisting of repair or reconstruction of the lateral ligaments, can be considered for those who fail initial nonoperative management or for elite athletes [79].

Syndesmotic injury without frank diastasis or dynamic instability on weight-bearing or stress radiographs can be managed nonsurgically [80]. Nonsurgical management consists of rest, ice, and immobilization for 3–5 days to allow inflammation to resolve. Weight-bearing is allowed in a boot with initiation of active and passive range of motion after 3–5 days. Once pain is resolved in the boot, a stabilizing brace is used and strengthening and functional exercises begin, followed by running and initiation of sport-specific activities. The ability to hop on the injured leg ten times is useful to help indicate that the athlete is ready to initiate sport-specific activities [80].

Unstable injuries necessitate surgical intervention, typically with ORIF of the syndesmosis with a screw or suture button construct [80]. Following fixation with syndesmotic screws, the patient is typically made nonweight-bearing for 4–6 weeks, and athletes may RTP between 10 and 12 weeks postoperatively if there is no symptoms of hardware irritation necessitating removal [80]. Stabilization with a suture button construct may allow more physiologic motion between the tibia and fibula and does not require hardware removal [80]. Following treatment of high and low ankle sprains, athletes are allowed to RTP when range of motion and strength has returned to baseline or at least 90% of the contralateral, uninjured extremity [78, 81].

1.5.5.4 Prevention of Injury

Prophylactic ankle taping has been the mainstay of ankle injury prevention, as it reduces ankle plantarflexion and inversion and improves proprioception [82–84]. However, it has been shown that ankle tape loosens with physical activity and may have a significant reduction in support within 30 min of initiation of exercise [85, 86]. Additionally, there is an added cost to the team for taping materials. Therefore, ankle orthoses or braces have been advocated due to `low cost and ability to reuse during the season [87, 88]. A recent randomized control trial compared taping with a commercially available ankle brace. The authors found no difference in ankle sprains sustained throughout the season between taping and bracing and concluded bracing was more economical and time-saving [89].

Summary/Take Home Messages

American football is a violent collision sport that places the athlete at risk for significant injuries including career-ending ligamentous knee injuries and fractures. Although a wide variety of injuries are sustained, five common injuries include concussions, ACL and MCL tears, glenohumeral shoulder instability, AC joint injuries and clavicle fractures, and ankle sprains and syndesmotic injuries. Concussions can have significant physical and mental sequela, and the key to prevention of concussions is recognition of symptoms, timely treatment, and knowledge of RTP guidelines. The majority of extremity injuries cannot be avoided, but can be limited with proper physical and mental training. Knee bracing can be effective for limiting MCL tears, while ankle taping and bracing is effective for limiting ankle sprains. Shoulder bracing has not been shown to prevent shoulder injuries and knee bracing has not been shown to prevent ACL tears. However, further research is needed to better understand the role of sports performance programs in injury prevention for athletes.

References

1. Mueller FO, Colgate B. Annual survey of football injury research, 1931–2009. Prepared for: The American Football Coaches Association, The National Collegiate Athletic Association and the National Federation of State High School Associations; 2010.
2. Shankar PR, Fields SK, Collins CL, Dick RW, Comstock RD. Epidemiology of high school and collegiate football injuries in the United States, 2005–2006. Am J Sports Med. 2007;35:1295–303.
3. Whiteside JA, Fleagle SB, Kalenak A, Weller HW. Manpower loss in football: a 12-year study at the Pennsylvania State University. Phys Sportsmed. 1985;13:102–14.
4. Dragoo JL, Braun HJ, Harris AH. The effect of playing surface on the incidence of ACL injuries in National Collegiate Athletic Association American Football. Knee. 2013;20:191–5.
5. Iacovelli JN, Yang J, Thomas G, Wu H, Schiltz T, Foster DT. The effect of field condition and shoe type on lower extremity injuries in American Football. Br J Sports Med. 2013;47:789–93.
6. Loughran GJ, Vulpis CT, Murphy JP, Weiner DA, Svoboda SJ, Hinton RY, et al. Incidence of knee injuries on artificial turf versus natural grass in National Collegiate Athletic Association American football: 2004–2005 through 2013–2014 seasons. Am J Sports Med. 2019;47:1294–301.
7. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. J Athl Train. 2007;42:311–9.

8. Kerr ZY, Cortes N, Ambegaonkar JP, Caswell AM, Prebble M, Romm K, et al. The epidemiology of injuries in middle school football, 2015–2017: the advancing healthcare initiatives for underserved students project. Am J Sports Med. 2019;47:933–41.
9. Kerr ZY, Simon JE, Grooms DR, Roos KG, Cohen RP, Dompier TP. Epidemiology of football injuries in the National Collegiate Athletic Association, 2004–2005 to 2008–2009. Orthop J Sports Med. 2016;4:2325967116664500.
10. Smith PJ, Hollins AM, Sawyer JR, Spence DD, Outlaw S, Kelly DM. Characterization of American Football injuries in children and adolescents. J Pediatr Orthop. 2018;38:e57–60.
11. Bradley J, Honkamp NJ, Jost P, West R, Norwig J, Kaplan LD. Incidence and variance of knee injuries in elite college football players. Am J Orthop (Belle Mead NJ). 2008;37:310–4.
12. Bakshi NK, Khan M, Lee S, Finney FT, Stotts J, Sikka RS, et al. Return to play after multiligament knee injuries in National Football League Athletes. Sports Health. 2018;10:495–9.
13. Bradley JP, Klimkiewicz JJ, Rytel MJ, Powell JW. Anterior cruciate ligament injuries in the National Football League: epidemiology and current treatment trends among team physicians. Arthroscopy. 2002;18:502–9.
14. Brophy RH, Lyman S, Chehab EL, Barnes RP, Rodeo SA, Warren RF. Predictive value of prior injury on career in professional American football is affected by player position. Am J Sports Med. 2009;37:768–75.
15. Lievers WB, Adamic PF. Incidence and severity of foot and ankle injuries in men's collegiate American Football. Orthop J Sports Med. 2015;3:2325967115581593.
16. McHale KJ, Vopat BG, Beaulieu-Jones BR, Sanchez G, Whalen JM, McDonald LS, et al. Epidemiology and outcomes of Lisfranc injuries identified at the National Football League Scouting Combine. Am J Sports Med. 2017;45:1901–8.
17. Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of shoulder injuries in elite collegiate football players. Am J Sports Med. 2005;33:1142–6.
18. Gibbs DB, Lynch TS, Nuber ED, Nuber GW. Common shoulder injuries in American Football athletes. Curr Sports Med Rep. 2015;14:413–9.
19. Lynch TS, Saltzman MD, Ghodasra JH, Bilimoria KY, Bowen MK, Nuber GW. Acromioclavicular joint injuries in the National Football League: epidemiology and management. Am J Sports Med. 2013;41:2904–8.
20. Chung AS, Makovicka JL, Hassebrock JD, Patel KA, Tummala SV, Deckey DG, et al. Epidemiology of cervical injuries in NCAA Football players. Spine (Phila Pa 1976). 2019;44:848–54.
21. Wascher DC, Bulthuis L. Extremity trauma: field management of sports injuries. Curr Rev Musculoskelet Med. 2014;7:387–93.
22. Ellenbogen RG, Batjer H, Cardenas J, Berger M, Bailes J, Pieroth E, et al. National Football League Head, Neck and Spine Committee's concussion diagnosis and management protocol: 2017–18 season. Br J Sports Med. 2018;52:894–902.
23. Lynall RC, Campbell KR, Wasserman EB, Dompier TP, Kerr ZY. Concussion mechanisms and activities in youth, high school, and college football. J Neurotrauma. 2017;34:2684–90.
24. Lessley DJ, Kent RW, Funk JR, Sherwood CP, Cormier JM, Crandall JR, et al. Video analysis of reported concussion events in the National Football League during the 2015–2016 and 2016–2017 seasons. Am J Sports Med. 2018;46:3502–10.
25. Patricios JS, Ardern CL, Hislop MD, Aubry M, Bloomfield P, Broderick C, et al. Implementation of the 2017 Berlin Concussion in Sport Group Consensus Statement in contact and collision sports: a joint position statement from 11 national and international sports organisations. Br J Sports Med. 2018;52:635–41.
26. Leong DF, Balcer LJ, Galetta SL, Evans G, Gimre M, Watt D. The King–Devick test for sideline concussion screening in collegiate football. J Opt. 2015;8:131–9.
27. Lau BC, Kontos AP, Collins MW, Mucha A, Lovell MR. Which on-field signs/symptoms predict protracted recovery from sport-related concussion among high school football players? Am J Sports Med. 2011;39:2311–8.
28. Echemendia RJ, Meeuwisse W, McCrory P, Davis GA, Putukian M, Leddy J, et al. The sport concussion assessment tool 5th edition (SCAT5): background and rationale. Br J Sports Med. 2017;51:848–50.
29. Yeo PC, Yeo EQ, Probert J, Sim SH, Sirisena D. A systematic review and qualitative analysis of concussion knowledge amongst sports coaches and match officials. J Sports Sci Med. 2020;19:65–77.
30. Zhang AL, Sing DC, Rugg CM, Feeley BT, Senter C. The rise of concussions in the adolescent population. Orthop J Sports Med. 2016;4:2325967116662458.
31. Cantu RC, Mueller FO. Brain injury-related fatalities in American Football, 1945–1999. Neurosurgery. 2003;52:846–53.
32. Daneshvar DH, Baugh CM, Nowinski CJ, McKee AC, Stern RA, Cantu RC. Helmets and mouth guards: the role of personal equipment in preventing sport-related concussions. Clin Sports Med. 2011;30:145–63.
33. Dave Singh G, Maher GJ, Padilla RR. Customized mandibular orthotics in the prevention of concussion/mild traumatic brain injury in football players: a preliminary study. Dent Traumatol. 2009;25:515–21.
34. Hollis SJ, Stevenson MR, McIntosh AS, Shores EA, Collins MW, Taylor CB. Incidence, risk, and protective factors of mild traumatic brain injury in a cohort of Australian nonprofessional male rugby players. Am J Sports Med. 2009;37:2328–33.
35. Mack C, Myers E, Barnes R, Solomon G, Sills A. Engaging athletic trainers in concussion detection: overview of the National Football League ATC Spotter Program, 2011–2017. J Athl Train. 2019;54:852–7.
36. Mack C, Sendor RR, Solomon G, Ellenbogen RG, Myers E, Berger M, et al. Enhancing concussion man-

agement in the National Football League: evolution and initial results of the Unaffiliated Neurotrauma Consultants Program, 2012–2017. Neurosurgery. 2019;87:312. https://doi.org/10.1093/neuros/nyz481.
37. Zuckerman SL, Elbin RJ, Sills AK, Crandall JR, Lessley DJ, Moran CM, et al. (2020) Concussions in the National Football League: the evolution of video review for assessing the frequency and reliability of visible signs. Phys Sportsmed; https://doi.org/10.1080/00913847.2020.17313791-6
38. Johnston JT, Mandelbaum BR, Schub D, Rodeo SA, Matava MJ, Silvers-Granelli HJ, et al. Video analysis of anterior cruciate ligament tears in professional American Football athletes. Am J Sports Med. 2018;46:862–8.
39. Chen L, Kim PD, Ahmad CS, Levine WN. Medial collateral ligament injuries of the knee: current treatment concepts. Curr Rev Musculoskelet Med. 2008;1:108–13.
40. Elkin JL, Zamora E, Gallo RA. Combined anterior cruciate ligament and medial collateral ligament knee injuries: anatomy, diagnosis, management recommendations, and return to sport. Curr Rev Musculoskelet Med. 2019;12:239–44.
41. Encinas-Ullán CA, Rodríguez-Merchán EC. Isolated medial collateral ligament tears: an update on management. EFORT Open Rev. 2018;3:398–407.
42. Granan L-P, Inacio MCS, Maletis GB, Funahashi TT, Engebretsen L. Sport-specific injury pattern recorded during anterior cruciate ligament reconstruction. Am J Sports Med. 2013;41:2814–8.
43. Musahl V, Karlsson J. Anterior cruciate ligament tear. N Engl J Med. 2019;380:2341–8.
44. Erickson BJ, Harris JD, Fillingham YA, Frank RM, Bush-Joseph CA, Bach BR, et al. Anterior cruciate ligament reconstruction practice patterns by NFL and NCAA Football team physicians. Arthroscopy. 2014;30:731–8.
45. Gifstad T, Foss OA, Engebretsen L, Lind M, Forssblad M, Albrektsen G, et al. Lower risk of revision with patellar tendon autografts compared with hamstring autografts. Am J Sports Med. 2014;42:2319–28.
46. Kane PW, Wascher J, Dodson CC, Hammoud S, Cohen SB, Ciccotti MG. Anterior cruciate ligament reconstruction with bone-patellar tendon-bone autograft versus allograft in skeletally mature patients aged 25 years or younger. Knee Surg Sports Traumatol Arthrosc. 2016;24:3627–33.
47. Kraeutler MJ, Bravman JT, McCarty EC. Bone-patellar tendon-bone autograft versus allograft in outcomes of anterior cruciate ligament reconstruction. Am J Sports Med. 2013;41:2439–48.
48. Schrock JB, Carver TJ, Kraeutler MJ, McCarty EC. Evolving treatment patterns of NFL players by orthopaedic team physicians over the past decade, 2008–2016. Sports Health. 2018;10:453–61.
49. Mai HT, Alvarez AP, Freshman RD, Chun DS, Minhas SV, Patel AA, et al. The NFL Orthopaedic Surgery Outcomes Database (NO-SOD). Am J Sports Med. 2016;44:2255–62.
50. McCullough KA, Phelps KD, Spindler KP, Matava MJ, Dunn WR, Parker RD, et al. Return to high school- and college-level football after anterior cruciate ligament reconstruction. Am J Sports Med. 2012;40:2523–9.
51. Okoroha KR, Kadri O, Keller RA, Marshall N, Cizmic Z, Moutzouros V. Return to play after revision anterior cruciate ligament reconstruction in National Football League players. Orthop J Sports Med. 2017;5:232596711769878.
52. Shah VM, Andrews JR, Fleisig GS, McMichael CS, Lemak LJ. Return to play after anterior cruciate ligament reconstruction in National Football League Athletes. Am J Sports Med. 2010;38:2233–9.
53. Derscheid GL, Garrick JG. Medial collateral ligament injuries in football. Am J Sports Med. 1981;9:365–8.
54. Kim C, Chasse PM, Taylor DC. Return to play after medial collateral ligament injury. Clin Sports Med. 2016;35:679–96.
55. Sugimoto D, Alentorn-Geli E, Mendiguchía J, Samuelsson K, Karlsson J, Myer GD. Biomechanical and neuromuscular characteristics of male athletes: implications for the development of anterior cruciate ligament injury prevention programs. Sports Med. 2015;45:809–22.
56. Albright JP, Powell JW, Smith W, Martindale A, Crowley E, Monroe J, et al. Medial collateral ligament knee sprains in college football: effectiveness of preventive braces. Am J Sports Med. 1994;22:12–8.
57. Sitler M, Ryan CJ, Hopkinson LW, Wheeler LJ, Santomier J, Kolb LR, et al. The efficacy of a prophylactic knee brace to reduce knee injuries in football: a prospective, randomized study at West Point. Am J Sports Med. 1990;18:310–5.
58. Salata MJ, Gibbs AE, Sekiya JK. The effectiveness of prophylactic knee bracing in American Football: a systematic review. Sports Health. 2010;2:375–9.
59. Hewson GF Jr, Mendini RA, Wang JB. Prophylactic knee bracing in college football. Am J Sports Med. 1986;14:262–6.
60. Rovere GD, Haupt HA, Yates CS. Prophylactic knee bracing in college football. Am J Sports Med. 1987;15:111–6.
61. Wright RW, Fetzer GB. Bracing after ACL reconstruction: a systematic review. Clin Orthop Relat Res. 2007;455:162–8.
62. Bernhardson AS, Murphy CP, Aman ZS, Laprade RF, Provencher MT. A prospective analysis of patients with anterior versus posterior shoulder instability: a matched cohort examination and surgical outcome analysis of 200 patients. Am J Sports Med. 2019;47:682–7.
63. Antosh IJ, Tokish JM, Owens BD. Posterior shoulder instability. Sports Health. 2016;8:520–6.
64. Gil JA, Defroda S, Owens BD. Current concepts in the diagnosis and management of traumatic, anterior glenohumeral subluxations. Orthop J Sports Med. 2017;5:232596711769433.

65. Mair SD, Zarzour RH, Speer KP. Posterior labral injury in contact athletes. Am J Sports Med. 1998;26:753–8.
66. Owens BD, Dickens JF, Kilcoyne KG, Rue J-PH. Management of mid-season traumatic anterior shoulder instability in athletes. J Am Acad Orthop Surg. 2012;20:518–26.
67. Watson S, Allen B, Grant JA. A clinical review of return-to-play considerations after anterior shoulder dislocation. Sports Health. 2016;8:336–41.
68. Delong JM, Jiang K, Bradley JP. Posterior instability of the shoulder. Am J Sports Med. 2015;43:1805–17.
69. Conti M, Garofalo R, Castagna A, Massazza G, Ceccarelli E. Dynamic brace is a good option to treat first anterior shoulder dislocation in season. Musculoskelet Surg. 2017;101:169–73.
70. Dellabiancia F, Parel I, Filippi MV, Porcellini G, Merolla G. Glenohumeral and scapulohumeral kinematic analysis of patients with traumatic anterior instability wearing a shoulder brace: a prospective laboratory study. Musculoskelet Surg. 2017;101:159–67.
71. Kirsch JM, Tyrrell Burrus M, Bedi A. Common injuries in professional football quarterbacks. Curr Rev Musculoskelet Med. 2018;11:6–11.
72. Li X, Ma R, Bedi A, Dines DM, Altchek DW, Dines JS. Management of Acromioclavicular Joint Injuries. J Bone Joint Surg Am. 2014;96:73–84.
73. Stanley D, Trowbridge EA, Norris SH. The mechanism of clavicular fracture. A clinical and biomechanical analysis. J Bone Joint Surg Br. 1988;70:461–4.
74. Allemann F, Halvachizadeh S, Waldburger M, Schaefer F, Pothmann C, Pape HC, et al. Different treatment strategies for acromioclavicular dislocation injuries: a nationwide survey on open/minimally invasive and arthroscopic concepts. Eur J Med Res. 2019;24:18.
75. Carver TJ, Schrock JB, Kraeutler MJ, McCarty EC. The evolving treatment patterns of NCAA division I football players by orthopaedic team physicians over the past decade, 2008–2016. Sports Health. 2018;10:234–43.
76. Robertson GAJ, Wood AM. Return to sport following clavicle fractures: a systematic review. Br Med Bull. 2016;119:111–28.
77. Burnier M, Barlow JD, Sanchez-Sotelo J. Shoulder and elbow fractures in athletes. Curr Rev Musculoskelet Med. 2019;12:13–23.
78. Gill LA, Klingele KE. Management of foot and ankle injuries in pediatric and adolescent athletes: a narrative review. Orthop Res Rev. 2018;10:19–30.
79. Maffulli N, Ferran NA. Management of acute and chronic ankle instability. J Am Acad Orthop Surg. 2008;16:608–15.
80. Hunt KJ, Phisitkul P, Pirolo J, Amendola A. High ankle sprains and syndesmotic injuries in athletes. J Am Acad Orthop Surg. 2015;23:661–73.
81. Van Dijk CN, Longo UG, Loppini M, Florio P, Maltese L, Ciuffreda M, et al. Classification and diagnosis of acute isolated syndesmotic injuries: ESSKA-AFAS consensus and guidelines. Knee Surg Sports Traumatol Arthrosc. 2016;24:1200–16.
82. Garrick J, Requa R. Role of external support in the prevention of ankle sprains. Med Sci Sports. 1973;5:200–3.
83. Laughman R, Carr T, Chao E, Youdas J, Sim F. Three-dimensional kinematics of the taped ankle before and after exercise. Am J Sports Med. 1980;8:425–31.
84. Robbins S, Waked E, Rappel R. Ankle taping improves proprioception before and after exercise in young men. Br J Sports Med. 1995;29:242–7.
85. Fumich RM, Ellison AE, Guerin GJ, Grace PD. The measured effect of taping on combined foot and ankle motion before and after exercise. Am J Sports Med. 1981;9:165–70.
86. Myburgh KH, Vaughan CL, Isaacs SK. The effects of ankle guards and taping on joint motion before, during, and after a squash match. Am J Sports Med. 1984;12:441–6.
87. Greene TA, Hillman SK. Comparison of support provided by a semirigid orthosis and adhesive ankle taping before, during, and after exercise. Am J Sports Med. 1990;18:498–506.
88. Rovere GD, Clarke TJ, Yates CS, Burley K. Retrospective comparison of taping and ankle stabilizers in preventing ankle injuries. Am J Sports Med. 1988;16:228–33.
89. Mickel TJ, Bottoni CR, Tsuji G, Chang K, Baum L, Tokushige KAS. Prophylactic bracing versus taping for the prevention of ankle sprains in high school athletes: a prospective, randomized trial. J Foot Ankle Surg. 2006;45:360–5.