PHYSICAL EXAMINATION OF
THE UPPER EXTREMITY

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Physcial Examination  
of the Upper Extremity  
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There are many common musculoskeletal conditions that produce symptoms easily confused with neurologic conditions involving the upper extremity. Conversely, primarily orthopedic conditions, such as a torn rotator cuff tendon, may mimic neurologic disease. The following discussion concentrates on physical examination findings in primarily orthopedic conditions that are often seen by neurologists and neurologic conditions often encountered by orthopedists, and common musculoskeletal conditions that often arise in the differential diagnosis of neurological illness.

Pain in the neck or upper extremity is a common clinical problem, and the potential causes are many. Pain may involve the neck, shoulder, arm, forearm or hand in virtually any combination. Common neurologic etiologies are cervical radiculopathy (CR), degenerative spine disease, brachial plexopathy and peripheral nerve entrapment.

The primary condition under consideration in the patient presenting with neck and arm pain is CR. There are a number of clinical conditions that may be confused with CR. These primarily include brachial plexopathies, entrapment neuropathies, and non-neuropathic mimickers. The more common musculoskeletal conditions causing confusion include cervical myofascial pain, shoulder pathology (bursitis, tendinitis, impingement syndrome), lateral epicondyritis, and DeQuervain's tenosynovitis. Facet joint disease and cervical vertebral body pathology can cause neck pain with referred pain to the arm. Pain can be referred to the neck, arm or shoulder from the heart, lungs, esophagus, or upper abdomen. In one large series, cervico-brachial pain was present at the onset in 98%, and was radicular in 65%. Pain on neck movement was present in 98%, paraspinal muscle spasm in 88%, decreased reflexes in 84%, weakness in 65%, and sensory loss in 33%. In another series, 70% had motor and sensory symptoms, 12% had motor symptoms only, and 18% had sensory symptoms only.

The history, especially patterns of pain radiation and paresthesias, can provide localizing information in suspected CR. Radiating pain on coughing, sneezing or straining at stool is significant but seldom elicited. Increased pain on shoulder motion suggests nonradicular pathology. Relief of pain by resting the hand atop the head (hand on head sign, Bakody sign) is reportedly characteristic of CR, but the author has seen this phenomenon with a Pancoast tumor. Hand paresthesias at night suggest carpal tunnel syndrome, but carpal tunnel syndrome can occur in association with CR ("double crush syndrome"), so nocturnal acroparesthesias do not exclude coexistent radiculopathy.

Most neck pain is benign, but cervicalgia can result from serious pathologic processes, such as malignancy, inflammatory arthritis, meningitis, osteomyelitis, and diskitis. Common causes of neck pain include fibromyalgia or myofascial pain, cervical osteoarthritis (OA), CR and diffuse idiopathic skeletal hyperostosis. Cervical spine disorders may cause pain that radiates to the shoulders, arms or periscapular regions, typically aggravated by neck movement. Pain due to disease of the articular structures of the vertebral columns may be accompanied by sensations of grating, clicking, and grittiness on movement of the neck. Cervical myofascial pain is usually localized to the posterior neck region, and is vague and diffuse, sometimes with a burning component. There are no neurological symptoms.
EXAMINATION OF THE NECK

Examination should include inspection for the presence of the normal cervical lordosis and any abnormal postures, scars, masses or other deformities. Note whether the patient moves the head normally and naturally. Note whether the shoulders are level and the trapezius ridges symmetric.

Palpation may be informative. Bony structures are best palpated with the patient supine to relax the neck muscles. The spinous processes should be normally aligned. The spinous process of C2 can be felt in the midline just beneath the external occipital protuberance. The C7 spinous process protrudes conspicuously, but the other spinous process are indistinct. The C4 and C5 vertebrae are approximately at the level of the thyroid cartilage. On deep palpation, the apophyseal joints feel like small mounds about 2.5 cm lateral to the spinous processes. Osteoarthritic apophyseal joints are frequently tender on palpation. OA tends to involve the upper cervical spine, cervical spondylosis more often involves the C5-6 and C6-7 levels. Paravertebral muscle spasm causes a feeling of tenseness and tightness of the involved muscles. The trapezius often has focal areas of pain and tenderness in myofascial neck pain, fibrositis and fibromyalgia.

In cervical myofascial pain, palpation may reveal a trigger point: a firm, discrete area of nodularity, particularly in the trapezius and neck extensor muscles. Pressure over the trigger point causes pain that may radiate distally. There is no muscle spasm. The muscle may twitch on palpation of the trigger point. Myofascial pain syndromes merge with fibrositis and fibromyalgia, all appear related and perhaps identical. The patient usually has pain on active movement of the neck, but passive ROM is normal. Neck pain is a common complaint in patients who are neurotic or depressed, malingering, or seeking compensation.

The cervical spine range of motion is highly informative. Patients with arthritic necks usually have restricted motion, often painless. Patients with a globally restricted cervical spine range of motion often have extensive degenerative disease. There may be palpable or audible crepitus. A single loud click on turning the head may indicate facet malalignment. Lateral flexion is affected earliest and to a greater degree in OA and degenerative spine disease, rotation is most impaired in rheumatoid arthritis because of involvement of the odontoid. Diffuse idiopathic skeletal hyperostosis and ankylosing spondylitis cause global restriction of neck motion in all directions.

Patients should be asked to put chin to chest and to either shoulder, each ear to shoulder and to hold the head in full extension; these maneuvers all affect the size of the intervertebral foramina. Pain produced by movements that narrow the foramen suggests CR. Pain on the symptomatic side on putting the ipsilateral ear to the shoulder suggests radiculopathy, but increased pain on leaning or turning away from the symptomatic side suggests a myofascial origin. Radiating pain or paresthesias with the head in extension and tilted slightly to the symptomatic side is highly suggestive of CR (Spurling sign or maneuver, foraminal compression test); brief breath holding or gentle Valsalva in this position will sometimes elicit the pain if positioning alone is not provocative. The addition of axial compression by pressing down on the crown of the head does not seem to add much. The Spurling test is specific, but not very sensitive. Light digital compression of the jugular veins until the face is flushed and the patient is uncomfortable will sometimes elicit radicular symptoms: unilateral shoulder, arm, pectoral or scapular pain, or radiating paresthesias into the arm or hand (Viets or Naffziger sign). A slight cough while the face is suffused may increase the sensitivity. Jugular compression is thought to engorge epidural veins or the CSF reservoirs, which in the normal individual is harmless. But when some element of foraminal narrowing and nerve root pressure exists, the additional compression causes the acute development of symptoms. The same mechanism likely underlies the exacerbation of root pain by coughing, sneezing, and straining. Like the Spurling test, the Viets/Naffziger sign is highly specific, but has low sensitivity. An occasional CR patient has relief of pain with manual upward neck traction, particularly with the neck in slight flexion. Some patients with CR have a decrease in pain with shoulder abduction (shoulder abduction relief test); this sign is more likely to be present with soft disc herniation. The mechanism is uncertain but probably related to the hand on the head sign. Flexion of the neck may cause Lhermitte sign in patients with cervical spondylosis or large disc herniations.

THE SHOULDER

Shoulder pain is a common complaint, and disorders of the shoulder can be mistaken for neurologic disease, especially cervical spine disease and brachial plexopathy. The shoulder is the most mobile joint in the body, but the price paid for this mobility is instability and susceptibility to strain, sprain, and a variety of diseases. The rotator cuff consists of the supraspinatus, infraspinatus, teres minor, and subscapularis, all of which insert into the greater and lesser tuberosities of the humerus. The tendon of the long head of the biceps passes through the intertubercular (bicipital) groove to insert on the superior rim of the glenoid. The greater tuberosity of the humerus makes up the outer wall of the intertubercular groove, the lesser tuberosity the inner wall. Disease involving the biceps tendon in the bicipital groove (bicipital tendonitis) causes pain on motion and may damage, and even cause eventual rupture, of the biceps tendon. Pain from shoulder structures is typically made worse by shoulder movement rather than neck movement. Pain due to acromioclavicular (AC) joint disease is located at the joint. With other shoulder disorders, pain may be located anywhere in the arm, neck or shoulder, but is usually referred to area of the
Adhesive capsulitis of the shoulder is characterized by pain and decreased shoulder motion due to adhesions within the glenohumeral joint or its capsule. Both active and passive ROM are limited, especially in abduction and external rotation. OA of the shoulder primarily involves either the glenohumeral or AC joints. There is pain, limitation of ROM, and often joint crepitus. Frozen shoulder is a general term describing all causes of loss of shoulder ROM. When severe there may be essentially no motion at the glenohumeral joint. Affected patients have difficulty raising the arm overhead, reaching across the body or behind the back.

Bicipital tendonitis is a common condition due to inflammation of the tendon of the long head of the biceps in the intertubercular groove. Overuse injuries involving the musculotendinous junction are common. Patients typically have anterior shoulder pain that occasionally radiates down to the elbow. The pain is worsened by shoulder flexion or forearm supination and relieved by rest.

A common cause of pain in the shoulder is disease involving the tendons of the rotator cuff. Most nontraumatic shoulder pain is related to disease of the rotator cuff. The condition usually begins as a tendonitis involving the supraspinatus tendon. With progression, other tendons may become involved and the process may extend to involve the subacromial bursa and joint capsule and lead to tendon rupture or frozen shoulder. With rotator cuff disease, pain is usually referred from the supraspinatus tendon to the area near the deltoid insertion, especially with active abduction. Pain caused by lying on the involved shoulder suggests supraspinatus tendonitis. In impingement syndrome, the pain initially occurs primarily after strenuous activity. With progression the pain may become constant, exacerbated by arm raising activities, and is particularly prone to occur at night. In dealing with a patient with shoulder pain, it is useful to ascertain the functional limitations. The patient may have difficulty dressing, especially reaching back to insert the arm into a coat sleeve, combing the hair, and reaching for a hip pocket wallet.

In the early stages of rotator cuff disease, the primary manifestations are impingement syndrome. In impingement syndrome, the inflamed and edematous tendons of the rotator cuff, primarily the supraspinatus tendon are prone to become trapped beneath the coracoacromial arch with activities that involve raising the arm, particularly with the shoulder internally rotated, as in reaching forward and upward to place something on a shelf. With progression, one or more of the tendons may rupture. The supraspinatus tendon is the structure most often involved, and the tear can be partial or full thickness. Rotator cuff tears rarely occur in young healthy shoulders, but may follow severe trauma such as shoulder dislocation. Examination in a rotator cuff tear usually discloses weakness of abduction and external rotation, often with disuse atrophy of the supraspinatus and deltoid. Isolated weakness of external rotation is often a sign of rotator cuff disease.

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Full active ROM should carry the shoulder through flexion, extension, adduction, abduction, and medial and lateral rotation. It is best to assess active ROM with the patient seated in order to avoid compensatory movements of the trunk. Posteriorly, note the motion of the scapula and the scapulohumeral rhythm. When there is severe shoulder pathology with restriction of glenohumeral motion, the patient abducts the arm primarily at the scapulothoracic joint. Excessive scapular motion during arm abduction signifies limited glenohumeral motion, as occurs with adhesive capsulitis and OA. Some or all of abduction may be accomplished by shrugging and the scapula and humerus move as a unit (reversal of scapulohumeral rhythm).

A convenient way to assess active ROM is the Appley scratch test, in which the patient makes three moves as if to scratch. The patient reaches to the opposite shoulder to touch it from the front, from behind the neck as if to touch the upper vertebral border of the opposite scapula, and from behind the lower back as if to touch the lower tip of the opposite scapula. The latter two can be combined by having the patient try to touch the fingertips together in the interscapular space, one hand from above and the other from below.

Impingement syndrome may produce a characteristic painful arc of motion because the diseased tendons pass beneath the acromion in the arc between 60 and 120 degrees of abduction. Abduction out to 60 degrees may be painless, between 60 and 120 degrees is very uncomfortable, but beyond 120 degrees, after the swollen and tender supraspinatus tendon has cleared the narrow confines of the subacromial space, motion is again painless.

Limitation of active ROM could occur because of some mechanical limitation, e.g., frozen shoulder, or because of pain or muscle weakness. Passive greater than active ROM excludes any mechanical limitation. To assess passive ROM, the examiner moves the shoulder through all its motions. Even when there is marked limitation of active ROM due to pain or a torn rotator cuff, gentle passive ROM may be normal. Palpation may reveal crepitus on motion, indicating OA of the glenohumeral joint, muscle spasm, or joint deformity such as a step off of the AC joint.

Two different impingement signs are in common use; both produce pain by trapping the rotator cuff tendons between the humeral head and the coracoacromial arch during passive movement of the shoulder. In the Neer impingement test, the arm is internally rotated, then raised directly overhead with the palm facing outward. In the Hawkins (Hawkins-Kennedy) impingement test, the arm is held in abduction and external rotation, then forcefully rotated internally, driving the supraspinatus tendon through the subacromial space. In another method, the elbow is flexed and the shoulder internally rotated as if to lay the forearm across the abdomen; the arm is then raised so that the forearm passes in an arc in front of the face and overhead. Internal rotation is a key part of the maneuver in the impingement tests, as it rotates the greater tuberosity anteriorly and narrows the space beneath the acromion. Inflamed and tender tendons are then trapped between the greater tuberosity and the acromion, causing pain during the maneuver. After injection of a small amount of local anesthetic into the subacromial space, these movements may be made painlessly, confirming the diagnosis of impingement syndrome. The pain may also lessen when the patient bends forward and lets the arm hang limp, distracting the inflamed tendons from the point of impingement, or if the examiner supports the flexed forearm at the elbow and pulls gently downward.

To look for the drop-arm sign, the examiner places the shoulder in 90E of abduction then releases the arm and asks the patient to slowly lower it. This may cause severe pain or the patient may not be able to lower the arm slowly and it may drop abruptly. A positive drop-arm sign suggests dysfunction of the supraspinatus tendon. The action of the supraspinatus can be relatively isolated by having the patient attempt to abduct the arm laterally with the shoulder internally rotated and forearm hyperpronated, as if to move the little finger toward the ceiling. The shoulder should be flexed about 30 degrees forward of the coronal plane of the body to line the humerus up in the plane of the scapula and isolate the supraspinatus. This is the same movement that would be made emptying a can and is sometimes referred to as the empty can test.

In Speed's test the patient flexes the shoulder (not the elbow) against resistance with the elbow held extended and the forearm supinated. This movement causes the biceps tendon to move through the bicipital groove and causes anterior shoulder pain in patients with bicipital tendinitis. The biceps is an elbow flexor and supinator, and Yergason's test uses both motions to cause the biceps to contract and its tendon to move in the bicipital groove, reproducing the pain in bicipital tendinitis. With the elbow flexed to 90 degrees and the forearm pronated, the patient attempts to simultaneously flex the elbow and supinate the hand against the examiner's resistance. The test is positive when the maneuver causes pain in the anterior shoulder over the biceps tendon.

To perform the apprehension test, the patient is seated or supine, and the arm is placed in abduction and external rotation with the elbow at about shoulder height, as if raising the hand in class. The examiner then pulls the proximal upper arm anteriorly. The patient who has suffered a previous shoulder dislocation will appear alarmed and fearful that the shoulder is going to subluxate. This is a positive apprehension sign. To test for pos-
terior instability, the shoulder is internally rotated and flexed forward and the examiner pushes directly backward on the elbow.

To test inferior stability the examiner pulls downward on the relaxed arm. This may cause a step-off to appear between the humeral head and acromion, referred to as a positive sulcus sign. When the humeral head subluxes downward, as may happen after stroke, there is a frank step off between the acromion and the humeral head.

THE ELBOW

Patients with pain in the elbow are not often thought to have a neurologic process. There are a few conditions that merit discussion: lateral epicondylitis, medial epicondylitis, the radial tunnel syndrome, and ulnar neuropathy at the elbow.

With the patient in anatomical position, holding the elbow extended and supinated, the forearm normally diverges laterally from the upper arm. The angle formed is referred to as the "carrying angle" of the elbow. An increased carrying angle, with the forearm deviated more laterally than normal, is referred to as cubitus valgus, a decreased carrying angle, in which the forearm actually deviates medially, is cubitus varus. Cubitus valgus is associated with ulnar neuropathy at the elbow. Olecranon bursitis is a common condition that causes fluid accumulation over the tip of the olecranon.

Lateral epicondylitis (tennis elbow) is a very common syndrome of pain over the lateral epicondyle that is most often an overuse injury involving the extensor and supinator muscles that originate from the lateral epicondyle. Examination typically discloses tenderness to palpation over the lateral epicondyle, with maximal tenderness just distal to the epicondyle. With the elbow extended, extension or supination of the wrist against the examiner’s resistance reproduces the pain. Forceful wrist flexion or pronation may stretch the inflamed region and also cause pain. In the chair raise test, the patient stands behind a chair, grasps the chair back with the hand pronated and the elbow extended and tries to pick it up, reproducing the pain.

Some clinicians believe cases of resistant tennis elbow may result from entrapment of radial nerve branches in the "radial tunnel," a dubious anatomical construct. Proponents of radial tunnel syndrome believe the nerve entrapment causes chronic lateral elbow pain in the absence of any objective neurologic dysfunction. Proponents of radial tunnel syndrome allege there is focal tenderness slightly more distal than that seen in lateral epicondylitis.

THE WRIST AND HAND

Orthopedic conditions of the wrist and hand may be confused with nerve entrapment syndromes, primarily with carpal tunnel syndrome (CTS) and with other neurologic conditions. Inspection may reveal atrophy of the hand intrinsics, a ganglion, arthritic deformity, trophic changes, or an abnormal hand posture.

The pisiform bone forms an easily palpable hump on the palmar aspect of the wrist at the base of the hypothenar eminence. The hook of the hamate lies about one inch distal to the pisiform, in line with the ulnar border of the ring finger, and can be felt by deep palpation. The pisohamate ligament joins the pisiform to the hook of the hamate. The pisohamate ligament can compress the deep palmar branch of the ulnar nerve. The superficial division of the ulnar nerve can be rolled from side to side over the tip of the hook.

The "anatomical snuff box" is a small hollow seen just distal to the radial styloid on the lateral aspect of the wrist when the thumb is fully extended. The extensor pollicis brevis and abductor pulses longus tendons form the volar border of the snuff box, the extensor pollicis longus tendon forms the dorsal border. With the thumb forcefully extended, the tendon of the extensor pollicis longus can be seen standing out and running to its insertion on the distal phalanx of the thumb. The superficial radial nerve crosses the tendon of the extensor pollicis longus, and can be palpated and rolled from side to side over the tendon.

A decrease in both active and passive range of motion suggests contracture or pathology involving the joint. When there is only loss of active range of motion, disruption of a tendon may be responsible. DeQuervain disease is an inflammatory tenosynovitis that involves the extensor muscles of the thumb, primarily the extensor pollicis brevis. Patients develop pain in the wrist and thumb, primarily involving the radial aspect of the wrist. There is tenderness to palpation over the anatomical snuff box and extension of the thumb against resistance causes pain. Passive extension of the thumb is painless. Finkelstein test is useful for the diagnosis of DeQuervain disease. The patient places the thumb in the palm and wraps the fingers around it. The examiner then slowly pushes the wrist in an ulnar direction. This stretching of the inflamed thumb extensor tendons repro-
duce the patient's pain. In chronic cases, small nodules may develop along the involved tendons. Mild discomfort with forced ulnar deviation is expected. Patients with active DeQuervain disease have exquisite pain with the Finkelstein test. The scaphoid (navicular) bone lies deep in the anatomical snuff box and disease of the scaphoid can cause chronic wrist pain and focal tenderness.

Rupture of tendons can cause weakness easily mistaken for a neurological process. Rupture of a finger extensor tendon causes isolated finger drop. A common type of extensor tendon injury involves the distal phalanx, causing the tip of the involved finger to droop (mallet finger, as the extended finger resembles a tiny mallet). Rupture of the extensor tendon to the proximal interphalangeal joint causes both middle and distal phalanges to droop (typewriter finger). When multiple tendons are involved, as sometimes happens in rheumatoid arthritis (Vaughan-Jackson syndrome), the appearance may simulate partial posterior intersosseous neuropathy. In the rheumatoid wrist, the extensor digiti minimi tendon usually ruptures first.

Jersey (sweater) finger is an injury that usually occurs when a player grabs a running opponent's jersey, avulsing the flexor digitum profundus tendon from the distal phalanx. The patient is then unable to flex the distal interphalangeal joint. This can be mistaken for flexor digitorum profundus weakness as might occur in anterior intersosseous nerve palsy.

**EXAMINATION OF MUSCLE STRENGTH**

While judgment of the force exerted in either initiating or resisting movement is the major criterion in the evaluation of strength, observation and palpation of either the contraction of the muscle belly or its movement of its tendon may be helpful adjuncts. Weakness may be masked when attempts to contract individual weak muscles are accompanied by activation of other muscles to compensate for the loss of power. In these substitution, or "trick," movements, the patient exploits a strong muscle with similar function to compensate for the loss of action of a weak muscle. Careful observation for alterations in normal movement patterns and substitution movements may indicate loss of function. Passive movements are often helpful to distinguish loss of range of motion due to contractures from other reasons such as weakness, pain, and muscle spasm.

**Examination of the scapular muscles**

The rhomboids can be tested by having the patient, with hand on hip, retract the shoulder, against the examiner's attempt to push the elbow forward. If the patient braces the shoulders backward as if standing at attention, the bulge of the rhomboids can be seen and palpated along the medial border of the scapula. Another test of rhomboid function is to have the patient place the back of the hand against the small of the back and to push backward with the palm against the examiner's resistance. The rhomboid major contracts vigorously as a downward rotator of the scapula. Lifting the hand off the small of the back is also used to test the subscapularis.

The different parts of the trapezius must be tested separately. One test of the upper fibers is to have the patient shrug the shoulders against resistance. A better test is resisting the patient's attempt to touch the occiput to the acromion. The middle fibers may be tested by having the patient retract the scapula against resistance, or having the patient hold the arm horizontally abducted, palm up, and attempting to push the elbow forward. The serratus anterior can be tested by having the patient make movements that involve forward reaching or pushing, and observing for evidence of scapular winging. The classical test is to have the patient push against a wall, comparing how well the scapulae remain against the chest wall on the two sides.

**Winging of the Scapula**

Normally, the medial border of the scapula remains close to the chest wall when the arms are raised. However, with weakness of either the serratus anterior or the trapezius, the vertebral border or the entire scapula protrudes posteriorly, away from the thoracic wall. This causes the deformity known as "winging." The trapezius is a rotator and retractor of the scapula and functions primarily during abduction of the arm to the side in the coronal plane of the body. When the trapezius is weak, scapular winging is more apparent on attempted abduction of the arm than on forward elevation. Trapezius winging may be made more conspicuous by having the patient bend forward at the waist so the upper body is parallel to the ground, then raise the arms to the sides, as if beginning a swan dive. This requires strong action by the trapezius to retract the scapula and accentuates the posterior displacement of the shoulder girdle. The serratus anterior is primarily a protractor of the scapula and functions during forward arm elevation. When the serratus is weak, the inferior angle is shifted medially and the entire vertebral border rides up from the chest wall. Serratus anterior weakness causes winging that is more obvious when trying to elevate the arm in front, in the sagittal plane of the body; it is less obvious when the arms are abducted to the sides. This difference aids in differentiating serratus anterior winging (as from a long thoracic nerve palsy) from the flaring of the scapula that occurs with trapezius weakness (as from a spinal accessory nerve palsy). Serratus winging may be accentuated by having the patient protract the scapula against resistance.

**The Glenohumeral Joint**

The principal movements at the glenohumeral joint are abduction, adduction, external and internal rotation, flexion, exten-
sion, and elevation of the arm. These movements are best appreciated as taking place in the plane of the body of the scapula rather than in the body as a whole. The deltoid is the most prominent muscle in the shoulder region, and has three portions: anterior, middle, and posterior. The middle deltoid and supraspinatus muscles abduct the shoulder. With deltoid contraction, the arm is abducted (raised laterally) to the horizontal plane. Further abduction, or elevation above the horizontal plane, is carried out by the associated action of the trapezius and the serratus anterior, which rotate the scapula and tilt the angle of glenoid fossa upward.

The major function of the deltoid is tested either by noting the ability of the patient to abduct the arm through the range up to 90 degrees against resistance, or to hold the arm in abduction to the horizontal level, either laterally or forward (the elbow may be either flexed or extended), and resist the examiner’s attempt to push it down. The supraspinatus helps abduct the shoulder through the first 15 degrees. The muscle belly lies in the supraspinous fossa of the scapula; its contraction can be palpated and sometimes seen when the arm is abducted less than 15 degrees against resistance.

The primary adductors of the shoulder are the pectoralis major and latissimus dorsi. On attempts to adduct the horizontally abducted arm against resistance, the contraction of the sternocostal and clavicular portions of the pectoralis can be seen and felt. The muscle can also be tested by having the patient move the horizontally abducted arm forward, or try to press the hands together with the arms in front, or try to internally rotate the forearms with the elbows at the side and flexed, in a position as if holding a book. The latissimus dorsi adducts, extends, and medially rotates the shoulder and may be tested in various ways. The muscle belly can also be felt when the patient coughs or pushes the arm downward and backward.

External rotation of the shoulder is carried out principally by the infraspinatus and teres minor muscles. To test these muscles, the patient attempts to externally rotate the shoulder by turning the forearm laterally and backward against resistance while the elbow is flexed at an angle of 90 degrees and held at the side. Internal rotation at the shoulder results primarily from contraction of the subscapularis, the chief internal rotator, and teres major muscles; other muscles also contribute. Internal rotation is tested by having the patient move the forearm medially against resistance with the elbow flexed and at the side—the opposite motion from external rotation. Internal rotation can also be tested by having the patient lift the back of the hand off the small of the back against resistance.

The Elbow

The principal movements at the elbow are flexion and extension at the elbow joint and pronation and supination at the radioulnar joint. Many muscles contribute to elbow flexion; the primary ones are the biceps brachii, brachialis, and brachioradialis. Which muscle is the prime mover depends on the position of the forearm. The biceps is an elbow flexor and also a strong supinator of the forearm. Its supination power is greatest when the forearm is flexed and pronated. Its flexion power is greatest when the forearm is supinated. The brachialis flexes the elbow regardless of forearm position. The brachioradialis acts as an elbow flexor when the forearm is held midway between pronation and supination (thumb up). The brachioradialis acts as a supinator when the forearm is extended and pronated, but as a pronator when the forearm is flexed and supinated.

Biceps and brachialis functions are tested by having the patient attempt to flex the elbow against resistance. The biceps contraction can be seen and felt, but the brachialis is buried. The brachioradialis is tested by attempts to flex the semi-pronated forearm. When the biceps muscle is weak, the patient may employ trick movements by putting the forearm into mid-pronation and bringing in the brachioradialis, or pulling the elbow backwards. The latter resembles the movement bartenders make when drawing a draft beer and has been called the "bartender’s sign."

The triceps brachii is the principal elbow extensor. To test it, place the elbow in a position midway between flexion and extension and have the patient attempt to either extend the elbow or to hold position against the examiner’s resistance. The triceps is ordinarily extremely powerful. It is less powerful when the elbow is fully flexed, and slight weakness may be more easily detected with testing in this position. The examiner may be able to pin the triceps in extreme flexion on the symptomatic side but not on the normal side.

Supination of the forearm is done primarily by the supinator muscle, assisted by stronger muscles for movements requiring power. The biceps muscle is the most powerful forearm supinator. Although the supinator is less powerful, it acts through all degrees of flexion and supination. Supination is tested by having the patient supinate against the examiner’s resistance. With the
forearm in extension, the brachioradialis also participates; with the forearm in flexion, the biceps also participates.

Pronation is brought about primarily by the pronator quadratus (PQ), which is assisted by the much stronger pronator teres (PT) for movements requiring power. The PT is also an elbow flexor. To test the PT and PQ, the patient attempts to pronate against resistance. To isolate the action of the PQ, pronation should be tested with the elbow extended, when the PT is maximally lengthened and exerts its weakest pull. Flexion of the elbow would signal that the patient is trying to bring the PT into play.

The Wrist

The principal movements at the wrist are flexion and extension. Flexion of the wrist is carried out primarily by the flexor carpi radialis (FCR) and flexor carpi ulnaris (FCU) muscles. Wrist flexion is tested by having the patient resist the examiner’s attempts to extend the wrist. The FCR can be tested individually by having the patient flex the wrist toward the radial side against resistance directed toward the thumb. Function of the FCU can be tested by having the patient flex the wrist toward the ulnar side while the examiner presses on the hypothenar region.

Extension (dorsiflexion) of the wrist is executed primarily by the extensor carpi radialis longus (ECRL), extensor carpi radialis brevis, and extensor carpi ulnaris. The ECRL is the most powerful wrist extensor. To test the wrist extensors, the forearm is held in pronation with the wrist partially extended. The patient then resists the examiner’s attempts to pull the wrist into flexion. Moderate weakness of the extensors results in involuntary flexion at the wrist when the patient attempts to make a fist; marked weakness causes a wrist drop, the major finding in a radial nerve palsy.

The Hands and Fingers

The muscles that power the hand can be divided into extrinsics and intrinsics. The extrinsic muscles originate in the forearm and insert on hand structures; the intrinsics originate and insert within the hand. Possible movements include flexion, extension, adduction, abduction, and opposition.

Flexion of the Fingers

The primary finger flexors are the flexor digitorum superficialis (FDS) and the flexor digitorum profundus (FDP). The FDS tendons pass through the carpal tunnel and then diverge to insert on the palmar surfaces of the middle phalanges. The FDS primarily flexes the proximal interphalangeal (PIP) joints of the four fingers. The tendons of the FDP pass through the carpal tunnel, and then pierce the tendons of the FDS and insert on bases of the distal phalanges. The main action of the FDP is flexion of the distal interphalangeal (DIP) joints.

The fingers are flexed at the MCP joints by the interossei and the lumbricals. On the dorsal surface of the proximal phalanx of each finger there is a dorsal extensor expansion, a fibrous enlargement of the tendon of the extensor digitorum. The finger extensor tendons blend into the expansion. The dorsal interossei lie between the metacarpal bones, from which they originate, and insert on the proximal phalanges. They also insert separately into the extensor expansions and are therefore functionally connected to the finger extensor tendons. From the insertion on the proximal phalanx, the dorsal interossei flex the MCP joint. From their insertion on the extensor expansion they extend the PIP joint and also abduct the fingers. The smaller palmar interossei arise from the palmar surfaces of the metacarpal bones and insert on the side of the extensor expansion so as to adduct the fingers; they also flex the MCP joint and extend the PIP joint. The lumbricals arise from the tendons of the FDP and insert into the extensor expansions on the dorsal surfaces of the phalanges. The lumbricals are weak flexors of the MCP joints. Their more important function is to extend the PIP joints.

Function of the FDP is tested by having the patient flex the distal phalanges of the individual fingers against resistance while the middle phalanges are fixed. The FDS is tested by having the patient flex the fingers at the PIP joints while the proximal phalanges are fixed. The interossei and lumbricals flex the MCP joints and extend the interphalangeal (IP) joints. Weakness of these intrinsic hand muscles causes loss of MCP joint flexion and loss of PIP joint extension, together with loss of adduction and abduction of the fingers. The hand assumes a position of rest in which the MCP joints are held in extension and the PIP and DIP joints are flexed (claw hand). Ulnar neuropathy is the most common cause of claw hand (ulnar griffe). Ulnar clawing primarily affects the ring and small fingers because both lumbrical and interosseous function are lost.

Making a fist requires flexion of the fingers at all joints. The strength of the grip depends on the degree of flexion at the MCP and IP joints, on the position of the thumb and its ability to flex and to brace the fingers, and on the synergistic actions of
the wrist extensors in fixation of the wrist. A firm fist can be made only with the wrist in extension. Although commonly done, grip power is not very useful in assessing upper-extremity motor function in neurological patients.

**Extension of the Fingers**

The long extensors of the fingers include the extensor digitorum communis (EDC), extensor indicis proprius (EIP, aka extensor indicis), and the extensor digiti minimi (EDM). The tendons insert on the dorsal extensor expansions of the first phalanges of the fingers. The primary action of the EDC is extension of the MCP joints, but it can exert some force to extend each joint it crosses. The EIP extends the index finger; the EDM extends the little finger. The interossei and lumbricals also extend the PIP and DIP joints of the fingers. To test the action of the EDC, EIP and EDM, the patient resists attempts to push the fingers down at the MCP joints with the forearm pronated and the wrist stabilized. The extensor function of the lumbricals and interossei is tested by having the patient try to extend the PIP and DIP joints against resistance while the MCP joints are hyperextended and fixed.

**The Thumb and Its Muscles**

The thumb is capable of movement in many directions. The difference in some of the motions is subtle (e.g., flexion vs. adduction), but the muscle involved and the clinical significance may be marked. Two sets of muscles control thumb motion: those in the forearm (extrinsic thumb muscles), and those that make up the thenar eminence (intrinsic thumb muscles).

The mobility of the opposable thumb requires more elaborate muscle control compared to the other digits. Because the classical anatomical terms describing directions of movement are not easily applied to the thumb, additional directions are designated: palmar, dorsal, ulnar, and radial. The IP and MCP joints can flex and extend. The carpometacarpal (CMC) joint can move in many directions. In palmar abduction, the thumb moves upward at right angles to the plane of the palm; in radial abduction, the thumb moves away in the plane of the palm. Ulnar and palmar adduction are movements that touch the first and second metacarpals together. Opposition (anteposition) is the motion of circumduction of the thumb with extended MCP and IP joints; this turns the thumb into semipronation and touches the palmar surface of the tip of the thumb to the palmar surface of the tip of the small finger.

The forearm muscles involved in controlling the thumb are the abductor pollicis longus (APL), extensor pollicis longus (EPL), extensor pollicis brevis (EPB), and flexor pollicis longus (FPL). The APL abducts the thumb and extends it to a slight degree.

The EPL extends the terminal phalanx; the EPB extends the proximal phalanx. The FPL flexes the distal phalanx of the thumb. To test the FPL, the patient flexes the distal phalanx of the thumb while the proximal phalanx is flexed and immobilized. The FPL is tested by having the patient extend the thumb at the IP joint while the proximal phalanx is immobilized. The EPB is tested by having the patient extend the thumb at the MCP joint while the metacarpal bone is immobilized.

The muscles that make up the thenar eminence are the abductor pollicis brevis (APB), opponens pollicis (OP), and flexor pollicis brevis (FPB). The APL and APB muscles produce palmar abduction. The OP pronates the thumb, turning the volar thumb surface down, to touch the tip of the thumb to the small finger. The FPB flexes the MCP joint of the thumb. In testing the FPB the patient is asked to flex the MCP joint of the thumb while keeping the IP joint extended.

Abduction of the thumb is carried out in two planes: in the same plane as the palm (radial abduction), and at right angles to the plane of the palm (palmar abduction). To test radial abduction, the thumb is moved outward if the hand is horizontal, and upward if the hand is vertical, against resistance. This movement is executed by the APL and EPB. The APB is a thin sheet of muscle lying just medial to the first metacarpal that performs palmar abduction. To test palmar abduction the thumb is moved upward at right angles to the palm, inside the radial margin of the hand, against resistance. It is very easy for both patient and physician to confuse abduction with extension. One trick is to place a pencil or similar object between the thumb and the palm, or radial to the thumb, perpendicular to the palm. The patient then raises the thumb to a point vertically above its original position, keeping it parallel to the pencil with the thumbnail at right angles to the palm. In paralysis of abduction the thumb is adducted and rotated, thumbnail parallel rather than perpendicular to the fingernails, falling into the plane of the palm (simian or ape hand).

Opposition of the thumb is tested by having the patient touch the little finger with the thumb. With the thumbnail on a plane approximately parallel to the palm, the palmar surface of the tip of the thumb should contact the palmar surface of the tip of the little finger. When the OP is weak, the patient may be able to oppose the thumb to the index or middle finger, but not the little finger. In testing opposition of the little finger by the opponens digiti minimi, the patient moves the extended little finger in front of the other fingers and toward the thumb. Opposition of the thumb and little finger may be tested in one maneuver. When both are opposed their extended tips meet and form an arch over the cupped palm. The strength of the combined movement may be gauged by the patient's ability to hold onto a piece of paper held between finger and thumb as
the examiner tries to pull it free, or the examiner may attempt to pull his finger between the touching tips of the thumb and little finger.

The adductor pollicis adducts the thumb and flexes the first metacarpal. Adduction of the thumb is also carried out in two planes: in the plane of the palm (ulnar adduction), and in a plane at right angles to the palm (palmar adduction). Ulnar adduction is touching the ulnar aspect of the thumb to the radial aspect of the second metacarpal and index finger, thumb in the same plane as the palm, the thumbnail as nearly as possible parallel with the other fingernails, as if to put the hand into salute position. In palmar adduction, the ulnar aspect of the thumb touches the palmar aspect of the second metacarpal and index finger so that the thumb and index finger lie perpendicular to each other, with the thumbnail at right angles to the other fingernails. A commonly used test of adduction power in either of these positions is to have the patient try to hold a piece of paper tightly between thumb and hand as the examiner tries to extract it. When thumb adduction is weak, the patient may make a substitution movement, flexing the IP joint with the FPL and trying to secure the paper with the tip of the thumb (Froment’s sign), a common finding in ulnar neuropathy.

**Abduction and adduction of the fingers**

Adduction of the fingers is the movement that brings the fingers tightly together; abduction spreads the fingers apart. Adduction is a function of the volar interossei; abduction is a function of the dorsal interossei. Abduction of the little finger is done by the ADM. Adduction may be tested in several ways. With the fingers abducted and extended, the patient may try to adduct the fingers against resistance. The patient may try to clutch a piece of paper between two fingers and resist the examiner’s attempts to withdraw it. The examiner may interdigitate his fingers between the patient’s and have the patient squeeze as tightly as possible. The usual test of abduction is to have the patient keep the fingers fully extended and spread apart and resist the examiner’s attempt to bring them together.

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**BIBLIOGRAPHY**


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