Upper Extremity Golf Injuries

Michael A. Cohn, M.D., Steven K. Lee, M.D., and Eric J. Strauss, M.D.

Abstract

Golf is a global sport enjoyed by an estimated 60 million people around the world. Despite the common misconception that the risk of injury during the play of golf is minimal, golfers are subject to a myriad of potential pathologies. While the majority of injuries in golf are attributable to overuse, acute traumatic injuries can also occur. As the body’s direct link to the golf club, the upper extremities are especially prone to injury. A thorough appreciation of the risk factors and patterns of injury will afford accurate diagnosis, treatment, and prevention of further injury.

The game of golf originated on the eastern links of Scotland. The earliest recorded mention of golf in Scotland was in a 1457 Act of the Scottish Parliament issued by King James II outlawing the game as he felt it was a distraction from archery practice for military purposes. The oldest golf course in the world is Musselburgh Links, which has documentation of play since 1672. There is even some evidence that Mary Queen of Scots played there as early as 1567.1

In recent decades, golf has seen a boom in popularity in part from television coverage, worldwide growth in golf course development, and the emergence of superstars such as Arnold Palmer, Jack Nicklaus, and Tiger Woods. Golf is an activity regularly enjoyed by many millions of people across the world. In 2008, the National Golf Foundation estimated there were 28.6 million golfers in the United States alone. There are an estimated 60 million golfers worldwide playing on 32,000 golf courses. The purpose of this paper is to review the epidemiology of golf injuries, the kinematics of the golf swing, and injury diagnosis and prevention in golfers.

Epidemiology

Golf has mistakenly been considered a sport without much physical demand. However, golfers do experience significant injuries. A recent study found that over a 2 year period, 60% of professionals and 40% of amateurs experienced a traumatic or overuse golf injury.2 Shoulder, elbow, wrist, and hand injuries rank amongst the most common in golfers.

McCarroll surveyed a cohort of professional and amateur golfers (Table 1).3 Too much play or practice was the most commonly reported mechanism of injury in both groups. Amateurs also blamed poor swing mechanics and hitting the ground for a large portion of their injuries. Batt surveyed 193 amateur golfers from a single English golf club about their golfing injuries.4 Thirty two percent of those surveyed reported sustaining injuries on the golf course. Poor swing mechanics and overuse were the two most commonly cited causes. In a group of amateur golfers, Thériault and coworkers observed a slightly more frequent pattern of overuse injury [67/123 (54.5%)] compared with a single traumatic event [56/123 (45.5%)].5 In a study of 412 amateur golfers, Jobe and Yocum noted the most common factor for injury was overpractice. They reported the most common sites of injury in descending order were the back, shoulder, elbow, and knee.6 McCarroll and associates, in a survey with 1,144 amateur respondents, reported the back as the most common site of injury, followed by the elbow, hand and wrist, and shoulder.7 In a study of professional golfers, McCarroll and colleagues found that wrist injuries estimated there were 28.6 million golfers in the United States alone. There are an estimated 60 million golfers worldwide playing on 32,000 golf courses. The purpose of this paper is to review the epidemiology of golf injuries, the kinematics of the golf swing, and injury diagnosis and prevention in golfers.
were most common, followed by injuries to the back, left hand, left shoulder, left knee, and left thumb (in reference to a right-handed golfer).7

The frequency of injuries increases with improved skill level, which is correlated to a golfer’s handicap. A golf handicap roughly estimates how many shots above par the golfer averages over an 18-hole round of play. More skilled golfers carry lower handicaps. In a 1990 survey of 1,144 amateur golfers, those with handicaps greater than 18 had a 59% rate of injury, while those with handicaps from 10 to 17 had a 61.8% rate of injury, and golfers with a handicap under 10 had a 67.5% injury rate.7 This can be attributed to the fact that highly-skilled golfers must practice the game many hours a week to maintain or improve their level of play, which lends itself to more overuse injuries.

There are several identifiable risk factors for golf injuries. Excessive play or practice leads to a spectrum of overuse injuries. Golfers also sustain hand, wrist, and elbow injuries when striking an unintended object at impact such as a tree root or rock.2,8,9 Additionally, risk factors for amateurs include injuries as a result of poor conditioning, inadequate warm-up, and faulty swing mechanics.3,4

### Swing Phases

Golf instructors and golf medicine experts have divided the swing into phases: address, backswing, downswing, impact, and follow-through. Each phase of the swing places stress on different aspects of the upper extremities, and there are characteristic injuries associated with each phase. Thinking about the golf swing in this way is helpful when diagnosing and treating an injured golfer. The following discussion of golf injuries are in reference to a right-handed golfer.

#### Address

The starting point in the golf swing is the address. The golfer should stand a comfortable distance from the ball with his or her feet about shoulder-width apart and body weight centered between the feet. The knees and hips are flexed to place the golfer in an athletic position while keeping the spine neutral. The arms should drape down naturally at ease from the shoulders. The club should be gripped as lightly as possible in order to minimize tension in the swing. Imaginary lines drawn across the shoulders, hips, and knees should all be parallel to each other and the target line. Mistakes in the address position lead to faults later in the swing that can cause injury as well as lead to worse ball striking and scoring.

#### Backswing

During the backswing, the club is elevated to its highest position while the shoulders and hips rotate around the spine’s axis, and the body weight shifts toward the right foot. At the top of the swing, the wrists are cocked in maximal radial deviation, and the forearm muscles are stretched. This maneuver loads the body for generation of clubhead speeds in excess of 100 mph in less than two-tenths of a second.10 Repetition and swing flaws can lead to wrist and elbow tendinitis, wrist impaction syndromes, peripheral neuropathies, and shoulder impingement syndrome.

#### Downswing

The downswing begins with the hips rotating towards the target while the weight shifts towards the left side. This lower body turn initiates the club’s downward descent while the wrists remain cocked until just before impact to create power. The most active muscles during this phase are the abdominals, pectoralis major, subscapularis, and latissimus dorsi muscles.11 Repetition and swing flaws in the downswing can lead to wrist, elbow, or rotator cuff injuries.9

#### Impact

The impact phase involves striking the ball, ground, or both. The majority of traumatic injuries occur at impact. Professionals and high-level amateurs often deliberately strike the turf at impact taking a divot. Amateurs can injure themselves by hitting shots “fat,” which is an unintentional ground strike just prior to ball impact. Golfers can also be

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**Table 1**  Causes of Golf Injuries in Professionals and Amateurs²

<table>
<thead>
<tr>
<th>Cause</th>
<th>Professional Golfers</th>
<th>Amateur Golfers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too much play or practice</td>
<td>270 (79.9%)</td>
<td>204 (28.9%)</td>
</tr>
<tr>
<td>Poor swing mechanics</td>
<td>0</td>
<td>150 (21.2%)</td>
</tr>
<tr>
<td>Hit ground</td>
<td>40 (11.8%)</td>
<td>171 (24.2%)</td>
</tr>
<tr>
<td>Overswing</td>
<td>0</td>
<td>85 (12.0%)</td>
</tr>
<tr>
<td>Poor warm-up</td>
<td>0</td>
<td>60 (8.4%)</td>
</tr>
<tr>
<td>Twist during swing</td>
<td>18 (5.3%)</td>
<td>22 (3.1%)</td>
</tr>
<tr>
<td>Grip or swing change</td>
<td>0</td>
<td>26 (3.7%)</td>
</tr>
<tr>
<td>Fall</td>
<td>2 (0.6%)</td>
<td>24 (3.4%)</td>
</tr>
<tr>
<td>Bending over putt</td>
<td>5 (1.5%)</td>
<td>8 (1.1%)</td>
</tr>
<tr>
<td>Injury secondary to cart</td>
<td>0</td>
<td>18 (2.5%)</td>
</tr>
<tr>
<td>Hit by ball</td>
<td>3</td>
<td>36 (5.1%)</td>
</tr>
</tbody>
</table>
injured at impact by striking unseen tree roots, rocks, and other objects lying near the ball or by hitting a ball out of very thick or long grass.

**Follow-Through**
During the follow-through phase, the body continues to rotate until facing the target. The left forearm supinates as the right forearm pronates and weight shifts almost completely to the left foot. The club decelerates to a rest over the lead shoulder. Approximately, 25% of all golf injuries occur during the follow-through. Back injuries account for 40%, and the shoulder is involved in about 17% of cases.8

**Shoulder**
The shoulder is a common source of pain in golfers. It ranks as the third and fourth most common site of injury in professionals and amateurs, respectively.2,3,5,8 Most of these are overuse injuries.2,8,9 Professional golfers routinely perform over 2,000 swings per week.12 Because golfers can play the sport for life, the damage from repetitive microtrauma makes many players vulnerable to injuries.

A successful golf swing requires a synchronized effort of the shoulder girdle and rotator cuff muscles. Jobe looked at professional golfers' shoulder muscle activity during the golf swing with electromyography.11 The subscapularis muscle was the most active in the shoulder girdle. The rotator cuff muscles of both shoulders were equally active during the golf swing. The deltoids were found to be relatively inactive throughout the entire swing. This is due to the fact that the shoulders do not require much elevation during the swing. The pectoralis major and latissimus dorsi muscles were very active during the acceleration of the downswing contributing to power. The investigators concluded that for increased power and injury prevention one should target rotator cuff, pectoralis major, and latissimus dorsi strengthening.

**Acromioclavicular Joint Problems**
The acromioclavicular joint is a common source of symptoms in golfers experiencing shoulder pain. In 1995, Mal-lon and colleagues reported on 35 high-level golfers with shoulder pain and found 53% had acromioclavicular joint disease as the cause of symptoms.13 The repetitive adduction of the lead shoulder at the top of the backswing places added load on the acromioclavicular joint. Over time this leads to spurring along the undersurface of the joint and can cause associated symptoms from rotator cuff impingement and bursal-sided rotator cuff tears. Over the years with repetitive stress, acromioclavicular joint arthritis can develop leading to pain and stiffness.12,13

**Impingement Syndromes**
Golfers can experience several forms of impingement syndromes in the lead shoulder. With external impingement, the golfer experiences pain when the rotator cuff impinges between the greater tuberosity and acromion upon shoulder elevation due to a decrease in the normal subacromial space from acromial spurs and inflamed bursal tissue. Rotator cuff tendonitis or partial tears can result. Rotator cuff tendinitis and impingement have been reported to be the second most common cause of shoulder pain in elite golfers.13

Internal impingement, a common diagnosis in overhead athletes, can also occur in golfers in the lead shoulder at the top of the backswing and the end of the follow-through. At the top of the backswing, the lead shoulder is maximally adducted causing the humeral head and rotator cuff to impinge against the anterior glenoid and labrum. The reverse situation occurs at the end of the follow-through. The lead shoulder is abducted and externally rotated resulting in humeral head and cuff impingement against the posterior glenoid rim and labrum. Labral tears, articular-sided rotator cuff tears, and humeral head articular lesions can result from either process.12

**Instability**
Younger golfers can develop symptomatic instability, which most often affects the lead shoulder. The etiology is often pre-existing hyperlaxity combined with overuse. The capsuloligamentous complex can undergo stretching leading to anterior and posterior subluxation with damage to the labrum and rotator cuff. The golfer may experience pain and a “pop or clunk” at the top of the backswing. Posterior instability is symptomatic at the transition from backswing to downswing as there is a tremendous posterior force across the shoulder during this transition. Hovis and coworkers found that posterior instability was the source of symptoms in a cohort of elite golfers with left shoulder pain.14 Their shoulder pain and instability was present at the top of the backswing. All of the golfers in the study had a positive load-and-shift test and posterior apprehension sign. Anterior instability is usually symptomatic in the lead shoulder upon the follow-through. The golfer may have a positive load-and-shift test and anterior apprehension sign. Treatment for both conditions usually consists of an initial course of rest and physical therapy directed at strengthening the rotator cuff and scapular stabilizing muscles. Surgery is indicated when non-operative management fails to relieve symptoms. It usually entails arthroscopic capsulorrhaphy or labral repair, debridement of partial rotator cuff tears and subacromial decompression, based on the underlying pathology.12,14

**Scapular Lag**
Weakness of the rhomboids and serratus anterior can lead to loss of normal scapulothoracic rhythm, or scapular lag, when there is an imbalance between the scapula and the movement of the torso.15 Proper strength and coordination of the scapular muscles is needed to provide a stable base for the shoulder during the golf swing. Scapular lag leads to an increase in overall shoulder injuries from the downswing
to the follow-through. Treatment involves strengthening of these scapular stabilizers through formal physical therapy.16

**Shoulder Injury Prevention**

Shoulder injuries result from excessive play, inadequate warm-up, and poor conditioning. Intensity of practice and play should be gradually increased in conjunction with proper warm up, stretching, and strengthening. Any play or practice session should begin with several minutes of stretching. Warming up for at least 10 minutes prior to play or practice has been shown to decrease the rate of injuries.2 Golfers should also routinely exercise and strengthen the rotator cuff and scapular muscles.

**Elbow**

Traumatic injuries are often the result of striking an object other than the golf ball. Professionals and amateurs can sustain elbow injuries when hitting the ball out of long, thick grass called heavy rough. When the clubhead sweeps through heavy rough, the hosel (the junction of the shaft and clubhead) can become entangled in the long grass creating a large deceleration of the clubhead through impact resulting in high strain across the forearm flexors. Similar deceleration injuries occur with hitting the ball “fat” or striking a tree root or rock.

Overuse injuries can be a consequence of repetitively gripping the club too tightly, which is a common fault in amateur golfers. Gripping too tightly strains the forearm musculature sometimes leading to injury.17 Elbow injuries are quite common in amateur and female golfers.2,4 Two of the most common elbow problems in golfers are lateral and medial epicondylitis.

**Lateral Epicondylitis**

Lateral epicondylitis most commonly involves the lead arm.3,5,18 It is usually an overuse injury due to repetitive, vigorous contraction of the extensor carpi radialis brevis as with gripping the club too tightly.19,20 The lead elbow experiences high stresses across the extensors. The extensor muscles are very active at impact to help stabilize the left wrist. Hitting the ground firmly at impact places added stress across the extensors. Amateurs have been shown to experience lateral epicondylitis, or “tennis elbow,” five times more frequently than medial epicondylitis, or “golfer’s elbow.” Signs include tenderness to palpation over the ECRB origin and pain with resisted wrist extension. There is often pain associated with gripping objects tightly or shaking hands.

Non-operative treatment of tennis elbow typically involves a combination of modalities. The patient should limit their golfing and other aggravating activities acutely along with a short course of non-steroidal antiinflammatory drugs to help with the pain. After the acute pain improves, a course of rehabilitation can begin consisting of stretching, strengthening, and modalities. Steroid injections are also an option. One study showed that steroids can alleviate pain but otherwise provided no benefit.21 Wrist splints can also play a role in treatment. There was a recently published randomized, prospective study of forearm straps versus extension wrist splints for the treatment of lateral epicondylitis. Along with bracing, patients were allowed icing and home stretching exercises. Functional outcomes were no different, but wrist extension splints provided greater pain relief at 6 weeks.22

Surgery should be considered if 6 to 12 months of non-operative treatment fails. Either open or arthroscopic techniques can be used with a high rate of successful outcomes.23 Proponents of arthroscopic treatment cite the added benefits of treating associated intra-articular pathology (40% to 63%), such as synovitis or loose bodies, and earlier return-to-work (6 to 8 weeks earlier). Ultimately, the surgeon should utilize the technique with which he or she feels most comfortable. On pathology, the diseased tissue is typically found within the extensor carpi radialis brevis origin. It consists of disorganized collagen, immature fibroblasts, and vascular elements termed angiofibroblastic tendinosis.24

**Medial Epicondylitis**

Medial epicondylitis is the second most common source of elbow complaints in golfers. It typically involves the trailing arm in golfers.18 Medial elbow injuries result from sudden deceleration of the clubhead, while lateral elbow injuries are attributed more commonly to overuse.25 Therefore, most medial elbow injuries in the golfer are of a traumatic nature occurring at impact. However, the common amateur swing fault of “casting,” or extending the wrists at the initiation of the downswing, overloads the right forearm flexors and can be a contributing factor to medial epicondylitis.9,26 At ball impact, the flexor muscles have an activity burst to 90% capacity to stabilize the right wrist.27 Striking the ground at impact adds to the stress at the medial elbow.

Non-operative treatment of medial epicondylitis is similar to the treatment of lateral epicondylitis. It typically involves a combination of modalities: rest, non-steroidal anti-inflammatories, physical therapy, bracing, and corticosteroid injections.

Operative treatment may be considered after at least 6 months of unsuccessful non-operative management.28 Surgery consists of an open debridement of pathologic tissue from the common flexor origin, repair of the defect, and reattachment of the flexor origin. The location of the diseased tissue is less consistent with medial epicondylitis but often is found in the interval between flexor carpi radialis and pronator teres. Symptoms of ulnar nerve compression may be encountered in up to 24% of patients treated operatively for medial epicondylitis. Consideration should be given to ulnar nerve decompression and possible transposition in these cases.26
Elbow Injury Prevention
The incidence of elbow injuries increases with frequency of play between the ages of 35 and 55. Mistakes in the backswing can lead to compensatory motions on the downswing to bring the clubhead back on plane. Both laying the club off at the top of the backswing or too steep of a backswing require compensatory use of the hands and wrists to get the clubhead back on track for ball impact. These swing faults performed over a long period of time may lead to overuse injuries at the elbow. Extending the wrists at the initiation of downswing not only leads to unpredictable shots but also stresses the forearm flexors and extensors. Additionally, oversized grips may help to decrease the forces across the forearm flexors and extensors to decrease the incidence of medial and lateral epicondylitis.[18]

Wrist and Hand
The wrist is a very common site of golfing injuries.4,8 The wrist accounts for up to 20% of amateur golf injuries and 20% to 27% of injuries in professional golfers.2,4,7,8 In order to execute a proper swing, both wrists must move through an extensive range of motion.29 Most wrist injuries occur at impact from sudden deceleration and are traumatic in nature. Amateurs often sustain these injuries from hitting “fat” shots or striking the ground with the clubhead prior to making contact with the ball. Professionals tend to get these injuries from striking a tree root, rock, or hitting out of thick, heavy rough. Depending on the force transmission, an acute injury may occur or if done repeatedly a pattern of overuse injury may develop. Flexor carpi ulnaris tendonitis, extensor carpi ulnaris dislocation, and hook of the hamate fractures all occur through this mechanism.30,31

Tendonitis
Tendonitis of the hand and wrist tends to involve the lead hand in the golfer. It can be associated with excessive radial deviation of the left wrist, thumb extension at the top of the backswing, or sudden deceleration at impact. Alterations in grip position can also play a role in tendonitis development. The flexor carpi ulnaris, flexor carpi radialis, extensor pollicis longus, and extensor carpi ulnaris can each be involved. These conditions usually improve with rest, non-steroidal medications, bracing, and steroid injection.

Extensor Carpi Ulnaris Instability
Rupture of the extensor carpi ulnaris (ECU) tendon sheath or subluxation out of the distal ulnar groove can occur when a sudden flexion, ulnar deviation, and supination movement occurs through the wrist.32-36 This injury happens in golfers when striking the ground or another object, such as a tree root, at impact giving a sudden ulnar load to the left wrist. With subsequent supination or pronation, there can be a painful snapping or clicking over the dorsoulnar wrist at impact. The diagnosis is confirmed with palpation of the subluxating ECU tendon, although the diagnosis may be difficult to make if the patient is unable to voluntarily subluxe the ECU.[17,37 Initial treatment for acute ECU instability consists of rest and long arm casting for 4 weeks with the wrist in extension, radial deviation, and supination. This is followed by an additional 4 weeks of removable splint usage. After 2 months, the golfer is allowed to gradually return to golf. With symptomatic recurrent ECU instability, surgery is

Figure 1 A. A golf club that is too short will leave the end of the club lying against the hypothenar eminence. B. This puts the hook of the hamate at risk of fracture at impact.
indicated. Options for surgical treatment include direct repair of sheath tears and reconstruction of the ECU sheath.\textsuperscript{32,34,36-38} The repair is protected with casting and splinting for 2 to 3 months prior to a gradual return to play.

**Hook of the Hamate Fracture**

Hook of the hamate fractures tend to occur in the hand grasping the end of the club (the left hand for a right-handed golfer). With a forceful ground strike at impact, the butt end of the club can fracture the hook of the hamate. There will usually be tenderness to deep palpation in the palm over the hook of the hamate. Pain is reproducible with gripping a club and grasping objects. Standard radiographs may be insufficient for diagnosis. In cases of suspected hook of the hamate fractures, a CT scan helps make the correct diagnosis. Initial treatment typically involves immobilizing the injured wrist to allow the fracture to heal. If symptoms persist, such as persistent pain, ulnar neuropathy, or tendon irritation, excision of the hook of the hamate can be considered.

**Carpal Tunnel Syndrome**

One million adults are diagnosed with carpal tunnel syndrome each year in the USA and 200,000 carpal tunnel releases are performed annually.\textsuperscript{39,40} Although golf has not been recognized as a source of carpal tunnel syndrome, the repetitive motion of the wrists and hands can exacerbate carpal tunnel symptoms in golfers. There is no data in the literature on the incidence of carpal tunnel syndrome in the golfer population.

**Wrist and Hand Injury Prevention**

Proper swing mechanics will avoid excessive wrist motion. Hand and wrist injuries can be minimized by sweeping the golf ball off the grass instead of taking a large divot. Golf clubs should be checked for proper length. The butt of the club should extend about one inch beyond the base of the palm. A club that is too short will have the butt end lying against the hypothenar eminence leaving the hook of the hamate vulnerable to injury (Fig. 1). Golfers should use light grip pressure and avoid an overly strong grip position to protect against injury (Fig. 2).\textsuperscript{41}

**Conclusion**

Golf is generally considered a low-demand, non-impact sport. However, thousands of golfers are injured each year, with the majority of golf injuries related to overuse. A pre-season fitness program will help avoid injury. It should consist of strength and flexibility exercises for the wrists, forearms, and shoulders. Good conditioning will enable a golfer to better withstand the repetitive forces involved in the swing over an entire season. A short period of stretching should preclude a session of practice or play. Equipment changes, such as woods and irons with enlarged sweet spots and graphite shafts, help dampen vibrations and can reduce overuse injuries to the arm.

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**References**