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Original Article

# An Evidence-Based Approach to the Orthopedic Physical Exam – Part 2: The Upper Extremity

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## ABSTRACT

Upper extremity conditions are a common musculoskeletal complaint. Establishing an accurate diagnosis for upper extremity conditions is intended to guide clinical management and improve patient care. The purpose of this article is to provide an overview of the evidence-based orthopedic physical exams for many upper extremity conditions. We have attempted to emphasize orthopedic physical exams that have demonstrated the highest diagnostic utility, or to point out when no such test exists. We encourage clinicians to utilize an evidence-based approach to clinical care, which deliberately combines the clinician's expertise with the best available research evidence and the patient's preferences, in an attempt to provide optimal patient care.

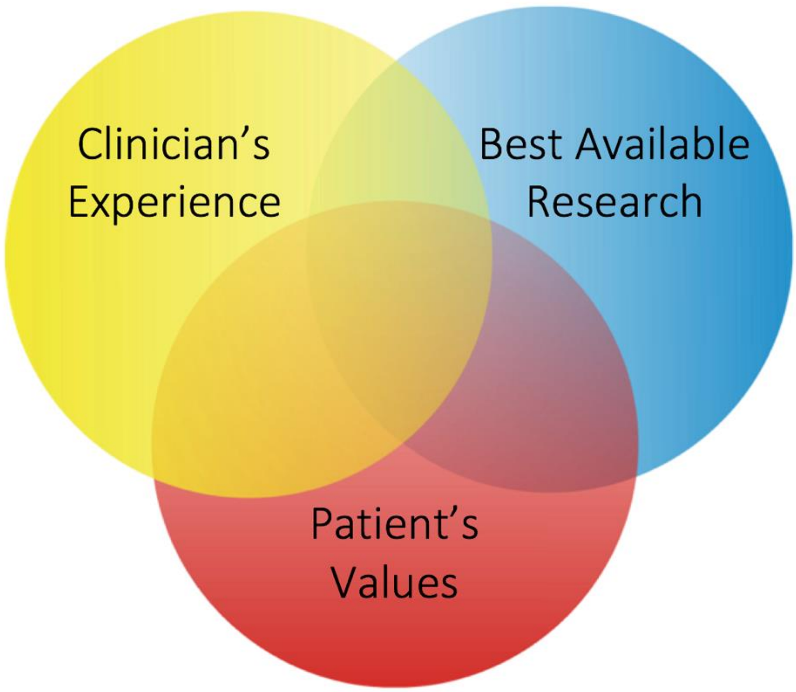
## KEY WORDS (MeSH terms)

Evidence Based Practice; Chiropractic; Differential Diagnosis; Injuries, Arm; Injuries, Shoulder; Injuries, Forearm; Injuries, Wrist

## Introduction

Diagnosing patients with orthopedic conditions is a complex process consisting of the patient interview and physical examination. A well-performed history serves to narrow the list of potential diagnoses, while the likelihood of various differential diagnosis is further refined during the physical examination (1,2). All of health care, including the chiropractic profession, is transitioning towards an evidence-informed approach to clinical care, known as evidence-based practice (3). This evidence-based approach to clinical care integrates three primary components, which are 1.) the best available research evidence, 2.) the practitioner's clinical expertise, and 3.) the individual patient's values and preferences (see Figure 1) (4). It is important to note that the relative proportion of each of these three components is rarely equal in the setting of real-world patient care. Therefore, far from being a "cookbook" approach to care, we view evidence-based practice as a dynamic approach to clinical decision-making where the emphasis of each of the three components varies among individual patients.

Figure 1 – Three Components of Evidence-Based Practice




Unfortunately, many orthopedic physical exam textbooks provide little guidance on the usefulness (utility) of the exams that they describe. Traditionally, these texts provide a detailed description of how to perform various orthopedic exams and which pathology the test purport to identify, while omitting information related to diagnostic utility (i.e. likelihood ratios, sensitivity, or specificity). The objective of this article is to provide clinicians with an overview of the diagnostic utility for many orthopedic physical exams used to evaluate for upper extremity conditions.

## Methods

This is a narrative review of the evidence-based orthopedic physical examinations used to evaluate many upper extremity conditions. Information used to write this article was collected from various sources, listed in Table 1. This article focuses on background information; therefore, authoritative textbooks on the topic of evidence-based orthopedic exams were emphasized, and the source articles informing these reference textbooks were obtained when additional information was needed. Source articles were assessed for quality using the QUADAS grading system. When multiple sources existed for a given test, information was used from the studies with the highest QUADAS scores, in lieu of lower-quality studies. We also utilized the iOS iPad application, known as CORE Orthopedics (Clinical ORthopedic Exam) by Clinically Relevant Technologies to assist in our review of the literature; this application links orthopedic exams with their source articles on PubMed.gov and provides a synopsis of the exam statistics.

Table 1 – Sources Used for this Narrative Review

| |
|---|
| Cook CE, Hegedus EJ. Orthopedic Physical Examination Tests: An Evidence-Based Approach, 2nd Ed. Indianapolis, IN. Pearson Education; 2013 |
| Cleland JA, Koppenhaver S. Netter's Orthopedic Clinical Examination: An Evidence-Based Approach, 2nd Ed. Philadelphia, PA. Saunders Elsevier; 2011 |
| Cook CE. Orthopedic Manual Therapy: An Evidence-Based Approach. 2nd Ed. Upper Saddle River, NJ. Pearson Education; 2012 |
| Clinically Relevant Technologies, CORE - Clinical ORthopedic Exam, iOS application, last updated on October 20, 2015 |
| Glynn PE, Weisbach PC. Clinical Prediction Rules: A Physical Therapy Reference Manual. India. Jones and Bartlett Publishers; 2011 |

## DISCUSSION

### Categories of Upper Extremity Disorders

The focus of this article is on evidence-based orthopedic exams for upper extremity conditions. The organization of this article begins by presenting material related to the proximal upper extremity, with the shoulder, and proceeds distally.

### Shoulder

Shoulder pain is a common condition that affects approximately 50% of the adult population (5). The shoulder is a complex joint that provides a diagnostic challenge to many clinicians. The shallow nature of the glenohumeral joint allows for a high degree of mobility, which comes at the cost of joint stability.

Shoulder dislocations or fractures frequently present with a sudden onset of pain following an acute injury and necessitate referral for radiological consultation. Shoulder dislocations and fractures are deemphasized in this article because these conditions are unlikely to present for initial evaluation to clinicians outside of the emergency department.

Obtaining a thorough history is important for narrowing down which structures may be involved with a patient's shoulder complaint and establishing a list of differential diagnoses. Table 2 contains characteristic patient presentations related to several shoulder conditions.

Table 2: Initial Shoulder Hypotheses Based Upon Patient Presentation

| History / Presentation | Initial Hypothesis |
|---|---|
| Obvious deformity at glenohumeral joint or acromioclavicular joint | Dislocation or Fracture |
| Age ≥ 60, pain or weakness with muscle loading, decreased shoulder ranges of motion, night pain | Rotator Cuff Tear |
| Shoulder instability, pain and apprehension with shoulder abduction and external rotation, possible clicking from shoulder joint | Instability / Labral Tear |
| Painful arc, anterolateral shoulder pain with overhead activities | Subacromial Impingement |
| Recent fall on shoulder with localized pain at acromioclavicular joint | Acromioclavicular Sprain |
| Shoulder stiffness, no pain, no trauma, slow onset after weeks of pain, reduced active/passive abduction or external rotation | Adhesive Capsulitis |

Adapted from Netter's Evidence-Based Orthopedic Exam, 2nd Ed. (6)

## Rotator Cuff Tears

A rotator cuff tear (RCT) can affect any of the four rotator cuff muscles. Our review of the literature revealed that most orthopedic exams related to RCTs focus on evaluating for supraspinatus and subscapularis tears. A test that shows utility for isolating both infraspinatus and teres minor tears is the external rotation lag sign (ERLS). ERLS for an infraspinatus tear has a sensitivity of 70% and a specificity of 100% (7). ERLS for a teres minor tear has both a sensitivity and specificity of 100% (7,8). Decreased rotator cuff muscle strength has been shown to be useful for identifying specific RCTs, whereas the location of pain has not been shown to have diagnostic utility. Patients are most likely to report pain in the lateral and anterior shoulder, regardless of the location of the tear (9). Table 3 and Table 4 provide a review of the test statistics related to diagnosing supraspinatus and subscapularis RCTs, respectively.

Table 3: Orthopedic Tests for Supraspinatus Tear

| Test | +LR | -LR |
|---|---|---|
| Rent Test (10) | 32 | 0.04 |

| | | |
|---|---|---|
| Lateral Jobe (11) | 7.36 | 0.10 |
| Empty Can/Supraspinatus Test* (9,12) | 6.67 | 0.44 |
| External Rotation Lag Sign (ERLS) (13) | 5.00 | 0.61 |
| Drop Arm Test (13) | 2.41 | 0.71 |

*When pain and weakness are considered positive for a full thickness tear
+LR = positive likelihood ratio; -LR = negative likelihood ratio; ERLS = External Rotation Lag Sign

Table 4: Orthopedic Tests for Subscapularis Tear

| Test | +LR | -LR |
|---|---|---|
| Belly Press Test (14) | 20.0 | 0.61 |
| Bear-Hug Test (14) | 7.23 | 0.44 |
| Internal Rotation Lag Sign (15) | 6.2 | 0.00 |
| Lift-Off Test* (15,16) | 44.5 | 0.11 |

*Small sample size additional studies required
+LR = positive likelihood ratio; -LR = negative likelihood ratio

## Glenohumeral Instability

Glenohumeral instability (GHI) exists when the humeral head will not remain centered in the glenoid fossa due to congenital joint abnormalities or laxity of the glenohumeral capsule. We would like to emphasize that clinicians should use caution when evaluating patients with possible GHI, since these tests may induce dislocation. Glenohumeral instability is most likely to occur in the anterior direction and is most likely to coincide with a labrum tear of the shoulder; therefore, patients with GHI should also be suspected of having labral tear. We have focused this review on the orthopedic tests involved with detecting anterior GHI, which are summarized in Table 5. It should be noted that most tests listed within this table are effective at ruling in GHI, due to the relatively high positive likelihood ratios (+LRs).

Table 5: Orthopedic Tests for Instability

| Test | +LR | -LR |
|---|---|---|
| Apprehension and Relocation (17) | 36.98 | 0.19 |
| Apprehension Test (17) | 18.0 | 0.29 |
| Modified Relocation Test (17) | 10.13 | 0.10 |
| Bony Apprehension Test (18,19) | 5.88 | 0.07 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio

Bony Apprehension Test included because of its merit in screening for instability due to Bankart or Hill-Sachs lesion (19).

## Glenoid Labrum Tear

A labral tear should be considered if a patient reports any of the following: their shoulder becomes “stuck” in a certain position, they experience sharp pain in specific positions, or shoulder movements reproduces a prominent clunk (5,20,21). Clinicians should be mindful that patient characteristics, such as advanced age and repetitive overhead work or sport activities, may be important factors for diagnosing labral tears (22).

It is important to note that a specific labral tear, the superior labral tear from anterior to posterior (SLAP lesion), is the type of labral tear that most orthopedic tests are designed to evaluate. Table 6 provides an overview of the orthopedic tests that have demonstrated the greatest diagnostic utility for evaluating patients with a suspected labral tear.

Table 6: Orthopedic Tests for Labral Tears

| Test | +LR | -LR |
|---|---|---|
| Jerk Test (18) (posteroinferior labral lesion) | 36.5 | 0.27 |
| Modified Dynamic Labral Shear Test (generic labral tear)* (23) | 31.57 | 0.29 |
| Biceps Load II (SLAP) (13,24) | 26.38 | 0.11 |
| MRI (13,24,25) | 5.25 | 0.63 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio

*Results are variable and further research is needed to establish test statistics related to this test (19,23)

## Subacromial Impingement

Subacromial impingement, also known as impingement syndrome or swimmer’s shoulder, develops following mechanical compression of the subacromial structures including; rotator cuff tendons and the subacromial bursa. This condition develops when the humerus undergoes excessive superior translation when abducting the arm, which results in decreased space between the humerus and the acromion process (5,19,23). Table 7 provides a review of the orthopedic tests that have been shown to have the greatest diagnostic utility when evaluating patients suspected of having subacromial impingement.

Table 7: Orthopedic Tests for Subacromial Impingement

| Test | +LR | -LR |
|---|---|---|

| | | |
|---|---|---|
| Internal Rotation Resisted Strength Test* (20,21) | 22 | 0.12 |
| Hawkins, Painful Arc, and Infraspinatus test (20) | 10.56 | 0.17 |
| 3 or more positive of: Hawkins, Neer, Painful Arc, Empty Can, External Rotation Weakness (26) | 2.92 | 0.34 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio
*Further studies are needed regarding Internal Rotation Resisted Strength Test as the one study conducted as the quality of the study is in question

Many of the previous shoulder conditions presented in this article (RCTs, labral tears, and instability) may alter the biomechanics of the shoulder joint complex, which predisposes patients to the development of subacromial impingement. For this reason, Cook notes that impingement tests are not strong diagnostic tools (22).

## Acromioclavicular Joint

Most acromioclavicular (AC) joint problems become evident during the patient history, observation, and palpation of the shoulder (5,6). Traumatic injuries involving a fall on top of the shoulder, which depresses the acromion, are the most likely cause of an AC joint injury (shoulder separation)(6). Table 8 contains a review of the best available orthopedic tests for screening patients suspected of having an AC joint injury.

Table 8: Orthopedic Tests for Acromioclavicular Joint Injury

| Test | +LR | -LR |
|---|---|---|
| Acromioclavicular (AC) Resisted Extension Test (27) | 4.80 | 0.32 |
| ≥ 2 of the following: Cross body Adduction, AC Resisted Extension, and Active Compression (27) | 7.36 | 0.21 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio
AC = acromioclavicular

## Adhesive Capsulitis

Patients with adhesive capsulitis (frozen shoulder) commonly present with gradually worsening shoulder pain in the absence of preceding trauma. They may also report poorly-demarcated shoulder pain, shoulder stiffness, or shoulder pain that is aggravated by movement and relieved by rest along with a marked reduction in active and passive abduction of the arm. Adhesive capsulitis is a disease of adulthood and is most likely to affect females over age 45 (6)(28). Patients with type II diabetes mellitus can be up to five times more likely to experience adhesive capsulitis than the general population (29).

Our review discovered only one orthopedic test that has demonstrated utility in confirming a diagnosis of adhesive capsulitis. This test is the Coracoid Pain Test, which yields a +LR of 8.73 and a -LR of 0.04. We would like to emphasize that the quality of this study was relatively low and clinicians are encouraged to combine the findings of this test with their own clinical experience.

### Additional Shoulder Conditions

Table 9 provides a brief overview of Shrug Sign and the Upper Cut Test, but we would like to emphasize that the relatively poor test statistics for these tests limits their diagnostic utility.

Table 9: Orthopedic Tests for Various Conditions

| Condition | Test | +LR | -LR |
|---|---|---|---|
| Osteoarthritis | Shrug Sign (30) | 2.21 | 0.16 |
| Biceps Tendinopathy | Upper Cut Test (16) | 3.38 | 0.34 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio

## Elbow & Forearm

Many orthopedic conditions of the elbow involve acute trauma or repetitive movements (5). A structured approach to evaluating elbow and forearm conditions begins by discerning whether the onset was gradual, related to repetitive use, or sudden, following a bony or ligamentous injury in the area of complaint. Determining the mechanism of injury and quality of the patient's pain is likely to assist in establishing a short list of differential diagnoses. Table 10 provides a summary of several initial diagnostic hypotheses, along with the associated patient history and clinical presentation, for many elbow and forearm conditions.

Unfortunately, there is a scarcity of well-designed studies evaluating the usefulness of orthopedic exams for elbow and forearm conditions. This review will emphasize the studies that have demonstrated the greatest utility, and will also highlight tests that lack validation.

Table 10: Initial Elbow & Forearm Hypotheses Based Upon Patient Presentation

| History / Presentation | Initial Hypothesis |
|---|---|
| Obvious deformity at the elbow joint and/or a history of acute trauma combined with bony prominence pain (5, 31) | Dislocation or Fracture |
| Valgus force trauma to the elbow(5) | Ulnar Collateral Ligament Injury (sprain or disruption) |
| Varus force trauma to the elbow (5) | Radial Collateral Ligament Injury |

| | |
|---|---|
| | (sprain or disruption) |
| A child has lateral elbow pain following sudden axial traction (5) | Nursemaid's Elbow |
| Lateral elbow pain upon gripping or extension of the wrist (32,33) | Lateral Epicondylitis |
| Medial elbow pain upon wrist flexion and/or pronation of the upper extremity (34) | Medial Epicondylitis |
| History of an elbow fracture or repetitive varus/valgus stress to the elbow, pain with minor movements and/or a sensation of looseness or instability (5) | Ligamentous Instability |
| Paresthesia along the ulnar nerve distribution of the forearm and hand, possibly following a history of repetitive throwing or repetitive occupational activities involving flexion & extension (35) | Cubital Tunnel Syndrome |
| Anterolateral forearm and hand pain that is worsened upon pronation and/or flexion of the elbow or wrist (36) | Pronator Teres Syndrome |
| Inflammation at the posterior elbow, possible history of acute or repetitive trauma to the olecranon process (37) | Olecranon Bursitis |

Adapted from Netter's Evidence-Based Orthopedic Exam, 2nd Ed.(6).

## Elbow Fractures

Patients who present with a history of acute elbow trauma should first be assessed for fracture or dislocation (31). Tests that are used to evaluate for a fracture involve performing active ranges of motion and a positive test result consists of an inability to fully perform the specified range. Table 11 demonstrates the test statistics associated with screening for elbow fractures.

Table 11: Orthopedic Tests for an Acute Elbow Fracture

| Test | Sensitivity | Specificity | +LR | -LR |
|---|---|---|---|---|
| Elbow Flexion Test (38) | 64% | 100% | As high as possible (∞) | 0.36 |
| Elbow Extension Test (38) | 100% | 100% | As high as possible (∞) | As low as possible (zero) |
| Elbow Pronation Test (38) | 34% | 100% | As high as possible (∞) | 0.66 |
| Elbow Supination Test (38) | 43% | 97% | 14.3 | 0.58 |

∞ = infinity; this results from an inability to calculate likelihood ratios when the sensitivity or specificity of a test is 100%; +LR = positive likelihood ratio; -LR = negative likelihood ratio

Our review of the literature failed to discover any orthopedic tests that have demonstrated utility for elbow dislocations. This apparent absence of research indicates that a clinician's most useful tool is a focus on the patient presentation and mechanism of injury. Traditionally, elbow dislocations occur following hyperextension injuries, and may cause frank deformity or a "generalized looseness" of the elbow(5). Elbow dislocations should be treated as medical emergencies due to the high risk for neurovascular or cartilaginous complications (39).

## Lateral Epicondylitis

Lateral epicondylitis (tennis elbow) is the most common form of epicondylitis and affects approximately 1 in 400 individuals (5,40,41). While this condition is reported to be evaluated with Cozen's Test, Resisted Tennis Elbow Test, and Maudsley's Test (22), we were unable to identify any studies that have evaluated the diagnostic utility of these tests (22, 40).

While there are no orthopedic tests that have been shown to assist in the diagnosis of lateral epicondylitis, there have been studies evaluating various manual therapies for the management of this condition; Table 12 provides a summary of these management studies.

Table 12: Review of Manual Therapies for the Management of Lateral Epicondylitis

| Study | Notable Findings |
|---|---|
| Clinical prediction rule for mobilization and exercise for lateral epicondylalgia(42) | This study found that patients with 2 or more predictor variables (below) had a +LR = 3.7 for a positive response to mobilization and exercise. Variables: age < 49, grip strength on affected side was >112 N (25 lbs., and the grip strength on the unaffected side was <336 N (76 lbs.) |
| Randomized controlled trial for manipulation and massage for lateral epicondylalgia(42,43) | Significant short-term improvements in pain and function were noted following Mill's manipulation and deep transverse friction massage (3x per week for 4 weeks). |
| Cervical spine manipulation for lateral epicondylalgia(42–44) | A single cervical spine manipulation was shown to immediately decrease pain (increased pressure pain threshold) and improved function (increased pain free grip) |
| Cervical spine manipulation for chronic lateral epicondylalgia(45) | Cervical manipulation was shown to improve function (increased pain-free grip strength) and decreased pain (increased pressure pain threshold) |

## Medial Epicondylitis

Medial epicondylitis (Golfer's elbow) is classically described as developing in the dominant arm of a golfer and represents about 20% of all cases of epicondylitis (46). This condition is reported to be evaluated via the Golfer's Elbow Test (46,47); however, we were unable to identify any studies that have evaluated the Golfer's Elbow Test for diagnostic utility.

## Elbow Instability

Injury to the collateral ligaments of the elbow is most likely to occur following repetitive trauma to the elbow in overarm-throwing sports, and up to half of all ligamentous injuries occur in children or adolescents (47,48,49).

### Ulnar Collateral Ligament Injury (Little League Elbow)

The ulnar collateral ligament is on the medial side of the elbow and provides valgus stability. This ligament may be injured by an acute valgus stress to the arm or repetitive trauma from throwing activities. While the Valgus Stress Test is commonly reported to evaluate the integrity of the ulnar collateral ligament, it has yet to be evaluated for utility. Fortunately, a newer test, known as the Moving Valgus Stress Test, has been shown to be useful for ruling out the presence of ulnar collateral ligament injury in the event of a negative test result (50). See Table 13 for the test statistics related to evaluating for elbow instability.

Table 13: Orthopedic Tests for Elbow Instability (ligamentous injury)

| Structure(s) Tested | Test | +LR | -LR |
|---|---|---|---|
| Ulnar Collateral Ligament | Moving Valgus Stress Test (50) | 4 | 0 |
| Ulnar Collateral Ligament | Valgus Stress Test | none established | none established |
| Radial Collateral Ligament | Varus Stress Test | none established | none established |
| Radial head position, relative to the annular ligament | None tests reported | none established | none established |

+LR = positive likelihood ratio; -LR = negative likelihood ratio

### Radial Collateral Ligament

The radial collateral ligament is a component of the lateral collateral ligament complex and protects the elbow against varus stress. Injury to this structure is commonly reported to follow acute varus stress to the arm and is relatively rare. The Varus Stress Test is commonly reported to evaluate the integrity of the radial collateral ligament, but just like the Valgus Stress Test, has yet to be evaluated for diagnostic utility.

### Nursemaid’s Elbow

Nursemaid’s elbow is an example of an orthopedic subluxation involving the malpositioning of the radial head relative to the ulna. Children (ages 2-4) are most likely to develop this condition following axial traction of the upper extremity (5). Diagnosis is typically made upon patient presentation and reduction is commonly achieved via passive elbow flexion and supination and/or pronation (5).

### Cubital Tunnel Syndrome (Ulnar Nerve Entrapment)

The most common site of ulnar nerve entrapment is the epicondylar (ulnar) groove along the medial elbow; this is the second most common site of upper extremity nerve entrapment, superseded only by carpal tunnel syndrome (51). Fortunately, orthopedic tests for this condition have been thoroughly studied and have yielded favorable results; please see Table 14 for a review of the cubital tunnel syndrome tests.

Table 14: Orthopedic Tests for Cubital Tunnel Syndrome

| Test | +LR | -LR |
|---|---|---|
| Elbow Flexion Test (52) | 75 | 0.25 |
| Pressure Provocation Test (52,53) | 45 | 0.11 |
| Tinel’s Test at the Elbow (52) | 35 | 0.31 |
| Elbow Scratch Collapse Test (54) | 69 | 0.31 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio

### Pronator Teres Syndrome

Pronator teres syndrome (median nerve pronator syndrome) is a form of median nerve entrapment in the forearm, where the median nerve is compressed between the two heads of the pronator teres muscle. This condition presents with sensory alterations, such as an “aching” pain in the anterior forearm, tenderness over the median nerve distribution, and numbness in the thumb and index finger (51, 52). Pronator teres syndrome is exacerbated via the following: deep palpation of the pronator teres muscle, resisted pronation combined with wrist flexion, and passive extension of the elbow and wrist (5,55). Unfortunately, these provocative maneuvers have yet to be evaluated and their utility is unknown.

### Olecranon Bursitis

Olecranon bursitis is an elbow condition where the subcutaneous olecranon bursa becomes inflamed following acute or repetitive trauma (5). Diagnosis of this condition appears to be based upon connecting the physical appearance of inflammation with a history of elbow trauma. We were unable to locate any orthopedic tests that purport to assist in the diagnosis of this condition.

## Wrist & Hand

As with any region of the body, an accurate diagnosis of wrist or hand conditions begins with a thorough history. The patient’s mechanism of injury and chief complaint are informative when establishing an initial diagnostic hypothesis and many wrist and hand conditions have well-established patient presentations (6). Table 15 provides a summary of several initial diagnostic hypotheses, along with the associated patient history and clinical presentation, for many wrist or hand conditions.

Table 15: Initial Wrist & Elbow Hypotheses Based Upon Patient Presentation

| History / Presentation | Initial Hypothesis |
|---|---|
| Acute trauma (fall on the outstretched hand) with visible deformity and wrist pain, worsened with supination or pronation | Fracture of the Distal Radius and/or Distal Ulna |
| History of acute trauma (fall on the outstretched hand) with wrist pain and/or anatomical snuffbox pain, worsened while loading the wrist or tightly grasping and object | Carpal Instability (carpal dissociation) or Carpal Fracture |
| Gradual onset of paresthesia in digits 1 - 3; may occur at night | Carpal Tunnel Syndrome |
| Arm and hand pain in digits 1 - 3, history of repetitive trauma | Pronator Teres Syndrome |
| Anterior proximal forearm pain combined with weakness in digits 1 - 3 (weak pinch grip) (5,56) | Anterior Interosseous Nerve Syndrome |
| Paresthesia of digits 4 - 5 | Ulnar Tunnel Syndrome |
| Dull/achy pain on lateral forearm | Radial Tunnel Syndrome |
| Pain near the radial styloid process that is exacerbated when gripping, possible history of repetitive activities involving a forceful grip | de Quervain’s Syndrome |
| Pain on the ulnar side of the wrist, worse with movement, possible history of acute wrist trauma | Triangular Fibrocartilage Complex (TFCC) Injury |
| Pain near the posterolateral wrist, possible history of repetitive wrist flexion or extension | Intersection Syndrome |
| Wrist pain that is still/achy, possibly history of repetitive trauma | Kienbock’s Disease |
| Generalized wrist and hand pain, worsened with movement, possible tenderness and/or swelling | Arthropathy (OA or RA) |

Adapted from Netter’s Evidence-Based Orthopedic Exam (6)
OA = osteoarthritis; RA = rheumatoid arthritis

## Fracture of the Wrist (and Distal Forearm)

When evaluating the hand and wrist it is important to begin by considering more serious pathologies, such as fracture, which necessitates immediate neurovascular and radiographic evaluation. Wrist fractures frequently develop following a direct blow or fall on an outstretched hand. Common fractures of the distal forearm and wrist involve the distal radius, distal ulna, and scaphoid. We were unable to identify any orthopedic tests to evaluate for fractures of the distal radius and ulna; therefore, clinicians are left to rely on the patient's history and their clinical judgement to determine whether radiographs are needed to confirm a fracture diagnosis.

Multiple orthopedic tests have been established to evaluate for a possible scaphoid fracture. Unfortunately, the theme that emerges from these studies is that these tests have little, if any, diagnostic utility. Please see Table 16 for a review the tests used to evaluate for scaphoid fractures.

Table 16: Tests Used to Evaluate for a Scaphoid Fracture

| Test | +LR | -LR |
|---|---|---|
| Scaphoid Compression Test (57) | 0.9 | 1.38 |
| Anatomical Snuffbox Tenderness (57,58) | 1.5 | 0.25 |
| Axial Loading of the Thumb (59) | 1.1 | 0.82 |
| Abduction AROM of the Thumb (59) | 1.45 | 0.55 |
| Ulnar Deviation AROM of the Wrist | none established | none established |
| Radial AROM of the Wrist (59) | 1.03 | 0.95 |
| Extension AROM of the Wrist (59) | 1.81 | 0.46 |
| Flexion AROM of the Wrist (59) | 1.43 | 0.57 |
| Power Grip of the Hand (59) | 0.83 | 1.67 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio; AROM = active range of motion

## Wrist Instability

Carpal instability involves any structural malalignment of the carpal bones. Carpal instability may also reflect a dynamic abnormality in the amount or quality of carpal bone movement, which may become evident when forces are applied to the wrist. While a complete review of the structure and function of the carpal ligaments is beyond the scope of this review, we have reported many useful or commonly-reported orthopedic tests related to carpal instability in Table 17.

Table 17: Tests Used to Evaluate for Instability of the Wrist

| Test | Structure being Evaluated | +LR | -LR |
|---|---|---|---|
| Watson Scaphoid Test (60) | Scaphoid Instability | 2.0 | 0.47 |

| | | | |
|---|---|---|---|
| Ballottement Test (Reagan Test) (60) | Lunotriquetral Ligament | 1.14 | 0.82 |
| Ulnomeniscotriquetral Dorsal Glide Test (60) | Triangular Fibrocartilage Complex (TFCC) | 1.8 | 0.5 |
| Supination Lift Test | Triangular Fibrocartilage Complex (TFCC) | yet to be established | |
| Press Test (axial loading of the wrist) (61) | General Carpal Instability | A 79% sensitivity when compared to MRI | |
| Grind Test | Trapeziometacarpal joint of the thumb | yet to be established | |

+LR = positive likelihood ratio; -LR = negative likelihood ratio

## Carpal Tunnel Syndrome

Carpal tunnel syndrome (CTS) is the most common form of median nerve entrapments and involves compression of this nerve within the carpal tunnel of the wrist (62). The primary feature of CTS is intermittent paresthesia of the median nerve distribution of the hand along digits 1 - 3, which may be exacerbated during specific activities (e.g., driving, typing). Other features reported to be associated with CTS involve weakness or clumsiness, reduced grip strength, pain in the median nerve distribution, nocturnal pain, atrophy of the thenar musculature, and relief when physically shaking the hands (5,6). Table 18 provides an overview of how useful many historical and neurological findings are for evaluating patients suspected of having CTS.

Table 18: Historical and Neurological Findings Associated with Carpal Tunnel Syndrome

| Test | +LR | -LR |
|---|---|---|
| Older than age 45-years (63) | 1.58 | 0.6 |
| Nocturnal pain (64) | 1.07 | 0.9 |
| Shaking hands improves symptoms (Flick Maneuver) (64,65) | 1.3 | 0.3 |
| Dropping objects (clumsiness) (63) | 1.7 | 0.47 |
| Thenar atrophy (66) | 1.6 | 0.9 |
| Abnormal vibratory sensation (median nerve distribution) (67) | 1.0 | 3.5 |
| Hypoesthesia (median nerve distribution) (68) | 3.4 | 0.6 |
| Semmes-Weinstein Monofilament Test (68,69) | 5.9 | 0.2 |
| Abnormal 2-Point Discrimination Test (64) | 1.6 | 0.9 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio

The orthopedic tests that have been reported assist in the diagnosis of CTS and have been extensively evaluated. Table 19 provides an overview of the tests that have been shown to have the greatest diagnostic utility. We have also included tests that are well known or commonly reported, but have little clinical value.

Table 19: Tests Used to Evaluate for Carpal Tunnel Syndrome

| Test | +LR | -LR |
|---|---|---|
| Phalen's Test (wrist flexion) (64) | 1.4 | 0.5 |
| Reverse Phalen's Test (wrist extension) (70,71) | 0.9 | 1.1 |
| Modified Phalen's Test (examiner overpressure) | none established | none established |
| Carpal Compression Test (70) | 10 | 0.2 |
| Wrist Flexion and Median Nerve Compression Test (72) | 17 | 0.1 |
| Therapeutic Ultrasound over the tunnel (exacerbates CTS) (54,73) | 14 | 0.11 |
| Scratch Collapse Test (54) | 64 | 0.32 |
| Tinel's Test at the Wrist (percussion) (65) | 1.4 | 0.7 |
| Gilliatt Pneumatic Tourniquet Test (71) | 1.2 | 0.9 |
| Upper Limb Tension Test A (63)<br>Upper Limb Tension Test B (63) | 0.86<br>0.91 | 1.9<br>1.2 |

+LR = positive likelihood ratio; -LR = negative likelihood ratio; CTS = carpal tunnel syndrome

More recently, a clinical prediction rule has been developed to help diagnose CTS and this study determined that a small set of variables were predictive for diagnosing CTS (see Table 20)(63). A patient who tests positive for 4 (out of 5) of these variables yields a +LR = 4.6 and a -LR = 0.28, while testing positive for all 5 variables yields a +LR = 18.3 and a -LR = 0.83.

Table 20: Five Variables used for the Carpal Tunnel Syndrome Clinical Prediction Rule

| Variables | |
|---|---|
| 1. | Older than age 45-years |
| 2. | Shaking hands relieves CTS symptoms (Flick Maneuver) |
| 3. | Wrist-Ratio Index >0.67[*] |
| 4. | Symptom Severity Scale score greater than 1.9[**] |

| | |
|---|---|
| 5. | Reduced sensation of digit 1 (median nerve field) |

CTS = carpal tunnel syndrome
* Wrist-Ratio Index is calculated by dividing the anterior-to-posterior wrist width by the medial-to-lateral wrist width (in centimeters), using a pair of sliding calipers to measure at the distal wrist crease (74,75)
** A higher Symptom Severity Scale score indicates worse CTS symptoms and is derived from an 11-item questionnaire (76)

It may be of interest to the readers of this article that manipulation has been studied as a management strategy for CTS (74). This study was a randomized controlled trial comparing non-surgical medical care and chiropractic care. In this study, medical care consisted of ibuprofen and nocturnal wrist splints, while chiropractic care consisted of soft tissue mobilization, upper extremity and spinal manipulation, ultrasound over the carpal tunnel, and nocturnal wrist splints. This study showed that both groups demonstrated significant reductions in pain and dysfunction along with improved nerve conduction and median nerve sensation. Importantly, this study demonstrates that chiropractic care can be as effective for managing CTS as non-surgical medical care.

### De Quervain’s Tenosynovitis

De Quervain’s tenosynovitis is an entrapment tendonitis involving the tendons of the abductor pollicis longus and extensor pollicis brevis. This condition produces lateral wrist and thumb pain that is exacerbated upon repetitive thumb movements (i.e. texting) or with resisted thumb extension (5, 77). The Finkelstein’s Test has long been associated with de Quervain’s tenosynovitis, but this test has minimal research supporting its use. We were only able to locate a single study that showed Finkelstein’s Test to have a +LR = 1.62 and a -LR = 0.38 (78). Therefore, a positive Finkelstein’s Test has little-to-no impact on ruling in de Quervain’s, while a negative Finkelstein’s Test may have some impact on ruling out the condition.

## Limitations

This report is a narrative review; therefore, the selection of relevant reference articles is subject to selection bias and the search results are less reproducible than in a systematic review of the literature. While we attempted to select reference materials with the highest methodological rigor, we did not formally grade all the articles used in this report.

## Conclusion

The purpose of this article is to provide clinicians with evidence-based information regarding orthopedic tests for upper extremity conditions. Unfortunately, relatively few of orthopedic tests reported to be useful for the upper extremity have demonstrated meaningful clinical utility. This is not to say that orthopedic tests without established validity are completely without value, but rather they should not be used in isolation. We encourage clinicians to emphasize orthopedic tests that have been shown to have the greatest utility in the interest of improving efficiency as well as diagnostic accuracy.

### List of Abbreviations

∞ = infinity

+LR = positive likelihood ratio

-LR = negative likelihood ratio

AROM = active range of motion

CTS = carpal tunnel syndrome

ERLS = external rotation lag sign

GHI = glenohumeral instability

OA = osteoarthritis

RCT = rotator cuff tear

ROM = range of motion

RA = rheumatoid arthritis

SJC = shoulder joint comple

**Competing Interests:** The authors declare that they have no competing interests related to this work.

### Author's Contributions

CBR conceived this project, contributed to the literature review, and participated in the drafting and revisions of this work. MA contributed to the literature review, drafting, and revisions of this work. Both CBR and MA met criteria to substantiate their authorship of this manuscript.

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Original Article

# Management of Iselin's disease in an 11-year-old female soccer player: A case report

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## Abstract

**Introduction:** This is a case study reporting injury to the lateral side of the right foot and treatment of an 11-year-old female soccer player.
**Case presentation:** She presented with a 2-week history of right lateral foot pain. The complaint was progressively worsening and effecting her athletic activities.
**Management and outcome:** She was seen twice a week for two weeks with treatments consisting of in office low wattage ultrasound after it was determined there was no fracture or ligament disruption. Athletic taping of the foot and arch was performed, and after two weeks soft arch supports were placed in her every day and sports shoes. The condition was substantially resolved within two months.
**Discussion:** Foot pain in running athletes is not uncommon. The concern was to differentiate this presentation from a stress fracture, Jones' fracture, apophysitis or joint sprain. It was determined this more than likely was Iselin's disease of the right fifth metatarsal head.
**Keywords:** Iselin's disease, lower extremity pain, repetitive stress injury foot, foot pain in young adults, orthotics

## Background

Iselin's disease is an uncommon condition that can be very confusing and difficult to distinguish from fracture, sprain or traction apophysitis. Iselin's is consistent with a traction apophysitis (1,2) Plain film imaging studies are helpful in ruling out fracture, disruption of the apophysis and/or other pathology. Young athletes are prone to foot injuries from running, jumping as well as sudden stops and starts. Improper footwear may contribute to global or localized foot pain as discernment of a proper fit may be difficult (3). The literature is scarce regarding Iselin's disease but it is felt by Barrett et al this may be due to the complex pathology of the proximal fifth metatarsal leading to the misdiagnosis of Iselin's disease. (4) The purpose of this paper is to make the clinician aware of the possibilities of foot pain over the 5$^{th}$ metatarsal to consider the pain being caused by Iselin's disease.

## Case Presentation

An 11-year-old female soccer player presented to a private chiropractic orthopedic office with a 2-week history of increasing insidious right lateral foot pain. These symptoms were provoked with running, jumping and sudden starting and stopping during the course of athletic activity. Her pain was more pronounced in the hours following the sporting activity. The patient was asked to rate her pain while walking, at rest or when running using a 0 to 10 scale. Her pain when walking was 2-4/10, it was 0-1/10 resting and running was 6-7/10. Her parents reported that her complaints were of mild pain initially but have been getting progressively worse. It seemed to be exacerbated with the introduction of basketball and her tight basketball shoes.
The patient has a history of successful treatment of Sever's disease in both heels and bilateral knee tendinopathy over the past 12-18 months. Sever's was concluded with examination and review of foot x-rays by a chiropractic radiologist. The tendinopathy was treated with ultrasound, Kinesio-tape and home care consisting of ice applications. She responded well to the treatment. She plays soccer both indoor and outdoor the year-round as well as basketball and participates in swimming and golf seasonally. Her parents report very little downtime from her sport.
Her examination revealed active and passive full bilateral ankle range of motion. Her dorsal pedis and posterior tibial pulses were firm and equal bilaterally. No swelling or discoloration was noted in her feet. Her skin was normal temperature to touch and good muscle tone was noted in the lower leg muscles. She had bilateral Morton's toes and a positive bilateral Helbing's sign. Bilateral pes planus and pronation was observed. Slight genu valgum was also observed. No gait abnormalities were present on observation. She had marked tenderness on palpation at the base of the right fifth metatarsal but not on the left. This included the proximal joint and into the upper one-third of the metatarsal. She had mild discomfort in the area of chief complaint when standing on her toes in this area. Manual compression of the forefoot was not significantly provocative.

Bilateral foot x-rays were ordered. The clinical findings met the standards of Ottawa rules for plain film radiographs of the knee, ankle and foot. This included pain at the base fifth metatarsal (5). The radiographs were unremarkable for fracture, dislocation or gross osseous pathology. Right compared to the left fifth metatarsal presented an identical appearance. (Figures 1 & 2)

Figure1. Oblique radiograph of the right foot


Figure 2. Lateral radiograph views of the left foot

## Management Outcome

Treatment included in office twice-weekly therapeutic ultrasound at 0.5 W underwater and pulsed at 50% for five minutes over the fifth metatarsal area, (6) passive mobilization to the forefoot was performed. Patient was instructed to ice of 2-4 times a day 3-weeks. Supportive athletic taping was applied to the arch for support. Stretching of the calf muscles was utilized daily at home and prior to the active sport participation. Basketball competition and practice was eliminated until the condition resolved. She continued with soccer 2-3 times a week with rest between practice and games. Soft arch supports from Spenco© were placed in both athletic shoes (7). She presented with lateral foot pain. Her father reported that within 2-months after the onset of pain and treatment there was no pain with her normal activities of daily living and only slight soreness reported with running, jumping and rollerblading. A follow-up three months later from the onset of pain to the office, she reported no complaints and no pain on evaluation. She was participating without any foot problems playing soccer. Her parents reported that they observed she was playing with no indication of foot pain or other adverse reactions to the sudden stopping, starting and kicking.

## Discussion

Injuries to young athletes are a significant concern to parents. The complications of such injuries may affect biomechanics of the joint but also a cascading effect of biomechanical joint problems above and below an injured area. The clinical features of Iselin's include focal pain over the proximal head of the 5$^{th}$ metatarsal. It may be a sudden onset or insidious. This case was a gradual onset from soccer and basketball. Improperly fitting shoes with sudden stops and starts contributed to this condition in the authors opinion. Treatment was successful in the office, but having parental understanding and cooperation is essential. They had the understanding that continuing to play both sports and the poor shoes contributed to the condition. New shoes were obtained during the period of treatment. It is important in the initial stages of injury that the clinician be as accurate as possible and staging initial and future treatment. Clinical experience, algorithms and guidelines may be helpful.
Foot pain in the young athlete is not uncommon. Iselin's disease was considered the most likely differential on this case due to the focal 5$^{th}$ metatarsal head pain. There are not many cases reported in the literature but it may be more common than reported as cases may be misdiagnosed. (4)

## Limitations

There is no certain manner to definitively confirm the diagnosis of Iselin's disease from that of a tendinopathy of the 5$^{th}$ metatarsal. Her condition could have been self-limiting. Due to the athletic nature of the of this female athlete and the pressure on her to participate, care and explanation was necessary for quick and favorable conclusion. The findings in this case will not necessarily apply to other young injured athletes.

## Conclusions

Arriving at a reasonable explanation to the parents and the need for care both office and home is essential for recovery. One may conclude it was or was not Iselin's disease. It was the authors opinion because of the focal pain, negative imaging study and no foot pain with motion, Iselin's was the most likely cause of this young athletes pain and limitations.

## Consent

Consent was provided by the patient's parents.


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## Competing interests

The author has no competing interest.


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Original Article

# Atypical Presentation of a Migraine in a Chiropractic Clinic: A Case Report

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## Abstract

**Introduction:** The purpose of this case report is to describe the management of a patient with an atypical migraine at an integrated veterans' hospital setting. Patients often utilize chiropractic for the treatment of headaches disorders. While headaches most commonly are benign, in some cases a headache may indicate a much more serious pathology.

**Clinical Features:** A 41-year-old male sought care for a severe episode of acute neck pain and neck stiffness, which was accompanied by abnormalities upon neurological examination. The patient exhibited nystagmus and complained of diplopia when cardinal planes of gaze were evaluated. The patient was unable to perform heel to shin, tandem gait, finger-nose, and finger-nose-finger tests. Initially, a vertebral artery dissection was suspected, based upon the patients age, and presentation. With concerns that this patient was suffering from a stroke, he was immediately transported to the emergency department (ED) on site where further examination was performed.

**Intervention and Outcome:** The arteries within the cervical spine and head were evaluated via vascular ultrasound and magnetic resonance angiography (MRA) to rule out cerebrovascular accident.

Advanced imaging determined that this patient was not experiencing a vertebral artery dissection or stroke, and the patient was diagnosed with an atypical migraine. The patient's migraine was treated in the ED with Dilaudid 1mg, Reglan IV and Compazine. He was discharged and directed to return to the chiropractic clinic the next morning. He returned to the chiropractic clinic the following morning, and he was treated utilizing diversified high-velocity, low-amplitude (HVLA) manipulation to the cervical spine. He reported relief following treatment.

## Conclusion

This case report demonstrates the need for thorough history and neurological exam when a patient presents with a migraine in the chiropractic office and serves as a reminder that life-threatening conditions should be ruled out before proceeding with chiropractic care.

## Background

Headaches are one of the most prevalent conditions afflicting humans. According to the World Health Organization, over a one year period 47% of the global population experiences a headache disorder. This condition can be incapacitating at times, accounting for 1.3% years lost due to disability among sufferers. [1] Among the many conditions treated by chiropractic, headaches are one of the most common reasons for visits to chiropractors. Research and anecdotal evidence supports the use of chiropractic in treating headache. [2] Since many patients seek chiropractic are for headache management, it is important for doctors of chiropractic to exhibit diligence and competency when examining and diagnosing this condition. [3]
Headaches can be the primary diagnosis, but often times they are a symptom secondary to an underlying condition. [4] The most ubiquitous primary headaches include migraine, which may be accompanied by an aura, tension-type, and cluster. [5] Secondary causes of headache are numerous and include a variety of metabolic, neoplastic, endocrine, ischemic, psychiatric, inflammatory, and traumatic conditions. [6] Headaches are multifactorial in their presentation and etiology, and a thorough examination should be performed to evaluate causative factors.
In recent years, attention has been placed on the possible association of headache-like symptoms with vertebral artery dissection (VAD). [7] VAD involves a tear in the wall of a cervicocerebral artery, which permits blood to penetrate into the wall of the affected artery, separating the layers of the arterial wall, which may cause vascular stenosis or dilatation. [8] Stroke is a sequelae of VAD, because the dissected artery causes cerebral ischemia and subsequent infarction. [9]
Patients with VAD typically present with severe unilateral head and neck pain that is reportedly unlike anything previous episodes of head or neck pain. Other symptoms associated with VAD include dizziness, vertigo, double vision, and dysarthria. [8] The initial presentation of a patient with a VAD commonly involves headache; therefore, many patients experiencing the initial stages of VAD are thought seek chiropractic care for the management of this head or neck pain.
While the overall incidence of VAD is low, approximately 1-1.5 per 100,000 adults [8], it is still important for physicians to be cognizant of the clinical features of this condition. It is common for VADs to be misdiagnosed, as the clinical presentation overlaps with other more prevalent and less life threatening conditions. [10] Migraines represent one condition whose clinical features mimic that of VAD. [11]

There are currently 324.1 million people who suffer with the disorder globally. [1] For most health professionals, the clinical presentation of migraine is simple to recognize. Patients typically describe the headache as unilateral head pain that is “pulsating” or “pounding” in nature. [12] Additionally, the migraine may or may not be preceded by an aura lasting 30 minutes to one hour. [13] During the attack, the patient may have sensitivity to light or sound, and nausea and vomiting have also been reported. [13] These represent classic signs and symptoms of a migrainous attack, but sufferers may have an atypical presentation, which complicates the diagnosis. Atypical migraines are complicated clinically, because patients may exhibit abnormal findings upon neurological examination. Exam findings such as vertigo, memory loss, dysphasia, hemiplegia, visual disturbances, and ataxia may prompt the physician to consider a more ominous condition like a stroke. [10] Migraines are generally a benign condition, but when presenting with a more complex symptomatology can easily cloud a physician’s differential diagnosis.

Conditions that resemble stroke are appropriately called stroke mimics. “Stroke mimic is a term for a nonvascular disease process that produces a stroke-like clinical picture. The presentation resembles or may even be indistinguishable from a stroke syndrome.” [14] The rate of misdiagnosis due to stroke mimics varies depending on the source, accounting for anywhere between 1.3%-30%. [15, 16] In other words, one in five people are diagnosed incorrectly as having stroke regardless of gender, age, and risk factors for the condition. [15] According to one study by Amort et al, the most common stroke mimics are migraines (23.6%) and epileptic seizures (43.7%). [10]

The history and neurological examination are critical tools for the identification and treatment of patients with suspected cerebrovascular disease. The likelihood of stroke increased with the following acute neurological deficits: facial droop, arm drift, or a speech disturbance or more commonly know as FAST. [18] FAST is an incredibly a useful tool in screening a patient for stroke. It is a pneumonic that stands for Face Arm Speech Test. Utilization of this technique has a positive predictive value of 64-77%. [18] Absence of all three factors in the test decreases the odds dramatically. [17]

Reliability for stroke diagnosis is lowest for historical items and subjective findings, but increases with objective findings and experience and confidence of the examining practitioner. [17] Despite the increased odds of stroke in patients who satisfy FAST requirements, appropriate neuroimaging and other tests are still required to exclude other potentially treatable etiologies and to better define the stroke subtype. [19]

In the chiropractic office, a thorough history and neurological exam are paramount when a patient presents with a headache. While the headache may be unlike others they have had in the past, in some cases the dissection-related headache may resemble their usual migraine attack. [9]

## Case Presentation

Patient is a 41-year-old Caucasian male who was previously seen in the chiropractic clinic at a Veterans Medical Center for low back and neck pain. He was last seen 2 months prior to this visit for neck pain. He received HVLA manipulation. On a follow-up visit, he presented with a complaint of severe right-sided neck pain and headache, which began three days prior to seeking care. The pain radiated from the right suboccipital region to the right side of his head. He also related blurred and double vision which began on the morning of his office visit. He reported his vision problems to be similar to “looking through Saran wrap.“ He denied any recent history of trauma and rated his pain as a 10 on an 11-point numeric pain rating scale (NRS). The patient’s history was significant for vein varicosity in his legs. He is on Coumadin for a history of deep vein thrombosis.

Physical exam findings included a blood pressure of 129/78 and moderate-to-severe pain upon palpation of his cervical spine and suboccipital muscles. Moderate spasm was noted in the bilateral cervical paraspinal musculature. The patient exhibited nystagmus and complained of diplopia when cardinal planes of gaze were evaluated. The patient was unable to perform heel to shin, tandem gait, finger-nose, and finger-nose-finger tests.
Due to the patient’s age, history of vein issues, and abnormal neurological exam findings the chiropractor determined that a vertebral artery dissection was among the list of likely differential diagnosis. No manipulation was performed. The patient was immediately transported by wheelchair to the emergency department.

Further examination in the emergency department revealed that the pupils were 4mm bilaterally and reactive. The patient complained of worsening headache and he developed dizziness with extraocular movements and light. No nystagmus was found. No bruits were noted. No abnormality was detected on examination of the respiratory and cardiac systems. The patient’s abdomen was unremarkable. No edema was present in the extremities. The cranial nerves were intact. The patient exhibited slow movements with mild dysmetria on the right, slow movements bilaterally with several cerebellar function tests (finger to nose, diadochokinesia, and heel to shin). Muscle strength was 4/5 proximally on the left lower extremity and 5/5 on the right lower extremity and the left distal lower extremity. Bilateral upper extremity strength was rated at 5/5. A magnetic resonance angiography (MRA) was ordered. Ultrasound of the carotid/vertebral system and also MRA head/carotids were performed to rule out cerebrovascular accident. The MRA of head and neck was normal. Carotid Doppler ultrasound was normal and no structure damage was detected.

The patient was diagnosed with a migraine headache and was given Dilaudid 1mg , reglan IV and compazine. The patient was allergic to toradol and morphine. The patient was instructed to return for further evaluation at the chiropractic clinic the following morning.
The next morning the patient related that his headache was better after medications the emergency department provided. However, the headache was "still bad." At the follow-up appointment, he rated his pain as a 7 on the NRS. His blood pressure was measured at 125/80. Severe pain on palpation was noted in the cervical spine and suboccipital area, with moderate pain on palpation in the lumbar paraspinal musculature. Moderate to severe muscle spasms were observed in the bilateral cervical paraspinal musculature.

Intersegmental motion was evaluated utilizing motion palpation and joint hypomobilty was noted in the left sacroiliac joint, the 10$^{th}$ thoracic vertebral motion unit as well as the 2$^{nd}$ and 5$^{th}$ cervical vertebral motion units. The patient's joint dysfunction was treated utilizing diversified HVLA manipulation and he reported improvement in his headache pain immediately following treatment.

## Conclusions

In this specific case, the patient was not having a VAD, but instead was having an atypical presentation of a common condition: migraine. The characteristics of pain associated with VAD are unspecific and can sometimes overlap and resemble a migraine. [9] The severity of consequences associated with VAD may be life-threatening, which emphasizes the importance of examination of patients with neurological signs and symptoms regardless of the final diagnosis. Whether the patient is truly experiencing a stroke, or the more common stroke mimic the two most important diagnostic determinants are the history and the neurological exam. [17] These factors direct the need for advanced imaging, which provides the final diagnosis.

While it is true that common conditions occur commonly and rare conditions occur rarely, the severity of an atypical condition makes it necessary to rule out. This case report represents an exercise in clinical decision-making for patients with complex presentations in the chiropractic office.

## Consent

Written consent for this publication was obtained from the patient.

## Competing Interests

The authors declare that they have no competing interests.

## Acknowledgements

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Editorial Review

# The sensitivity and specificity of clinical measures of sport concussion:three tests are better than one

Jacob E Resch, Cathleen N Brown, Julianne Schmidt, Stephen N Macciocchi, Damond Blueitt, C Munro Cullum, Michael S Ferrara

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## Authors Abstract

**Context**: A battery of clinical measures of neurocognition, balance and symptoms has been recommended for the management of sport concussion (SC) but is based on variable evidence.

**Objective**: To examine the sensitivity and specificity of a battery of tests to assess SC in college athletes.

**Design**: Cross-sectional.

**Setting**: Research laboratory

**Patients or other participants**: Division 1 athletes diagnosed with a SC (n=40) who were 20.2±1.60 years of age and 180.5±11.12 cm tall and healthy athletes (n=40) who were 19.0±0.93 years of age and 179.1 ±11.39 cm tall were enrolled.

**Intervention(s):** Participants were administered Immediate Postconcussion Assessment and Cognitive Test (ImPACT), the Sensory Organization Test (SOT) and the Revised Head Injury Scale (HIS-r) prior to and up to 24 h following injury between the 2004 and 2014 sport seasons. Sensitivity and specificity were calculated using predictive discriminant analyses (PDA) and clinical interpretation guidelines.

**Main outcome measures**: Outcome measures included baseline and post injury ImPACT, SOT and HIS-r composite scores.

**Results**: Using PDA, each clinical measure's sensitivity ranged from 55.0% to 77.5% and specificity ranged from 52.5% to 100%. The test battery possessed a sensitivity and specificity of 80.0% and 100%, respectively. Using clinical interpretation guidelines, sensitivity ranged from 55% to 97.5% individually, and 100% when combined.

**Conclusions**: Our results support a multidimensional approach to assess SC in college athletes, which correctly identified 80–100% of concussed participants as injured. When each test was evaluated separately, up to 47.5% of our sample was misclassified.Caution is warranted when using singular measures to manage SC.

**Clinical Relevance:** Sports concussions are difficult to correctly identify. This study notes that single SC tests have lower acceptable reliability. If however, the three current tests in use are combined, the specificity and sensitivity reach close to 100%.

### JACO Editorial Summary:

1. The article was written by the Exercise and Sport Injury Laboratory Department of Kinesiology at The University of Virginia, Charlottesville, VA and St. Mary's Athletic Training Research Laboratory, Department of Kinesiology, University of Georgia, Athens, Georgia, USA
2. The purpose of the study was to investigate the sensitivity and specificity of current testing protocols for sports concussion diagnosis.
3. The investigative researchers provided a cross-sectional study involving 40 athletes with a diagnosis of sports concussion and compared these individuals to 40 matched controls using three studies; Immediate Postconcussion Assessment and Cognitive Test (ImPACT), the Sensory Organization Test (SOT) and the Revised Head Injury Scale (HIS-r). This was performed prior to and up to 24 h following injury between the 2004 and 2014 sport seasons.
4. The researchers noted the need for accuracy in sport concussion diagnosis and the reduced sensitivity utilizing only one of these tests. They then discussed how the use of all three tests would increase the sensitivity and specificity for on field diagnosis.
5. These investigators also noted previous studies and how their current conclusions differ from the previous studies. Previous studies had in some circumstances not enjoined their participants in diagnostic questioning or testing for up to 5 days. This time delay would diminish symptoms necessary for diagnosis and skew the results.
6. They also note that these athletes included in this study have already agreed with the concussion diagnosis. Many athletes prior to diagnosis might report diminished

symptoms upon questioning due to a fear of being withdrawn from competition. There is a "stay in the game" mentality that can reduce the accuracy of diagnosis.

## Summary

This study is relevant to the controversial subject of sports concussion syndrome. These concussions can possibly lead to CTE (chronic traumatic encephalopathy) now associated with sports that involve significant impact. Certainly, second impact syndrome can be lethal so diagnosis is so important. The question of testing and test relevance is important as either a missed on-field concussion or falsely diagnosed concussion that takes a player out of action are both failures of treatment.

These authors compared three currently used tests to determine sensitivity and specificity for the Immediate Postconcussion Assessment and Cognitive Test (ImPACT), the Sensory Organization Test (SOT) and the Revised Head Injury Scale (HIS-r). Their conclusions note the need for all three tests to be utilized to deliver the highest sensitivity and specificity.

The question for any chiropractic sports team physician is if there is the time necessary to deliver all three tests and is there a previous baseline test available necessary for the ImPACT conclusions? These tests take 60 minutes so an athlete would effectively be out of the game for this period of time, even if they did not have a concussion.

This study behooves the chiropractic sports team physician to be knowledgeable about these examinations, be prepared to administer the tests and be capable of protecting an athlete by removing them from competition until concussion resolution.

All in all, a good paper and helpful for the chiropractic sports team physician.

Editorial Review

# Return to Play after Cervical Spine Injuries: A consensus of Opinion

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## Author's Abstract:

**Study Design:** Survey.

**Objective**: Sports-related spinal cord injury (SCI) represents a growing proportion of total SCI's but lacks evidence or guidelines to guide clinical decision-making on return to play (RTP). Our objective is to offer the treating physician a consensus analysis of expert opinion regarding RTP that can be incorporated with the unique factors of a case for clinical decision-making.

**Methods**: Ten common clinical scenarios involving neurapraxia and stenosis, atlantoaxial injury, subaxial injury, and general cervical spine injury were presented to 25 spine surgeons from level 1 trauma centers for whom spine trauma is a significant component of their practice. We evaluated responses to questions about patient RTP, level of contact, imaging required for clinical decision, and the time to return for each scenario. The chi-square test was used for statistical analysis, with $p < 0.05$ considered significant.

**Results:** Evaluation of the surgeons' responses to these cases showed significant consensus regarding return to high-contact sports in cases of cervical cord neuropraxia without symptoms of stenosis, surgically repaired herniated disks, and nonoperatively healed C1 ring or C2 hangman's fractures. Greater visibility was found in recommendations for patients showing persistent clinical symptomatology.

**Conclusion:** This survey suggests a consensus among surgeons for allowing patients with relatively normal imaging and resolution of symptoms to return to high-contact activities;; however, patients with cervical stenosis or clinical symptoms continue to be a challenge for management. This survey may serve as a basis for future clinical trials and consensus guidelines.

## JACO Editorial Summary:

1. This is an original, well written and researched article published April, 2016 in Global Spine Injury.
2. Sports related spinal cord injury (SCI) lacks empirical data regarding decision making on return to play (RTP). This article presents an expert opinion consensus on RTP for treating physicians.
3. Return to sport (RTP) has no universally accepted guideline. There is not any currently accepted criteria, decisions are mainly subjective and poorly validated.
4. Consensus opinion regarding RTP ma provide better evidence than individual case reports or small case series regarding opinions about returning to sport activity.
5. Twenty-five spine surgeons in the Spine Trauma Study Group (STSG) who considered spine trauma to be a significant component of their practice, all from separate level 1 spine trauma centers were surveyed.
6. Parameters included: Level of contact, sport, cervical neurapraxia and stenosis. Atlantoaxial cervical injury with or without fusion, subaxial cervical injury with or without fusion.
7. Scenario 'keywords' included: Spine, trauma, spinal cord injury, imaging, canal dimensions, congenital stenosis and cord signal changes. Sudden onset paresthesia resolving with on-field evaluation, resolving within a few hours. Fracture with operative and non-operative treatment.
8. Full clinical recovery was defined as minimal to no neck pain, return of full or near full range of motion, and return of normal motor and sensory function.
9. There were no differences between orthopedic and neurosurgeons, so data was analyzed as one group, which is consistent with previous finding from this group of fellowship trained spine surgeons regarding evaluation of cervical dislocation injuries.
10. The case scenarios set forth do not cover the entire gamut of potential cervical injuries but they were thought to include a broad representation of the common injury patterns may be made. Although the study will not completely answer the questions about RTP, it establishes a reasonable consensus of expert surgical opinion with substantial expertise to guide the treating physician involved in similar case scenarios.

## Summary

Recently, chiropractic has played a more significant role in athletic evaluation and treatment of injury during sport. Often, chiropractic physicians are actively involved in a multi-disciplinary approach to athletic care. Today, youth and young adults involved in contact sport has grown linearly with the increased population in the United States. When evaluation and treatment is rendered in-office, determining return to play (RTP) may have been difficult due to lack of literature and studies. Without evidence, expert guidance is often relied on for navigating such difficult decisions. This article provides clinical decision guidelines using a consensus developed by surgeons in the Spine Trauma Study Group. Chiropractors engaged in athletic injury, particularly contact resulting in cervical spine injury, may find this article helpful in developing protocol for return to play (RTP).

# MRI Evidence of Neuropathic Changes in Former College Football Players

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## Author's Abstract:

**Objective:** To examine effects of participating in collegiate football on neural health several years after retirement. We hypothesized that relative cortical thinning and loss of white matter integrity would be observed in former players.

**Design:** Former NCAA Division I football players were compared with demographically similar track-and-field athletes with regard to cortical thickness and white matter integrity.

**Setting:** Participants participated in MRI scans at the Center for Imaging Research at the University of Cincinnati.

**Participants:** Eleven former football players and 10 demographically similar track-and-field athletes.

**Main Outcome Measures:** Normalized cortical thickness was compared between groups using 2-tailed Student t test. As a secondary analysis, Spearman correlation coefficient was calculated between cortical thickness and number of concussions. Fractional anisotropy for regions-of-interest placed in frontal white matter tracts and internal capsule were compared between groups using 2-tailed Student t test.

**Results:** Football players showed significantly lower cortical thickness within portions of both the frontal and temporal cortex. Affected frontal regions included left frontal pole and right superior frontal gyrus. Affected temporal regions included portions of the superior temporal gyrus, left inferior temporal gyrus, and right middle and superior temporal gyri. Cortical

thickness inversely correlated with number of reported concussions over most of these regions. In addition, fractional anisotropy was lower in the right internal capsule of former football players, relative to controls.

**Conclusions:** These findings suggest that at least some consequences of high-level collegiate football play persist even after the cessation of regular head blows. Longer-term studies are warranted to examine potential cognitive and functional implications of sustained cortical atrophy.

### JACO Editorial Summary:

1. This authors are from the University of Cincinnati, Ohio. The lead author is in the department of psychiatry, and the others have varying appointments in varying other departments.
2. The main purpose of this study was to see the effect of collegiate level football playing on structural changes in the brain – namely the thickness of the cortex and the integrity of white matter, using MRI.
3. Chronic traumatic enchphalopathy (CTE) is a progressive neurodegenerative condition due to blunt head trauma with acceleration-deceleration forces, commonly seen in football. CTE correlates with premorbid, degenerative neurological and behavioral findings.
4. There is hypothesized correlation between concussions and cognitive outcome which has spurred the motivation on preventing concussion and delaying return-to-play – however, several studies indicate possible neuropathic effects are not directly related to concussions, suggesting that repeated subconcussive impacts may have an effect, and there are some studies that suggest these neuropathic effects persist even after rest when cognitive performance deficits typically resolve. These neuropathic effects may in some individuals progress to CTE.
5. 11 former Division I football players and 10 demographically similar current and former track-and-field athletes participated in this study.
6. This study found persistent cortical thinning in former Division 1 football players several years after the end of their playing career, compared with demographically similar track-and-field athletes, who did not have blunt head trauma or reported history of concussion.
7. Cortical thinning was found in the prefrontal and temporal brain regions involved in sustained attention, memory, and executive abilities – these are cognitive domains essential to long-term professional and social function.
8. Some white matter pathology is suggested in the right internal capsule, which may be an early marker for neurocognitive change, and may be related to deficits in core cognitive domains including attention and affective regulation.

### Summary

There are several limitations to this study, but there is strong suggestion that even with several years of rest and resolution of neurocognitive deficits, there are persistent cortical and white matter changes seen in former Division I collegiate level football players. These persistent changes may present a risk to developing CTE later in life.

Editorial Review

# Role of magnetic resonance imaging in acute spinal trauma: a pictorial review

Yogesh Kumar and Dalchi Hayashi
JACO Editorial Reviewer: Deanna O'Dwyer, DC

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Generally speaking, computerized tomography (CT) is the standard of care for the emergency room trauma setting, mainly due to its' accessibility and relatively lower cost. However, the role of magnetic resonance imaging (MRI) is becoming more sophisticated and available. Compared to CT, MRI has more clear visualization of both ligaments as well as soft tissue. This is demonstrated most markedly by the visualization of the 5 cervical ligaments and their relative anatomical position. This paper speaks to cervical spine imaging and trauma.

Typically, the indications for an MRI would be:
1) Suggested ligamentous injury via radiograph or CT finding.
2) Visualize epidural hematoma or disc herniation prior to closed reduction of facet dislocation (cervical).

- Identify cause of neurologic impairment.
- Evaluate ligamentous or boney injury in "negative radiograph" patients.
- Evaluate the ligamentous and boney stability of a cervical spine trauma.
- Diagnose and predict prognosis of hemorrhagic vs. non-hemorrhagic spinal cord injury.

There are various types of MRI which have different functionality.

- T1weighted (T1W) visualizes fracture and normal v. abnormal anatomy
- T2 weighted (T2W) visualizes some fat suppression and cord edema.
- T2 gradient recall echo sequence (GRE) visualizes cord hemorrhage
- Sagittal short tau inversion recovery (STIR) visualizes soft tissue and ligamentous damage, as well as, more uniform fat suppression than T2W.

Unfortunately, as good as MRI is, it is most diagnostic within 72 hours of ligamentous damage.

The spine consists of 5 ligaments which help to both increase stability and prevent excess movement. The anterior longitudinal ligament (ALL), posterior longitudinal ligament (PLL), ligamentum flavum, interspinous ligament, supraspinous ligament.
The cervico-occipital joint consists of extra stabilizing ligaments which differ from the rest of the spine. The only of these ligaments which can be visualized on MRI are the tectorial membrane and the transverse ligament. The alar ligament is not well visualized due to lack of contrast.

Many anatomists subscribe to the "Denis classification". This divides the spinal column into a posterior, middle and anterior column. The posterior column is composed of all structures posterior ro the PLL. The middle column includes the posterior 1/3 of both the vertebral body and intervertebral disc and the PLL. The anterior column consists of the ALL, the anterior 2/3 of both the disc and the vertebral body.

Spinal stability is a result of whether the trauma results in more than 1 column being affected. Normally, on MRI undamaged ligaments will demonstrate low signal intensity with some high signal intensity due to normal fat visualization. Partial ligamentous tears will show high signal intensity. Complete tears will also demonstrate high signal intensity on STIR examination due to the edema and hemorrhage.

The mechanism of injury will determine the most likely structural injury (eg: hyperextension injury generally result in anterior or posterior column damage). Visualized as a hypointense line anterior to the vertebral body the ALL is the main stabilizing ligament of the anterior column. Injury results in focal disruption of the hypointense signal in all sequences. Similar results occur in injury to the PLL and the posterior column. The ligamentum flavum (recall it attaches the lamina) will demonstrate most appropriately in the sagittal STIR series. LF injuries are usually associated with posterior column fracture with focal disruption. Capsular inuries are demonstrated by widening of the facet joints.

Another scoring classification, devised by the Spine Trauma Study Group is based on 3 injury traits: injury morphology demonstrated on plain film, posterior ligament complex integrity and neurologic status. This is called the "Thoracolumbar Injury Classification and Severity Score (TLICS). This newer type of classification helps to triage patients into surgery vs. non-surgery treatment groups.

MRI is a better study of choice for disc herniations, extramedullary hemorrhage and fluid collections. MRI vs CT reveals better soft tissue resolution and hematoma visualization.

Blunt force and penetrating trauma to the neck generally involves the vertebral arteries more commonly than the carotid arteries. Less significant traumas could potentially lead to cerebral/cerebellar infarctions. Vascular injury is usually visualized as irregularity or loss of flow in T2W. If there is a question of injury to vascularity, a CT angiography could be employed.

Spinal cord injuries are classified according to the American Spinal Injury Association (ASIA) uses a A-C grading. A=Complete loss of motor and function in the sacral segments. B=Incomplete loss of sensory but not motor function below the level of the lesion to the sacral levels. C= Incomplete Motor function preserved below the level of the lesion with muscle preservation of <3/5. D=motor function preserved belothe level of the lesion with muscle intact at >/= 3/5. E=normal. In spinal cord injury axial and sagittal T1 and T2W GRE images are most diagnostic with hyperintense T2 abnormality resultant of cord edema.

Other osseous or soft tissue injury can be well visualized with MRI vs. CT. CT is hard to image when whereas MRI reveals areas of hyperintense signal demonstrating edema or hemorrhage. If the injures involve the ligaments, there is thickening of the ligament visualized on MRI.

Chronic fracture vs. acute fracture can be enhanced with MRI enhancement of the marrow. Generally, acute fracture will demonstrate more water content than a chronic fracture. Marrow edema is visualized as low intensity on T1W and high intensity on T2W and STIR images. Chronic fractures demonstrate fatty marrow high signal intensity on T1W and T2W without edema.

Osteoporotic fracture usually causes a horizontal band of abnormal signal intensity with a separation of normal fatty marrow. Metastatic fracture involves the entire vertebral body with abnormal marrow edema.

The drawback of MRI mainly involve artifacts which may result from metallic clips or dental implants, the sensitivity is lower for posterior element fracture as well as craniocervical fracture. MRI is more sensitive than other imaging modalities for soft tissue, edema, ligamentous and cord injury compared to CT. While CT is more diagnostic for osseous stable vs unstable injury.

Editorial Review

# Carotid artery dissection and motor vehicle trauma: patient demographics, associated injuries and impact of treatment on cost and length of stay.

Jared E. Kray, Viktor Y. Dombrovskiy, Todd R. Vogel

BMC Emergency Medicine 2016;16:23 DOI 10.1186/s12873-016-0088-z
JACO Editorial Reviewer: Steven G. Yeomans, DC, FACO

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## Authors' Abstract:

**Background**: Blunt carotid arterial injury (BCI) is a rare injury associated with motor vehicle collision (MVC). There are few population based analyses evaluating carotid injury associated with blunt trauma and their associated injuries as well as outcomes.

**Methods**: The Nationwide Inpatient Sample (NIS) 2003–2010 data was queried to identify patients after MVC who had documented BCI during their hospitalizations utilizing ICD-9-CM codes. Demographics, associated injuries, interventions performed, length of stay, and cost were evaluated.

**Results**: 1,686,867 patients were estimated having sustained MVC; 1,168 BCI were estimated. No patients with BCI had open repair, 4.24% had a carotid artery stent (CAS), and 95.76% of patients had no operative intervention. Age groups associated with BCI were: 18–24 (27.8%), 47–60 (22.3%), 35–46 (20.6%), 25–34 (19.1%), >61 (10.2%). Associated injuries included long bone fractures (28.5%), stroke and intracranial hemorrhage (28.5%), cranial injuries (25.6%), thoracic injuries (23.6%), cervical fractures (21.8%), facial fractures (19.9%), skull fractures (18.8%), pelvic fractures (18.5%), hepatic (13.3%) and splenic (9.2%) injuries. Complications included respiratory (44.2%), bleeding (16.1%), urinary tract infections (8.9%), and sepsis (4.9%). Overall mortality was 14.1% without differences with regard to intervention (18.5% vs.

13.9%; P = 0.36). Stroke and intracranial hemorrhage was associated with a 2.7 times greater risk of mortality. Mean length of stay for patients with BCI undergoing stenting compared to no intervention were similar (13.1 days vs. 15.9 days) but had a greater mean cost ($83,030 vs. $63,200, p = 0.3).

**Conclusions**: BCI is a rare injury associated with MVC, most frequently reported in younger patients. Frequently associated injuries were long bone fractures, stroke and intracranial hemorrhage, thoracic injuries, and pelvic fractures which are likely associated with the force/mechanism of injury. The majority of patients were treated without intervention, but when CAS was utilized, it did not impact mortality and trended toward increased costs.

**Clinical Relevance**: This large population study suggests that BCI is rare and appears to require significant trauma in MVC to occur. When BCI is present, other significant trauma is likely to occur simultaneously. The majority of BCI (95.76%) did not require surgery, none required open repair while 4.24% required CAS, and intracranial hemorrhage and stroke was associated with a 2.7 times greater risk of mortality.

**JACO Editorial Summary:**

- The article was written by authors from the Division of Vascular Surgery, University of Missouri, School of Medicine, Columbia, MO.
- The purpose of the study was to investigate the rare condition of blunt carotid arterial injury (BCI) associated with blunt trauma with MVC using a population based approach considering the associated injuries and outcomes.
- The authors reviewed records between 2003-2010 using ICD-9-CM codes and identified 1, 686,867 MVC patients of which 1,168 patients had documented BCI. These patients were evaluated for demographics, associated injuries, interventions performed, length of stay, and costs.
- Few population based analyses exist for blunt trauma to the carotid artery resulting in dissection. Given the large disproportionate difference between occurrence rates of ischemic strokes comparing the general population (20% in patients <45 years old) vs. those from blunt trauma in MVC (<2%), this study is important.
- Results showed the age group of 18-24 had the highest frequency of BCI.
- Associated injuries included long bone fractures (28.5%), stroke and intracranial hemorrhage (28.5%), cranial injuries (25.6%), thoracic injuries (23.6%), cervical fractures (21.8%), facial fractures (19.9%), skull fractures (18.8%), pelvic fractures (18.5%), hepatic injuries (13.3%), and splenic injuries (0.2%).
- BCI associated complications included respiratory (44.2%), bleeding (16.1%), urinary tract infections (8.9%), and sepsis (4.9%). Overall mortality following BCI was 14.1% with no significant difference in mortality between those with versus those without intervention (stenting).

- Stroke and intracranial hemorrhage was independently associated with a 2.7 times greater risk of mortality. The mean length of stay for patients with BCI was similar comparing those undergoing stenting compared to those with no carotid artery intervention.
- This study points out that BCI occurred more frequently in younger patients, was associated with long bone fractures, thoracic injuries, and pelvic fractures. This suggests that the mechanism of injury is more important than the anatomic location of injury. Also, the study points out that carotid artery stenting was not associated with improved mortality and, it carried an increase in total costs.
- Appropriate early identification of BCI and appropriate treatment were reported as important to reduce the risk of stroke. Utilizing the Denver or Memphis screening criteria, those meeting the criteria were further evaluated with CT angiography in order to identify BCI early which was previously reported to reduce the risk of complications.
- BCI typically starts with an initial tear of the intima and when subendothelial collagen is exposed, it acts as a thrombogenic agent which starts the cascade of platelet aggregation resulting in a thrombus formation.
- Because it is well known that there is a latent period ranging between hours and days during which neurological deficits may manifest, most patients initially have no overt neurological deficits.
- The mechanism of injury (rapid deceleration, hyperextension and/or severe flexion with rotation of the neck) and the presence of long bone fractures, thoracic injuries, pelvic fractures, cervical fractures, facial fractures and skull fractures should raise suspicion of BCI.
- While there is currently no standard treatment algorithm, it is generally accepted that interventional carotid artery stenting is not initiated until dissection has progressed to pseudoaneurysm or in the event of a rapid progression of the disease resulting in hemodynamic instability increasing risk for arterial occlusion or transection.
- Utilizing the Denver grading scale, most recent evidence suggests only grade II and III injuries be considered for endovascular stenting. Routine stenting is believed to add risk of stroke without any added benefit and this study reported an obvious increase in cost without improved outcomes.
- Optimal treatment for BCI remains unclear. Antithrombotic therapy either with systemic heparinization or with antiplatelet agents has been associated with improved neurologic outcomes. Care must be taken however given the high rate of numerous co-existing injuries as noted in the study where therapeutic anticoagulation may be contraindicated and have been reported to lead to longer hospital stays and increased morbidity/mortality.

## Summary

The results of this study should raise the awareness for those that manage patients injured in MVC that although BCI is rare, early detection and anti-thrombotic therapy is appropriate to obtain optimal outcomes and reduce the likelihood of unnecessary morbidity and mortality. Multi-system trauma, especially long bone fracture, thoracic spine injury, cranio-fascial and pelvic fracture in MVC should raise the suspicion of BCI. Noteworthy, the authors made a point to comment in the introduction about the disparity between the incidence rates of ischemic stroke in the general population (20%) vs. those with BCI reported in this study (2%), but did not further address this in the discussion section, which is unfortunate.

# Return to play in athletes with spinal cord concussion: a systematic literature review.

Narihito Nagoshi, Lindsay Tetreault, Hiroaki Nakashima, Aria Nouri, Michael G. Fehlings

The Spine Journal 2016
JACO Editorial Reviewer: Brandon Steele DC, FACO

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## Authors' Abstract:

**Background:** The study aimed to evaluate whether spinal cord concussion (SCC) patients can safely return to play sports and if there are factors that can predict SCC recurrence or the development of a spinal cord injury (SCI). Although SCC is a reversible neurologic disturbance of spinal cord function, its management and the implications for return to play are controversial.

**Methods:** We conducted a systematic search of the literature using the keywords Cervical Spine AND Sports AND Injuries in six databases. We examined return to play in patients (1) without stenosis, (2) with stenosis, and (3) who underwent single-level anterior cervical discectomy and fusion (ACDF). We also investigated predictors for the risk of SCC recurrence or SCI.

**Results:** We identified 3,655 unique citations, 16 of which met our inclusion criteria. The included studies were case-control studies or case series and reports. Two studies reported on patients without stenosis: pediatric cases returned without recurrence, whereas an adult case experienced recurrent SCC after returning to play. Seven studies described patients with stenosis. These studies included cases with and without recurrence after return to play, as well as patients who suffered SCI with permanent neurologic deficits. Three studies reported on patients who underwent an ACDF. Although some patients played after surgery without problems, several patients experienced recurrent SCC due to herniation at levels adjacent to the surgical sites. With respect to important predictors, a greater frequency of patients who experienced recurrence of symptoms or SCI following return to play had a "long" duration of symptoms (>24 hours; 36.36%) compared with those who were problem-free (11.11%; $p=.0311$).

**Conclusions:** There is limited evidence on current practice standards for return to play following SCC and important risk factors for SCC recurrence or SCI. Because of small sample sizes, future prospective multicenter studies are needed to determine important predictive factors of poor outcomes following return to play after SCC.

**Clinical Relevance:** Clinicians should evaluate the risks, symptom duration, age, and pre-existing conditions before football players are allowed to return to play. Nagoshi et al. reviews four major questions that affect patient prognosis after SCC.

### JACO Editorial Summary:

1. The article originates from authors at the University of Toronto, Keio University School of Medicine and Nagoya University Graduate School of Medicine.
2. SCC is a reversible transient disturbance of the cord membrane usually due to sub-maximal stretching of the nervous system secondary to trauma.
3. Symptoms usually resolve within 48 hours including motor weakness, burning, paresthesia, and/or paralysis. Complete recovery is expected in most athletes.
4. This study aims to conduct a systematic review of the literature to (1) evaluate the criteria for return to contact sports after SCC, and (2) determine whether demographic, imaging, and surgical factors are predictors of SCC recurrence or SCI.
5. This study attempts to answer these four questions.
    - Q1. Can SCC patients without canal stenosis or disc herniation return to play?
    - Q2. Can SCC patients with canal stenosis or disc herniation return to play?
    - Q3. Can SCC patients return to play after single-level anterior cervical discectomy and fusion (ACDF)?
    - Q4. After return to play, are there clinical, sports-related, imaging, or surgical factors that predict recurrence of SCC or SCI?

### Results:

- Q1. Upon review of the included studies all patients returned to play with no further spinal cord injury. There were re-exacerbations of spinal cord concussions without long-term symptoms in two cases.
- Q2. In the case studies reported: most patients who returned to play after SCC with cervical stenosis did not have any serious complications. However, two studies reported spinal cord injury with permanent neurologic deficit following return to play in athletes with previous episodes of SCC.
- Q3. Patients undergoing a single level ACDF and returned to play yielded mixed results. All studies were case series or reports limiting their statistical power. Many of these players that returned to play developed reoccurrence of symptoms with stenosis and/or herniation at adjacent levels. Others either retired or did not return to play.
- Q4. One study by Torg demonstrated three factors predicting reoccurrence of cord injury or concussion. 1. Smaller spinal canal to vertebral body ratio. 2. Smaller disc–level diameter. 3. Less physical space available for the spinal cord. Younger patients with a longer duration of symptoms from initial injury also demonstrated the greatest risk for re-injury.

**Summary:**

There is a high risk of selection and information bias due to the limited amount of studies meeting the inclusion criteria. Given a low number of studied occurrences on return to play following SCC it would be difficult to draw concretes conclusions. However, this information may become useful as a guide to patient prognosis and education following a spinal cord concussion. Four main points are from this article are:

1. Risks of permanent spinal cord injury do not increase with past spinal cord concussions.
2. There is a high risk of re-occurrence of SCC (56%) in football players.
3. Players with preexisting stenosis have increased risk of SCI in contact sports.
4. Patients with single level fusions may develop adjacent level spondylosis.

I don't believe the author presents a strong case for their first aim: evaluate the criteria for return to contact sports after SCC. There are other criteria well defined in the literature to assist in the return to sport decision after a SCC. I have included supplemental information in the commentary section.

**Commentary:**

After a quick literature review I have found that caution and protection are the mainstays of concussion management. Patients with suspected SCC should be removed from physical activity and not allowed to return until evaluation by an experienced clinician demonstrates resolution of symptoms. Athletes must reach the following progressive benchmarks before being allowed to return to play.

1. Complete clearing of all symptoms at rest, with no pain medications.
2. No symptoms after provocative testing, i.e. cycling, running, or other exercise that elevates heart rate.
3. Full return of cognitive ability, memory, and concentration. (1-4)

A widely accepted graded return to play program (4) begins by avoiding physically and cognitively stressful activity until symptoms have resolved. At that point, the patient may begin light aerobic activity that maintains the heart rate below 70% max, i.e. walking, stationary cycling, etc. Structured aerobic activity has been shown to improve cerebral blood flow and reduce symptoms. (5-7) If low intensity aerobic testing does not exacerbate symptoms, the patient may slowly incorporate progressively more demanding activity, i.e. push-ups and running, eventually performing more complex, non-contact sport specific drills. After the patient is asymptomatic at both rest and after provocative exercise challenge, some form of neuropsychological testing should be performed to ensure the patient’s memory, concentration, and cognitive ability have returned to baseline. (1) Many teams are now performing a pre-season baseline assessment to allow better comparison with post-concussive test results. Athletes should obtain a "written clearance to participate" from a clearly qualified healthcare professional before returning to full activity. (8,9)

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# Dens Fractures: A Review

Alicia M. Yochum RN, DC, DACBR, RMSK

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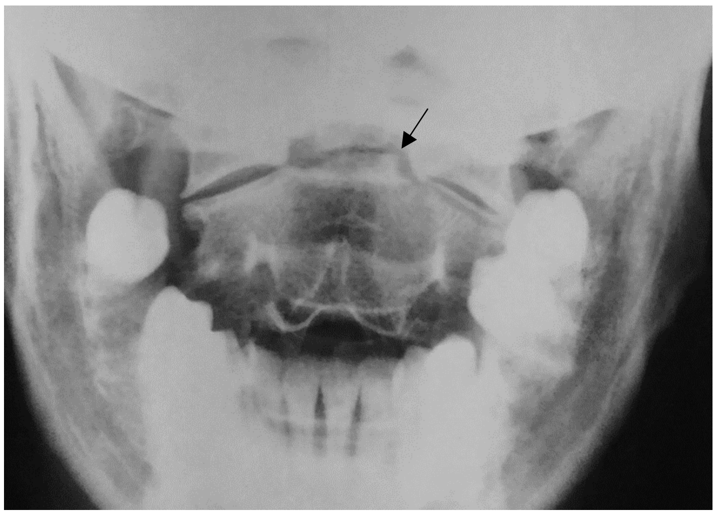

**Figure 1:** Horizontal fracture through the base of the dens (arrow). Note the lateral tilt of the dens >5° indicating the underlying fracture.

A dens fracture has also been termed an odontoid process fracture or a peg fracture. This fracture can occur in both flexion or extension with or without axial loading. It is a common fracture, which makes up approximately 40- 50% of axis fractures. Up to 30% of dens fractures will be associated with other fractures in the cervical spine therefore careful evaluation of the entire cervical spine is indicated when a dens fracture is present.

Radiographic signs that would indicate dens fracture include a fracture line, displacement, enlargement of the C2 body, lateral tilting of the odontoid process > 5°, alteration in the posterior cervical line, and enlargement of the retropharyngeal soft tissues (retropharyngeal swelling). If there is suspicion for a dens fracture without clear evidence on plain film radiography, a computed tomography (CT) examination can be performed to better evaluate the fracture line. Magnetic resonance imaging (MRI) may also be beneficial to evaluate the integrity of the spinal cord. An MRI should be performed if there are symptoms of spinal cord compression or a upper motor neuron lesion on clinical examination.

The classification system that is most commonly used for dens fractures is called the Anderson and D’Alonso classification. This classification system is based on the location of the fracture and is divided into three types.

The type I dens fractures include the uppermost part of the dens. It has been considered a form of avulsion fracture due to the attachment of the alar ligament in this location. It is usually considered a stable fracture and is the least common form of dens fracture. The appropriate treatment for this type of injury, if isolated, is immobilization.

A type II dens fracture is the most common type of odontoid process fracture. It occurs at the base of the dens at its junction with the axis (Figure 1). This type of fracture has a very high risk of non-union due to the reduced blood flow to the fracture fragment. The type II dens fracture is considered unstable and patients should undergo surgical stabilization when there is displacement (> 5 mm) which reduces the possibility of non-union. If there is no displacement, halo immobilization can be used for treatment.

The type III dens fracture occurs through the dens but also includes a portion of the lateral masses of the axis. This type of the fracture has the best prognosis for healing because of the larger surface area of the fracture in the lateral masses. This fracture is usually stable if there is minimal displacement and treatment would include immobilization. There is no need for surgical intervention in most cases.

## Ortho Quiz

by Steven L. Kleinfield D.C.,F.A.C.O.

1) Heberden Nodes are typically associated with which condition:
    a. Osteoarthritis
    b. Rheumatoid Arthritis
    c. Psoriatic Arthritis
    d. Gouty Arthritis

2) Bouchard Nodes are typically associated with which condition:
    a. Osteoarthritis
    b. Rheumatoid Arthritis
    c. Psoriatic Arthritis
    d. Gouty Arthritis

3) Haygarth Nodes are typically associated with which condition:
    a. Osteoarthritis
    b. Rheumatoid Arthritis
    c. Psoriatic Arthritis
    d. Gouty Arthritis

4) The term "Distal Tufting" is typically associated with which condition:
    a. Osteoarthritis
    b. Rheumatoid Arthritis
    c. Psoriatic Arthritis
    d. Gouty Arthritis

5) The term "Ulnar Drift" is typically associated with which condition:
    a. Osteoarthritis
    b. Rheumatoid Arthritis
    c. Psoriatic Arthritis
    d. Gouty Arthritis

# Current Events

- The Academy of Chiropractic Orthopedists announces the on-line Part I examination dates will be May 19, 2017 and July 20, 2017.

  Information about sitting the Board is available from the Executive Director Dr. Jerry Wildenauer.

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- 2017 Convention of the American College of Chiropractic Orthopedists

  April 27-29, 2017 Tropicana Hotel Las Vegas, Nevada

- Apply for the Lipe Scholarship

  Details at http://www.accoweb.org/lipescholarship.html

## Answers to Ortho Quiz

1. a. ***Osteoarthritis***
   http://www.healthline.com/health/osteoarthritis/heberdens-nodes#Overview1

2. a. O***steoarthritis***
   https://www.verywell.com/what-are-bouchards-nodes-2552022

3. b. ***Rheumatoid Arthritis***
   http://www.medilexicon.com/dictionary/60638

4. c. ***Psoriatic Arthritis***
   http://patient.info/doctor/psoriatic-arthritis-pro

5. b. ***Rheumatoid Arthritis***
   http://medical-dictionary.thefreedictionary.com/ulnar+drift