

Chapter 22: Cumulative Trauma Disorders

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I. Background

A. Definition¹

1. Disorders of the muscle, tendon, ligament, bone, spinal disc, vascular, or nervous system caused or exacerbated by repeated movements or stresses.
2. Often involve the upper extremities.
3. Also known as Repetitive Strain injuries (RSI), Repetitive Motion Injuries (RMI), Musculoskeletal Disorders (MSD), and Work-Related Musculoskeletal Disorders (WRMSD).

B. Mechanism of Injury/Risk Factors:

1. Awkward posture² (See Figure 1)
2. Force²
3. Repetition²
4. Vibration²
5. Duration of exposure/Sustained or static postures.²
6. Direct pressure (also called Contact stresses).¹
7. Exposure to cold.³
8. Personal factors such as age and obesity²
9. Psychosocial factors including:
 - a. Job stress²
 - b. Job dissatisfaction.²
 - c. Monotony of job tasks.²
 - d. Low levels of control.²
 - e. Low levels of peer support.⁴
 - f. Low levels of organizational support.²
 - g. High work demands.²

C. Common characteristics of these disorders:

1. Multifactorial (more than one causal factor).²
2. Often insidious onset with vague symptoms initially.²
3. Accurate diagnosis is difficult, especially in early stages.²
4. Develop over weeks, months, or years.
5. May develop into chronic conditions.
6. Recovery takes weeks, months, or years.
7. May be exacerbated by non-work factors.²
8. Women at greater risk.⁵
9. Smoking^{6,7,8}
10. Obesity^{6,7,8}

D. Psychosocial aspects therapists can address²

1. Coping skills.
2. Relaxation techniques.
3. Grading & pacing.
4. Personal goal setting for work & leisure.

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5. Social skills training.
6. Stress management.

II. Incidence & Costs

- A. 346,400 cases of CTD requiring time away from work in 2010. This translates to 34 cases per 10,000 full time workers.⁹
- B. CTD accounted for 29% of all work related injuries and illnesses requiring time away from work.⁹
- C. Direct and indirect costs of work-related injuries are estimated to be \$54 billion annually.³

III. Pathogenesis

- A. Pathogenesis specific to soft tissue:
 1. Overuse/overload, abnormal biomechanics, trauma¹⁰, or fatigue⁴ cause mechanical stress that exceeds the limits of what the body can adapt to or heal.
 2. Pathologic changes occur in the tissue.⁴
 3. In tenosynovitis the tendon sheath tissue changes to irregular connective tissue that significantly increases the sheath's thickness.¹¹
 4. The compression inhibits blood flow, nutrition, and healing¹¹ while causing changes in the tendon such as an enlarged nodule or narrowing.¹⁰
 5. Tendons in general have poor vascularity which may contribute to their poor healing.¹²
 6. Current research indicates that many chronic tendon disorders in the UE (such as lateral epicondylitis and DeQuervain's) are degenerative in nature and not inflammatory.^{10, 12, 13}
 7. The presence of neurochemicals related to pain¹² and the changes to the innervated tenosynovium¹¹ may explain why these non-inflammatory tendinoses often result in pain.
- B. Pathogenesis specific to nerve compression: ¹⁴
 1. Pressure causes breakdown of the blood/nerve barrier.
 2. Subperineurial edema & fibrosis follows.
 3. Local demyelination occurs and eventual Wallerian degeneration.

IV. Musculotendinous disorders

- A. Epicondylitis: Traditionally referred to as tendonitis or epicondylitis these terms are incorrect. Recent research has shown that these conditions are not inflammatory, rather they are degenerative. Therefore epicondylitis is a more appropriate term. Most commonly affects the dominant arm.¹²
 1. Lateral Epicondylitis (Tennis elbow): Chronic degeneration of the extensor carpi radialis brevis (ECRB) origin and at times the extensor digitorum communis.¹³
 - a. As there is not active inflammation the actual cause of pain is not known. It has been proposed that chemical mediators from the soft tissue damage may activate the nociceptors.^{12, 15}

Signs/Symptoms:

1. Activity-related pain near the lateral epicondyle which may radiate into the forearm.¹³
2. Pain with palpation of the ECRB and possibly EDC origins at the lateral epicondyle.¹³
3. Pain exacerbated with activities that require gripping.¹²

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4. Pain with resisted wrist extension, radial deviation, finger extension, or forearm supination. These may be worse when performed with elbow extension.¹²
5. Positive Cozen's test – The examiner's thumb lies on the lateral epicondyle as one hand supports the elbow. Resisted wrist extension and radial deviation that cause pain at the lateral epicondyle is considered a positive test.¹²
6. The EDC origin can be tested by beginning with elbow extension, pronation, and finger extension. Resistance given at the MCPs of all digits or of the middle finger only. Positive if pain produced at lateral epicondyle and not radial tunnel.¹³
7. Pain with passive stretch into pronation, wrist flexion, and elbow extension.¹²
8. Pain free grip strength (performed with elbow extension) can be used to assess progress.¹²

Causes:

1. Overuse involving force, repetition, and awkward postures.¹²
2. Repetitive forearm and wrist movements such as keyboard & mouse use, plumbing, meat cutting, writing, etc.¹⁵
3. Prolonged arm use with extended elbow and wrist extension.
4. Occasionally may be due to a single traumatic or forceful activity such as heavy lifting.^{12, 15}

Differential Diagnosis:

Cervical radiculopathy C5-C7, TOS, Radial Tunnel Syndrome¹² radiocapitellar joint pathology, posterolateral rotatory instability of elbow, radial plica syndrome¹³ (a band of synovial tissue that snaps and is painful with elbow motion).

Maximum tenderness and pain is within 1-2 cm of the lateral epicondyle. If pain is further distal other conditions such as Radial Tunnel Syndrome are a more likely cause.¹³ See RTS section for detail in differentiating these two diagnoses.

Clinical Tip: Care must be taken to differentiate radial tunnel syndrome from lateral epicondylitis. While a counterforce brace is a common treatment for epicondylitis it could exacerbate compression of the radial nerve.¹⁶

Conservative Management:

Focus placed on decreasing stress to injured tendon and increasing its tolerance of stress through increased strength and endurance.¹³ May take 2-3 months.

1. Relative rest¹⁵ and avoiding repetitive wrist flexion and extension, gripping activities, and awkward or static postures.¹²
2. Ergonomic modifications.¹²

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- a. Split keyboard that is tented/raised in the middle to eliminate ulnar deviation at the wrist and decrease pronation.¹
 - b. Alternative input device to avoid moving mouse with wrist deviation and provide more neutral wrist posture. Examples could include graphic/pen tablet or alternative mouse shape that reduces pronation and wrist extension postures. (See Figure 2)
 - c. Proper height of keyboard & mouse to eliminate wrist extension or flexion.¹⁷
 - d. Proper matching size of tool handle to the client's hand.^{12, 15}
 - e. Teach lifting techniques that keep arms close to the body and supinated¹² and avoid lifting with elbows extended.
3. Counterforce bracing to reduce stress applied to tendon by dispersing force.¹² Worn during stressful activities, work, sport, and rehabilitative exercise.¹³
 4. Modalities
 - a. Ultrasound – to reduce pain and stimulate healing.¹²
 - b. Phonophoresis¹²
 - c. Iontophoresis¹²
 - d. Laser or Low Level Light Therapy¹²
 - e. Electrical stimulation to reduce pain and stimulate healing¹² specifically high-volt stimulation.¹⁵
 - f. Heat¹²
 - g. Ice massage¹²
 5. Professional correction of sport technique.^{12, 13}
 6. Stretch of ECRB & EDC.¹²
 7. NSAIDS may be used for management but have no long term curative effect.¹³
 8. Steroid injections provide short term relief but multiple injections may actually be deleterious to the tendon.^{13, 15}
 9. Cross-friction massage is a common treatment though there are not adequate studies to determine it's effectiveness.¹²
 10. Wrist extension orthoses are advocated by some though care must be taken due to concern of atrophy.¹⁵ Commonly done in 15 degrees of extension though some authors recommend 35-40 degrees of wrist extension to rest affected structures and improve grip.¹²
 11. Strengthening and endurance exercises done in 2 phases, with counterforce brace. There is not consensus on the best protocol or whether exercises should be progressed by the absence of pain¹³ or include painful eccentric strengthening.¹²

Generally the initial focus is on pain reduction, eliminating aggravating forces, and strengthening. Exercises often done in 90 degrees of elbow flexion and gradually increase in repetitions.¹³ These typically include:

- a. Parascapular and postural exercises^{12, 13}
- b. Isometrics of the wrist and forearm¹²
- c. Hand strengthening¹²

They are progressed to increase repetitions and force with concentric and eccentric strengthening to include the entire upper extremity. Some authors

Chapter 22 Figures



FIGURE 1.

Repetitive twisting and awkward positions place undue strains on muscle-tendon units placing workers at risk for developing cumulative trauma disorders.



FIGURE 2

Graphic tablets allow more neutral upper extremity postures than a standard mouse.

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advocate progressing only once pain free at rest and minimal resting pain¹²
though this is an area lacking consensus.

Surgical Management:

For clients who do not respond to ≥ 3 months of conservative treatment.¹³

1. Open, percutaneous, or arthroscopic procedure to remove diseased tissue.¹²
2. 85-97% success rate.¹⁸ Complete recovery including strength, flexibility, and pain resolution typically 2-6 months.¹³
3. Clients with arthroscopic and percutaneous techniques return to work approximately 3 weeks earlier than open procedures.¹⁸

Post-operative rehabilitation:

1. Gentle AROM started a few days after surgery.¹³
 2. Modalities to decrease pain and edema.¹⁸
 3. May initially include wrist orthosis to protect healing tissues.¹⁸
 4. Scar desensitization and management.¹⁸
 5. Progressive return to activity as tolerated.¹³
 6. At 6-12 weeks begin strengthening as tolerated with counterforce strap and exercises above.¹⁵
2. Medial Epicondylitis (Golfer's elbow): Microtearing and chronic degenerative tendinosis of the origin of the pronator teres and flexor carpi radialis.¹³

Signs/Symptoms

1. Pain and tenderness at or just distal to the medial epicondyle at the flexor pronator origin.¹³
2. If pain further than 1-2 cm distal to medial epicondyle other diagnoses should be considered.¹³
3. Occurs more in males than females by a 2:1 ratio.⁸
4. Associated ulnar neuropathy in 50% of cases.⁸
5. Starting in slight elbow flexion and supination, pain with resisted wrist flexion and indicates FCR tendon involvement.¹³
6. With elbow extension and forearm neutral grasp as if shaking client's hand. Medial elbow pain with resisted pronation indicates pronator teres involvement while paresthesias in radial digits may indicate pronator syndrome.¹³
7. Pain with passive elbow extension, supination and wrist extension stretch.¹⁸

Causes:

1. Overuse with repetitive pronation and flexion of the elbow against resistance^{13, 18}
 - a. Examples include golf, throwing, brick laying.¹³

Differential Diagnosis:

Cervical radiculopathy, TOS, musculoskeletal disorders of shoulder, Cubital tunnel syndrome, snapping medial head of triceps, triceps tendinopathy is more posterior and reproduced with resisted elbow extension, medial ulnar collateral ligament injury, arthritis.⁸

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Conservative Management: Successful in 90-95% of cases⁸

1. Same treatments listed above for lateral epicondylitis.¹³
2. Avoid lifting with supinated forearms. Lift in pronation with arms close to side to minimize stress of the flexor pronator origin.¹³
3. Corticosteroid injection.¹³

Surgical Management: 95% good to excellent results unless significant ulnar nerve involvement. May take 6-24 months^{8, 18}

1. The degenerated tendon is excised.¹³
2. May include release of ulnar nerve to prevent compression from post-operative swelling.¹³
3. If ulnar nerve subluxation then subcutaneous transposition performed.¹³

Post-operative rehabilitation:

1. Post-operative rehabilitation similar to lateral epicondylitis.¹⁸
2. Possible immobilization for 1-3 weeks or use of a wrist orthosis initially.¹⁸

- B. DeQuervain's Tenosynovitis: Degeneration and thickening of the tendon sheath of the abductor pollicis longus & extensor pollicis brevis tendons as they pass through the first dorsal wrist compartment.¹¹

Signs/Symptoms:

1. Pain & edema over the radial styloid that may radiate into the thumb or forearm.¹¹
2. Ganglion may be present in the same area.¹³
3. Women > men 4:1, especially if pregnant or new mothers.¹¹
4. Pain with Finkelstein's test (thumb flexed within fist and ulnarly deviation).¹¹
5. Finkelstein's test may be modified by adding wrist flex which should increase symptoms and extension should reduce symptoms.¹¹
6. Pain with resisted thumb extension.¹¹

*Causes:*¹¹

1. Forceful, sustained, or repetitive thumb abduction with ulnar deviation of the wrist such as when opening jars, using scissors, or typing while ulnarly deviated.
2. Radial deviation with pinch may also strain the tendons at distal edge of pulley.
3. Traumatic injury can occur due to sudden twisting of wrist and thumb while restraining an object.

Differential Diagnosis: Arthritis, scaphoid fracture, carpal instability, intersection syndrome, Wartenberg's syndrome (DRSN compression).¹¹

Conservative Management:

1. Split ergonomic keyboard to eliminate ulnar deviation at wrist.¹¹
2. Power tools with pistol grip that minimize wrist deviation.¹¹
3. Avoid lifting with neutral forearm position, especially with ulnar deviation as occurs when lifting a child.¹³
4. Long opponens orthoses are common though not currently proven in the literature.¹³
5. Corticosteroid injection – 1-2 injections have a success rate of 50-90%.¹¹

Surgical Management: Insufficient relief with conservative management can be treated with release of first dorsal compartment.¹³

Post-operative management:

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1. Long opponens orthosis with IP free for 7-14 days.^{11, 13}
2. Tendon gliding and gentle AROM started in first few days to eventually reproduce Findlestein's test without pain.¹¹
3. Grip and pinch strength at 2 weeks.¹¹
4. 6 weeks, resume heavy activities.¹¹

- C. Intersection Syndrome: Stenosing tenosynovitis of the radial wrist extensors (ECRB & ECRL) in the second dorsal wrist compartment where the tendons cross underneath the APL and EPB tendons.

Signs/Symptoms:

1. Pain & edema over dorsal wrist 4-8 cm proximal to Lister's tubercle.¹¹
2. Crepitus or squeaking with thumb and wrist motion.¹¹
3. Painful weak grip and pinch.¹¹
4. Pain with resisted wrist extension.¹³
5. Pain with passive wrist flexion.¹³

Causes:

Overuse from repetitive wrist extension or thumb motion such as in turning or twisting. Common in activities such as weight lifting, skiing, & rowing.^{11, 13}

Conservative treatment:

1. Long opponens or wrist extension orthosis.^{11, 13}
2. Avoid aggravating activities such as repetitive wrist flex and extension.¹⁴
3. Corticosteroid injection.

Surgical Management:

Surgical release of second dorsal wrist compartment and possible removal of inflamed bursa.¹¹

Post-operative Rehabilitation:

1. Wrist orthosis in 20 degrees of extension 1-2 weeks.¹³
2. At that point, wean orthosis and perform ROM.

- D. Wrist tendinopathies: Several tendons inserting into or travel past the wrist are prone to tendinopathy. The FCR, FCU, EPL, EIP, ECU, and insertions of the ECRL and ECRB can undergo microtearing, fraying, stenosing tenosynovitis, and/or degeneration.¹¹

Causes:

1. Repetitive overuse of wrist and thumb in activities such as using a screwdriver or wringing out a cloth.¹¹
2. Racquet sports such as golf or tennis that require repetitive wrist motions and sudden acceleration and deceleration.¹¹

Signs/symptoms:

1. Pain may be present at the site of insertion or radiate proximally or distally.¹¹
2. Edema¹¹
3. Reproduction of pain with passive stretch or resisted contraction of the involved structures.¹¹
4. Crepitus¹¹

Conservative Management:

1. Wrist orthosis to shorten and rest the tendon.¹¹
2. Modalities to reduce pain, edema such as ice.¹¹
3. Activity modification to alter ADL and work tasks to avoid exacerbating motions and activities (such as avoiding pressure through extended wrist and pisiform/FCU)¹¹
4. Correction of sport and musical instrument technique¹¹
5. NSAIDS¹¹
6. Corticosteroid injection¹¹

Surgical Management:

If conservative treatment fails, surgery to release tendon sheaths and decompress the tendon may be beneficial.¹¹

Post-operative Management:

Depends on specific structures involved but may include scar management, pain management with physical agent modalities, tendon gliding, activity modification and ergonomic training.¹¹

- E. Finger/Trigger Thumb: Swelling, thickening, and degenerative changes of the tendon and tenosynovium typically at the A1 pulley^{11, 13}

Signs/Symptoms:

1. Palpable nodule¹¹
2. Pain at A1 pulley or PIP joint.¹³
3. Dorsal pain can occur due to secondary strain on extensor tendon.¹¹
4. Catching of tendon, locking, or triggering of digit. In severe cases passive assist may be necessary to extend digit.¹¹
5. Flexion contracture at PIP joint.¹³

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Causes:

1. High force gripping.¹¹
2. Direct compression of A1 pulley from tool use or other sources.¹¹ (See Figure 3)

Differential diagnosis: Extensor tendon subluxation, loose body in MCP joint, volar plate avulsion, tumor, tendon laceration, rheumatic conditions.¹³

Conservative Management:

1. Activity modification to eliminate causative factors.¹⁹
2. Modify tools with larger handles to require less finger flexion and more evenly distribute forces. Some tools have large triggers that can be operated with several fingers.
3. Trigger finger: Orthosis with MCP or DIP joint in extension. Trigger thumb: IP extension orthosis.¹³
4. Hook fist AROM for tendon gliding.¹¹
5. PROM to prevent or improve stiffness of joint.
6. Corticosteroid injections 50-94% effective.¹¹

Surgical Management: Indicated if failed conservative treatment or if fixed flexion contractures. Open or percutaneous procedures have $\geq 85\%$ success¹¹ and return to unrestricted work is typically in 4-8 weeks.¹⁹

Post-operative Rehabilitation:

Immediate AROM and tendon gliding, edema management, scar management & desensitization, and ROM for PIP contractures. Strengthening at 3 weeks but not to include forceful composite fistings.¹¹

V. Neurovascular Disorders

- A. Thoracic Outlet Syndrome (TOS): Compression of the brachial plexus (neurogenic TOS), subclavian vein (venous TOS) and/or artery (Arterial TOS) in the thoracic outlet.²⁰ Compression can occur at the interscalene triangle, between the clavicle and the first rib, or beneath the coracoid process. (See Figure 4)

Signs/Symptoms

1. Affects women more often than men (3:1 ratio)¹⁶, typically between 20-50 years of age.²¹
 2. Symptom presentation makes it difficult to differentiate from other nerve compression syndromes.
1. Neurogenic TOS:
 - a. Most commonly results from neck trauma such as whiplash injury with scarring of the scalenes, hypertrophy, and fibrosis of the anterior scalene.²⁰
 - b. Repetitive stress injuries are the second most common cause.²⁰
 - c. Poor posture.²⁰Neurogenic can be further divided into 2 categories

Chapter 22 Figures

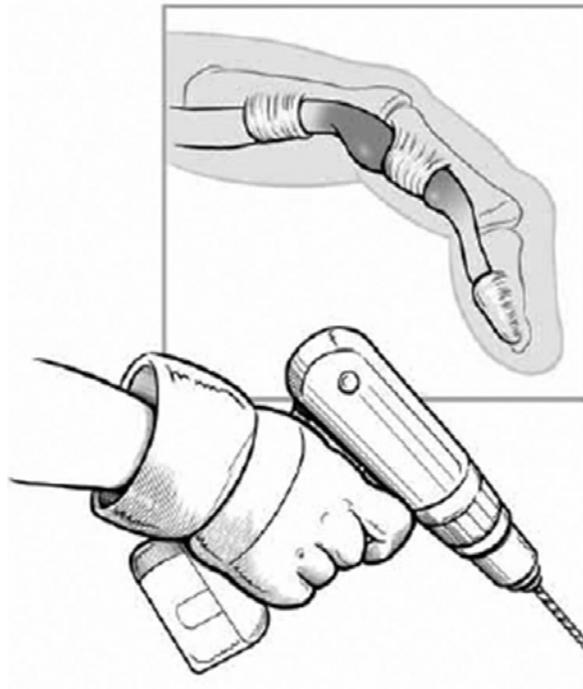


FIGURE 3

Forceful grip and pressure from the tool surface can lead to the development of trigger finger.

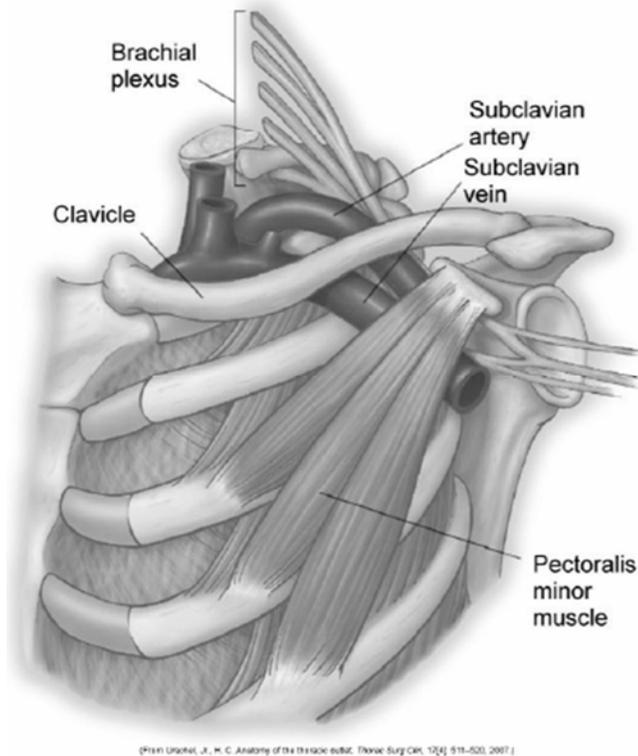


Figure 4

Anatomy of the Thoracic Outlet

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- i. True TOS – rare, with objective signs of nerve compression, usually in lower brachial plexus.
 - A. Symptoms include paresthesias in medial forearm, ring, and small finger; intrinsic wasting; decreased grip; hypothenar atrophy, and minimal pain.
 - B. Almost always occurs from bony anomaly such as a cervical rib.²⁰
- ii. Disputed TOS – most common type of TOS. No objective findings or positive electrodiagnostic tests, therefore diagnosis is mostly clinical.²⁰
 - A. Symptoms vague and include shoulder pain, extremity weakness, headache, neck and scapular muscle spasm, arm dysesthesia, paresthesias in medial forearm and digits 4, 5 or entire arm.²⁰
 - B. Fatigue of extremity especially in intrinsic muscles.²⁰
 - C. Symptoms worse with overhead activity.²⁰
 - D. Vascular symptoms such as swelling, cyanosis, and a cool hand.²⁰

2. Arterial TOS

- a. Less than 1% of TOS cases.
- b. Typically from a bony abnormality such as well-developed cervical rib with dense fascial bands, elongated transverse process of C7, or clavicular malunion.²⁰
- c. Rapidly evident and can result in limb-threatening ischemia.²⁰

*Signs/symptoms*²⁰

1. Pain
2. Pallor
3. Pulselessness
4. Paresthesias
5. Unilateral Raynaud's disease may be indicative.
6. Possible positive Adson's test or Wright's hyperabduction maneuver.
7. Treatment requires surgical decompression.

3. Venous TOS²⁰

- a. Represents 2-3% of TOS cases.
- b. Typically occurs in costoclavicular space.
- c. Tx with surgical decompression by transaxillary first rib resection.

Causes: Compression has been associated with

1. fascial bands²⁰
2. anatomical anomalies of the first rib, scalene anatomy, or cervical ribs.²⁰
3. Space occupying lesions or hematoma.²⁰
4. Inflammation²⁰
5. Fibrosis due to trauma.²⁰
6. Overuse of scalene.²⁰
7. Poor posture with drooping shoulders.²⁰
8. Overhead work can cause compression as abduction stretches the neurovascular bundle around the coracoid and tenses the pec minor.²⁰

Differential diagnosis: Primarily a clinical diagnosis with studies to rule out other diagnoses.²⁰

Cervical radiculopathy, myofascial trigger points, visceral pathology, impingement, distal nerve compression.^{20,16}

May occur simultaneously with other nerve compressions in a double-crush phenomenon.

Carpal tunnel syndrome is the most common co-morbid compression.²⁰

Diagnostic studies may include c-spine & chest radiographs, electrodiagnostic tests,

Somatosensory Evoked Potential²⁰, noninvasive vascular labs such as Duplex

ultrasonography, MRI, & CT angiography. Angiography and venography are gold

standard for arterial and venous TOS. No gold standard studies to confirm neurogenic

TOS.²⁰

Provocative Tests & Physical Exam for TOS:

Numerous tests have been advocated over the years but none are as reliable, sensitive, & specific as would be desired.^{20,22} A thorough patient history and clinical exam is essential in correct diagnosis.²¹

1. Adson's test: Arm at side and hyperextend neck, turn the face toward affected side, client takes deep breath. Positive if obliteration of radial pulse with inspiration and symptom reproduction. Controversial as to value in TOS diagnosis (Tests for neurogenic and arterial compression)²⁰
2. Modified Wright's Hyperabduction test: Arm external rotation and horizontally abducted with 90° of elbow flexion. Positive exam if decrease in pulse as client inhales. Reproduction of symptoms considered positive result by some. Some advocate test done with extended elbow.²⁰
3. Roos' test (Elevated arm stress test): 90 degrees of abduction and elbow flexion and external rotation. Open and close hands slowly for 3 mins. Reproduction of symptoms or rapid fatigue is positive. Most diagnostic value with rapid symptoms. Positive in up to 94% with neurogenic TOS.²⁰
4. Hunter's Test (Brachial plexus tension test for lower plexus): arm at 90 degrees abduction, elbow extension, wrist extension, and supination. Positive if reproduce pain and paresthesias in medial forearm & digits 4,5.²⁰
5. Upper limb tension test of Elvey performed in 3 positions.
 - Position 1: ABDuction of both arms to 90° with elbow extended.
 - Position 2: Position 1 plus extension of wrists.
 - Position 3: positions 1 & 2 plus tilt head to contralateral side.Positive test with pain and paesthesias radiating down arm. Position 1 shows strongest evidence if in position 1. Positive in 98% of patients with TOS.²⁰

Conservative treatment:

1. Postural correction including scalene & pectoralis stretches, strengthening of rhomboid and parascapular muscles.^{20,21,16}
2. Nerve glides²⁰
3. Education on avoiding overhead activity and body mechanics.¹⁶

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Surgical Management: If conservative treatment fails after 3 months first rib removal or scalenectomy and neurolysis are recommended.¹⁶ If venous or arterial compromise surgery may be done immediately.²⁰ 70-90% have good to excellent results with surgery²⁰ and may take 3-4 months.¹⁶ Factors associated with persistent disability after surgery include history of major depression, being unmarried, & less than a high school education.²⁰

B. Pronator Syndrome: Compression of the median nerve in the proximal forearm.

Areas of possible compression (proximal to distal): ligament of Struthers, lacertus fibrosus (also known as the bicipital aponeurosis), between the heads of the pronator teres muscle, fascial arch of the flexor digitorum superficialis²³, or vestigial muscles and variations in muscular anatomy.²⁴

Signs/Symptoms:

1. Pain in the volar forearm with occasional proximal radiation often described as dull¹⁶, aching,²³ or fatigue-like that often starts insidiously.²⁴
2. Numbness in the median nerve distribution of the hand including over the thenar eminence & palm (as the palm typically has intact sensation with carpal tunnel syndrome this may aide in differential diagnosis).²³
3. Symptoms are not typically present at night. This may aide in differentiating pronator syndrome from carpal tunnel syndrome.²³
4. Possible weakness in opposition and resisted pronation.¹⁶
5. More common in women.²⁵

The site of compression can be assessed with positive findings on the following tests.

Pronator Teres:

1. Pain with resisted pronation with neutral forearm as elbow gradually extended.²³
2. Pressure applied to the pronator teres muscle (4 cm distal to the elbow crease) can be compared to the asymptomatic extremity. Positive if paresthesias occur in the median nerve distribution of involved extremity within 30 seconds and do not occur in the uninvolved arm.²³ This test may be modified by adding resisted pronation while the pressure is applied.²⁴

Lacertus fibrosis (Bicipital aponeurosis)

Resisted supination and elbow flexion at 120-130 degrees causes the bicep to tighten the lacertus fibrosis and pain.²³

Flexor Digitorum Superificalis

Symptoms with resisted flexion of the MF PIP from tightening the fibrous arch of the origin of the FDS.²⁴

Causes:

1. Repetitive strenuous motions involving pronation/supination such as weight training, driving, or work tasks.²⁴
2. Repetitive elbow flexion/extension.²⁵

Diagnosis:

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1. Diagnosis must often rely on history and physical exam.²⁴
2. Electrodiagnostic tests typically are not positive and may provide the most benefit by ruling out other median nerve entrapments such as carpal tunnel syndrome.^{23, 24}
3. MRI and radiography may identify space-occupying lesions or a supracondylar processes of the humerus.¹⁶

Differential diagnosis:

Cervical radiculopathy, TOS, CTS.²³ (See Table 1)

Conservative treatment:

1. Avoid repetitive pronation/supination, elbow flexion/extension, or forceful gripping activities. This should include work tasks as well as ADL/IADLs such as holding steering wheel at 9 and 3 o'clock position and pushing items such as shopping carts and lawnmowers with neutral forearms.²⁵
2. Ergonomic recommendations including an adjustable split keyboard to minimize pronation while typing, vertical mouse or alternative input device such as a pen tablet that will avoid pronation, & use of tools with a pistol grip to maintain a neutral forearm.²⁵
3. Posterior elbow orthosis with 90 degrees elbow flexion and a neutral forearm for 2 weeks removed for gentle ROM.²⁵
4. Neural mobilization²⁵
5. Kinesiotaping to unload the flexor-pronator mass.²⁵
6. Corticosteroid injection²³

Surgical Management: Recommended if not progressing with conservative treatment in 2-3 months.²³ Decompression of median nerve along anterior medial side of elbow and forearm at site of entrapment.¹⁶ This involves a long incision that must be addressed post-operatively. The Pronator Teres origin is often released and reattached and therefore must be protected by avoiding end range supination.²⁵ Excellent outcomes are shown to be 85%-90% following decompression.²³

Post-surgical Rehabilitation:

1. Elbow immobilized in orthosis at 90 degrees of flexion. Some surgeons may include 45 degrees of pronation and slight wrist flexion.²⁵ Wearing schedule varies from until wound healing and sutures removed to night time only after follow up visit at day 3-5.²³
2. Elbow and wrist and fingers ROM initially avoiding end range supination.^{23, 25}
3. Avoid resistance for 6-8 wks if Pronator Teres released and reattached.²⁵
4. Strengthening may be initiated between 4-8 weeks depending on the procedure.^{25, 16}
5. Neural mobilization²³
6. Scar Management and desensitization.²³

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Return to work:

Typically able to return to work without restrictions in 6-8 weeks.²³

- C. Anterior Interosseous Nerve (AIN) Syndrome: Compression of the anterior interosseous branch of the median nerve from the tendon or origin of humeral head of pronator teres, arch of the FDS, accessory head of FPL, accessory lacertus fibrosis, or tendon of an anomalous palmaris profundus.²³

Signs/Symptoms:

1. Vague or deep pain in proximal forearm aggravated with repetitive forearm motion which subsides quickly.^{23, 24}
2. Absence of paresthesias as this is a purely motor deficit.²³
3. Weakness of Flexor Pollicis Longus, Flexor Digitorum Profundus to index and middle fingers, and the Pronator Quadratus.^{23, 16}
4. Lack of dexterity or weak pinch²⁴ resulting in difficulty with fine motor tasks such as writing, buttons, or picking up small objects.
5. Inability to flex the distal IP joints of the IF and thumb.^{23, 24}
6. Due to the inability to flex the thumb IP and index DIP they hyperextend during pinch (as when making the OK sign).²⁴

Clinical tip: The Pronator Quadratus can be tested by having the elbows at right angles against the side as this reduces the contribution of the Pronator Teres and isolates Quadratus.²⁴

Causes:

Repetitive strenuous motions involving pronation/supination such as weight training, driving, or work tasks.²⁴

Differential Diagnosis:

Cervical radiculopathy, TOS, CTS,²³ Parsonage-turner syndrome after viral illness or vaccination,²⁵ tumor, thrombosed vessels, or fractures that may contribute to compression.²⁵

Clinical tip: To distinguish between an FDP avulsion and AIN syndrome use the tenodesis effect. Bring the wrist and thumb into passive extension. If function is impaired due to AIN denervation but the tendon is intact the IPs of the thumb and index will flex. If there is tendon rupture the IPs will not flex.¹⁶

Conservative Management:

1. Patient education on how to avoid aggravating activities such as those that require repetitive gripping and forearm rotation.²³
2. Improve fine motor function through compensation with zipper pulls, large diameter pens.²⁵
3. Silver ring or Oval-8 orthoses can stabilize IP joints in flex to aide tip pinch.²⁵

Surgical Management: Surgery typically not done for 6 months to be sure symptoms do not resolve independently.²⁴ The surgical technique is the same as for pronator syndrome.

*Post-surgical Rehabilitation:*²⁵

1. Same treatments as under conservative management
2. Scar management
3. Edema control
4. Pain management
5. Recovery may take > 6 months.

- D. Carpal tunnel syndrome (CTS): Compression of the median nerve at the carpal tunnel. The carpal tunnel is a passage formed by the carpal bones and the transverse carpal ligament (flexor retinaculum.) Nine flexor tendons and the median nerve pass through the carpal tunnel.²⁶

Signs/Symptoms:

1. Intermittent or constant numbness and paresthesias in the thumb, index, middle, and radial aspect of the ring finger.^{26, 16}
2. Wrist or hand pain²⁶
3. Motor deficits (hand weakness/clumsiness/thenar atrophy) often evident in advanced cases.^{26, 16}
4. Symptoms generally worse at night^{26, 16}
5. Symptoms may occur with forceful or sustained grip/pinch, repetitive wrist motions, or prolonged awkward positions^{14, 16, 26, 27}
6. Decreased sensibility on Semmes Weinstein in chronic CTS²⁶
7. Positive Carpal Compression Test^{16, 26, 28}
8. Positive Phalen's Test^{16, 26}
9. Positive Tinel's^{16, 26}
9. Positive Lumbrical IncurSION/Berger's Test

Causes:

1. CTS occurs from increased pressure within the carpal tunnel. Increased carpal tunnel pressures can result from vibration²⁹, wrist postures, sustained holding or gripping, or external pressure.²⁷ (See Figure 5)
2. There is conflicting evidence regarding the relationship between work factors and CTS. Some studies show an increased risk for CTS with combined work factors such as repetition, faulty postures,²⁷ speed of work, absence of rest breaks²⁹, and forceful grip.²⁶ Other studies have not found an association and a cause-and-effect relationship has not been definitively proven.²⁷
3. Most frequent in women between ages of 37 and 55.^{29, 16}
4. Complication of distal radius fractures.²⁶

Diagnosis:

Positive Nerve conduction study, however up to 15% of patients with surgically relieved symptoms have normal electrical studies.²⁶

Symptom resolution after local steroid injection confirms diagnosis and may be indicative of a favorable surgical outcome.²⁶

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Differential diagnosis:

C6-8 cervical radiculopathy, more proximal median nerve compression such as pronator syndrome, diabetic neuropathy, tenosynovitis of digits or wrist.^{26,27}

Conservative Management: Used for mild CTS, typically not effective for moderate or severe CTS.²⁶

1. Immobilize the wrist in an orthosis in neutral at night or full time. Correct orthosis adjustment is important as intraneural pressure in the wrist can be increased by 20 degrees of flexion or extension.²⁷ The optimal wrist position in the orthosis is 2 degrees flexion and 3 degrees ulnar deviation.²⁷
2. Lumbrical incursion into the carpal tunnel has been shown to increase intratunnel pressures. For individuals with well developed lumbricals and those who repetitively flex the fingers the metacarpals may be included in the wrist orthosis and positioned between 20-40 degrees of flexion to limit lumbrical incursion.²⁷ (See Figure 6)
3. Avoid positions and tasks that increase carpal tunnel pressure (sustained or repetitive wrist flexion or extension, sustained or repetitive pinch, forceful grip, direct pressure over the carpal tunnel, and vibration).^{27,29}
4. Ergonomic changes to include:
 - a. Split, tentable (raised in the middle), low-force keyboard to minimize awkward postures in the wrist and required typing force¹
 - b. Avoiding direct pressure on the volar wrist from hard surfaces¹ such as the desktop
 - c. Proper workstation height, specifically of the keyboard and mouse, to optimize wrist and UE postures¹
5. Tendon and nerve gliding exercises^{28,30,31}
6. Modalities including pulsed ultrasound³², low level laser therapy^{28,33} phonophoresis,³⁴³⁵ & iontophoresis.³⁶
7. Carpal bone mobilization.³⁷
8. Steroid injection.¹⁶

Surgical Management:

Surgical release recommended for clients with moderate to severe CTS, especially those with atrophy or significant sensory impairment.²⁶

Release of the transverse carpal ligament using an open or endoscopic technique.¹⁶

Post-operative Rehabilitation

Post-operative treatment results in faster return to work, however it had no effect on functional recovery or symptom reoccurrence.²⁷

Post-op treatments may include use of wrist orthosis for 2-3 weeks to prevent wound site tension, scar management, tendon gliding, nerve gliding, edema control, wound care, ROM for the fingers and wrist, and ergonomic recommendations.²⁷

Return to work

Time between surgery and return to work dependent upon motivation, handedness, affected side, and specific work requirements.²⁶

- E. Cubital Tunnel Syndrome: Compression or trauma to the ulnar nerve at the cubital tunnel just proximal or distal to the medial epicondyle. The site of compression can be the at the Arcade of Struthers (8 cm proximal to the medial epicondyle)²⁴; medial head of triceps¹⁶; an anomalous

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	Carpal Tunnel Syndrome	Pronator Syndrome
Nocturnal symptoms	+	-
Muscular fatigue	-	+
Proximal radiation	±	+
Thumb paresthesias	±	+
Thenar atrophy	+	-
Phalen's sign	+	-
Pronator signs	-	+
Electromyography	+	-

TABLE 1.
**Comparison of Findings Between the Carpal Tunnel Syndrome
and the Pronator Syndrome**



FIGURE 5
**Improper mouse and keyboard height create
awkward wrist postures and contact pressures.**



FIGURE 6
**Wrist and MCP orthosis to
minimize lumbrical incursion
into the carpal tunnel.**

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muscle called the anconeus epitrochlearis near the medial epicondyle²⁴; the cubital tunnel retinaculum²⁴, or between the heads of the FCU¹⁶. (See Figure 7)

Signs/Symptoms:

1. Paresthesias in digit 5, the ulnar aspect of digit 4, and the dorsoulnar hand. These may be worsened by elbow flexion & may awaken patient from sleep.²⁴
2. Sensory loss in digits 4,5 and dorsoulnar hand.²⁵
3. Decreased Semmes – Weinstein in ulnar nerve distribution.¹⁶
4. Abnormal two –point discrimination in severe cases¹⁶
5. Weakness in FDP to ring and small fingers and intrinsics may cause minimal clawing.^{24, 16}
6. Wasting of 1st dorsal interossei in thumb-index web space.¹⁶
7. Clumsiness and weakness of grip and lateral pinch²⁵
8. Wartenberg's sign (inability to adduct small finger) indicates weakness of intrinsic musculature.³⁸
9. Tinel's sign at the cubital tunnel.¹⁶
10. Froment's sign as FPL compensates for FPB.²⁵
11. Palpable subluxation of nerve at cubital tunnel with elbow flexion.²⁵
12. Positive elbow flexion test²⁵ with supination and wrist neutral for 60 seconds.²⁵
13. Positive pressure provocation test with 20 degrees of elbow flexion and supination pressure applied to nerve for 60 seconds.³⁹
14. The pressure provocation and flexion tests can be combined.
The combined pressure provocation and flexion test is the most sensitive and specific of these tests.

Causes: Compression or pressure, stretch, traction, or friction from one of the following:

1. Direct pressure¹
2. Flexion of elbow causing narrowing of the cubital tunnel and increased pressure on the nerve.²⁵
3. Hypermobile nerve that subluxes from posterior to anterior of medial epicondyle.^{6(p.1100)}
4. Cubitus valgus or varus deformities.²⁴
5. Repeated resisted elbow extension may cause the Anconeus epitrochlearis, an anomalous muscle, to contract and compress the nerve.²⁵
6. Arthritis or ganglion from elbow joint.²⁴

Differential Diagnosis:

C7-C8 radiculopathy²⁴, TOS, ulnar nerve compression at Guyon's canal¹⁶, double crush syndrome²⁴
EMG/NCV can determine presence and severity of compression.¹⁶

Conservative Management:

1. Education to modify activities to minimize sustained elbow flexion (such as lowering keyboard/mouse height⁴⁰ and use of a phone headset²⁵, avoid repetitive elbow flexion/extension, and direct pressure on nerve (leaning on the elbow²⁵, armrest, desk, or hard work surface).¹ Round and pad any edges of the work surface where the elbow may be rested (See Figure 8)
2. If need to support arms while typing, rest on the forearms and avoid pressure on the cubital tunnel.²⁵
3. Avoid elbow flexion greater than 60°. Use of night orthosis or pillow helps achieve this.²⁴

4. Postural correction/exercise²⁵
5. Avoid tricep strengthening.⁴⁰
6. Anti-claw orthosis as needed.²⁵
7. Nerve glides²⁵
8. Modalities³⁸

Surgical Management: Recommended if motor involvement, symptomatic subluxing ulnar nerve, or failed conservative treatment. Options including simple decompression/release, anterior submuscular or subcutaneous transposition, and medial epicondylectomy.¹⁶

Post-operative Rehabilitation: Continue with conservative management as well as the following.²⁵

- A. Submuscular Transposition – Treatment starts 2-3 weeks after surgery.
 1. Long arm orthosis with 90 degrees elbow flexion, forearm between neutral and slight pronation, and slight wrist flexion to protect the reattached flexor-pronator group.
 2. Orthosis removed several times a day for AROM of elbow, forearm, & wrist while maintaining slight pronation and wrist flexion to protect the reattached muscle group.
 3. Edema management
 4. Scar management
 5. Sensory desensitization
 6. Neural mobilization at 4 weeks.
 7. At 6 weeks PROM can be initiated and the orthosis discontinued.
 8. Strengthening at 8 weeks.

An alternate protocol is to begin only PROM at 2 weeks post-op to protect the reattached muscles and AROM at 4 weeks.

- B. Subcutaneous transposition²⁵–
ROM & sensory desensitization can begin without restriction post-operatively.
Neural mobilization with elbow held at 60-90 degrees of flexion.
Scar management;
Strengthening at 3-4 weeks.

Clinical tip: Paresthesias in volar **AND** dorsal aspect of the small finger and ulnar ring finger indicate the lesion is likely at the level of the elbow.⁵

Paresthesias or sensory changes **ONLY** in the volar small finger and ulnar ring finger indicates compression at Guyon's canal.^{23, 25} Significant clawing also typically occurs due to a wrist level lesion.^{24, 25}

- F. Ulnar Tunnel Syndrome or Guyon's Canal Syndrome: Compression of the ulnar nerve as it passes through Guyon's canal in the wrist.¹⁶ Only the ulnar nerve and ulnar artery pass through the canal; it contains no synovium, and for this reason compression here is less common than the median nerve in the carpal tunnel.

Compression sites (proximal to distal):²³

1. Zone 1: At wrist/transverse carpal ligament level. Both motor and sensory symptoms. Most common zone of injury.
2. Zone 2: Motor branch compression near hook of hamate. Motor deficits only.
3. Zone 3: Level of superficial sensory branches. Sensory deficits only.

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Signs/Symptoms: ²³

1. Pain and paresthesias in volar small and ulnar ring finger. Pain typically worse at night & may be exacerbated with wrist flexion or extension.
2. Sensory changes in volar small and ulnar ring finger.
3. Tenderness at hook of hamate.
4. Weakness in the intrinsic muscles, especially the interossei, ulnar lumbricals, and adductor pollicis. Hypothenar muscles may be spared with zone 2 injuries.
5. Ulnar claw deformity may result from prolonged compression.

Causes:

- A. Vibrational¹⁹ or pneumatic tools²³
- B. Direct pressure from bicycle handlebars²³, automotive steering wheels, & tools.²⁵ (See Figure 9)
- C. Using the hand as a hammer.²³
- D. Ganglia, tumors, and anomalous structures.²³
- E. Hook of hamate fractures.¹⁶

Differential Diagnosis: Cubital tunnel syndrome, TOS, C8 radiculopathy.¹⁶

Electromyography and NCV can confirm site of compression and severity¹⁹, CT or radiographs can rule out fracture of the hamate. Vascular studies to confirm vascular involvement such as aneurism. MRI to confirm mass, thrombosis/aneurism, hamate fracture, and flexor tendon pathology.¹⁶

Conservative management:

- A. Ergonomic modifications to include:
 1. Cessation of using hand as hammer.
 2. A split keyboard to eliminate ulnar deviation at the wrist and wrist extension to reduce nerve tension.²⁵
 3. Gel pads or wrist rests to redistribute direct pressure^{23, 25} when working on computer.
 4. Use or modify tools such as pliers with larger sleeves or foam wraps to make the handle longer so it does not end in the palm and more evenly distributes pressure to avoid nerve compression.⁴¹
 5. Padded gloves to protect from direct pressure in heavy or construction jobs.²⁵
 6. Avoid vibration or use antivibration gloves.¹⁹
 7. Avoid weight bearing or pressure on hypothenar eminence.²⁵
 8. Resting wrist orthosis²³
 9. Anti-claw orthosis as needed to improve grasp and hold.²⁵
 10. NSAIDS²³

Surgical management:

Recommended for space occupying lesion, aneurism, fracture, or if conservative treatment fails and proper diagnosis is certain.¹⁹

Ulnar tunnel release is used to decompress any areas of entrapment.²⁵

Often does not require post-op therapy unless pain or hypersensitivity persist.²⁵

Cold intolerance may occur after surgery for arterial disorders.¹⁹

Post-operatively most patients return to work at 6-8 weeks and achieve maximum medical improvement at 3-6 months.¹⁹

- G. Radial Tunnel Syndrome (RTS): compression of the radial nerve in the proximal forearm.¹⁶

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Signs/Symptoms:

1. Deep burning or aching pain in the extensor wad and along the course of the radial nerve. Pain occurs 4-5 cm distal to lateral epicondyle and may radiate proximally and distally.²³
2. Pain worse at night²³
3. Pain often present at rest²³
4. Pain worsened with pronation and wrist flexion activities.^{23, 25}
5. Sensory or motor symptoms not typical.²³
6. Resisted middle finger extension with elbow extension, pronation and neutral wrist. Positive when reproduces pain in area of radial nerve.²³
7. Pain with palpation in extensor musculature 4-5 cm distal to elbow.²³
During provocative testing the location of pain differentiates nerve compression from lateral epicondylitis.²³

Clinical Tip: The following tests are commonly positive in lateral epicondylitis but not in RTS:

1. Pain with passive stretch of common extensor origin (elbow extension with wrist and finger flexion).
2. Pain with resisted wrist extension.²³

Causes:²⁵

1. Use of pinching tools.
2. Repetitive force exertion greater than 1 kg (2.2#) more than 10x/hour.
3. Work in elbow extension.
4. Working with sustained forearm pronation or supination.
5. Compression from counterforce brace for lateral epicondylitis.

Differential diagnosis: PIN compression (see next diagnosis), intra-articular elbow pathology, lateral epicondylitis, TOS, cervical radiculopathy.²³
There is not consensus on whether electrodiagnostic exam is beneficial in RTS.²³

Conservative Management:²⁵

1. Education to avoid repetitive forearm rotation, wrist flexion/extension, elbow extension and prolonged static pinch and grip.
2. Ergonomic modifications to reduce static pronation and achieve neutral wrist:
 - a. Split & tented (raised in the middle) keyboard.
 - b. Alternative input device such as vertical mouse or graphic tablet using pen style input device.
 - c. Use of hand or power tools with pistol grip.
3. Restore length of supinator and ECRB muscles.
4. Neural mobilization
5. Wrist hand orthosis (wrist orthosis) in slight extension.
6. Kinesiotape to unload wrist extensors and facilitate supination.
7. Postural retraining

Surgical Management: If conservative treatment fails there are several approaches to decompression of the radial nerve.²³

Post-operative Rehabilitation:²⁵

8. AROM initiated at 3-5 days post-op.
9. Avoid combined elbow extension, pronation, and wrist flexion to avoid tensioning radial nerve and released soft tissues.

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10. Wrist extension orthosis not typical but if needed can be used intermittently for comfort and protection with ADL and work.
 11. Scar management and sensory desensitization.
 12. Neural mobilization
 13. Wrist and hand strengthening may be initiated at 3 weeks with progression to elbow and forearm at 6 weeks.
- H. Posterior Interosseous Nerve Syndrome: compression of the Posterior Interosseous Nerve (PIN) branch of the radial nerve. As this is a motor nerve weakness is the primary deficit. Recovery may take > 6 months.²⁵

*Areas of compression (proximal to distal):*²³

- 1) Thickened fascia from capsule of radiocapitellar joint.
- 2) Fibrous origin or fibrous bands from the ECRB.
- 3) Leash of Henry (blood vessels that travel across the radial nerve)
- 4) Proximal border of supinator (Arcade of Frohse) – most common area of compression.
- 5) Distal edge of supinator. (See Figure 10)
- 6) Resisted supination with elbow extension may be painful in patients with PIN compression at Arcade of Frohse.
**See RTS section to aide in differentiation from lateral epicondylitis.

Signs/symptoms:

1. Weakness of the supinator, digital extensors, and wrist extensors (excluding the ECRL.) This can be partial or complete loss of motor function.^{23, 25} These motor deficits differentiate PIN compression from RTS.
2. Pain may occur along radial or posterior interosseous nerve before the onset of motor deficits.²³

Differential diagnosis:

Radial Tunnel Syndrome as well as those diagnoses listed under the RTS differential.

*Conservative Management:*²⁵

If palsy present, may need dynamic wrist and digital MCP extension orthosis to improve function.
Avoid repetitive gripping and forearm rotation.
Adaptive equipment education to increase function.

Surgical Management:

If conservative treatment fails there are several approaches to decompression.²³

Post-operative Rehabilitation:

Scar management²⁵

Pain management²⁵

As well as all conservative and post-operative treatments listed under RTS.

ROM at 1-2 weeks post-op. Strengthening at 4-6 weeks.¹⁶

- I. Wartenberg's Syndrome (Dorsal Radial Sensory Nerve {DRSN} entrapment): Compression of the sensory branch of the radial nerve. Compression can occur where the DRSN emerges between the brachioradialis(BR) and extensor carpi radialis longus(ECRL) or in the subcutaneous tissue in the distal forearm.²³

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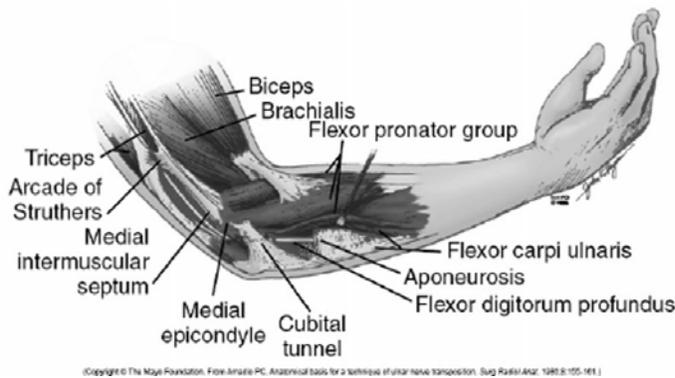


FIGURE 7
Compression sites in the Cubital Tunnel.

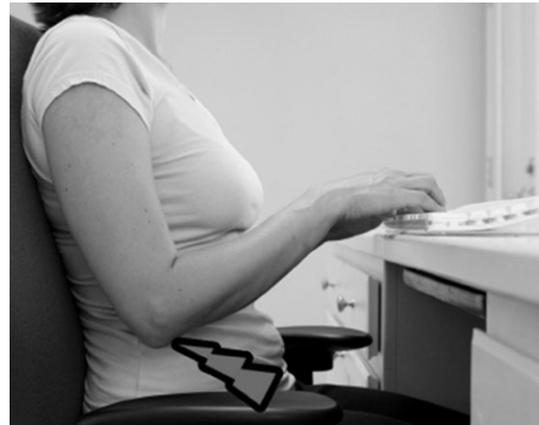


FIGURE 8
Sustained elbow flexion compresses the ulnar nerve within the cubital tunnel.



FIGURE 9
Direct pressure (contact stress) from the hard edge of a handle ending in the palm. Handle could be lengthened and pressure better distributed with built up handle or foam to minimize risk of nerve compression.

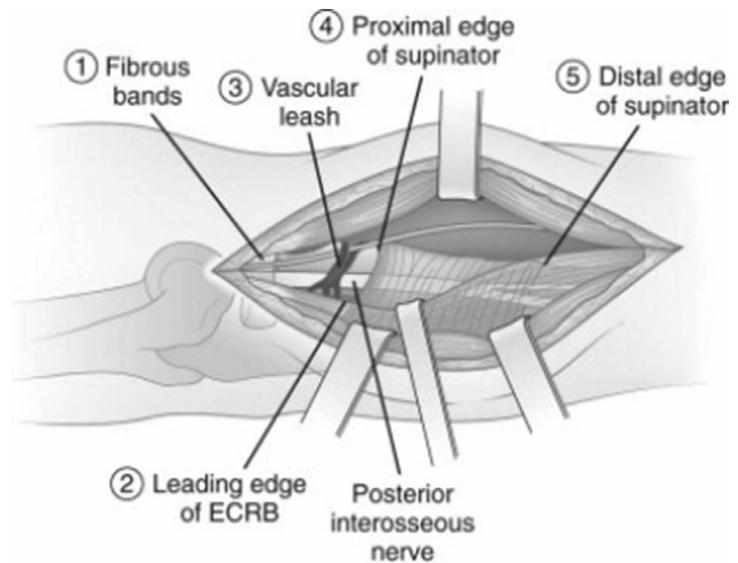


FIGURE 10
PIN compression sites.

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Signs/Symptoms:

1. Pain and burning in the dorsoradial forearm and wrist.²³
2. Pain may be exacerbated with pronation, wrist flexion and ulnar deviation.²³
3. Diminished sensation on dorsum of the hand, thumb, index, and middle fingers.²³
4. Numbness in dorsum of the hand, thumb, index, and middle fingers.⁴²
5. Grip strength may be limited secondary to pain.²³
6. Pain with passive wrist flex with UD, tested in pronation.²⁵

Causes:

1. Repetitive pronation and supination may cause compression between BR and ECRL.^{23, 25}
2. Repetitive wrist flexion and ulnar deviation can cause tension and compression in the subcutaneous tissue. Examples include screwdriver use and improper positioning while using computer keyboard^{23, 25} or mouse. (See Figure 11)
3. Direct pressure from an external source such as a watch, jewelry, handcuffs,²³ or compressive orthosis straps.⁴³
4. Repeated exposure to severe cold.²³
5. Non-occupational causes such as trauma, lipoma, or diabetes mellitus.²³
6. Tinel's 4 cm proximal to Lister's Tubercle where BR and ECRL meet.²⁵
7. Symptoms with resisted wrist extension with RD, tested in supination.²⁵

Differential diagnosis:

DeQuervain's tenosynovitis (will have normal sensory exam in distribution of DRSN)²³, cervical radiculopathy, TOS, other sites of radial nerve compression, intersection syndrome. There is not agreement if electrophysiologic tests are needed for diagnosis.^{16, 23}

Clinical tip: To differentiate DeQuervain's Tenosynovitis from Wartenberg's Syndrome: Perform Finkelstein's test in neutral forearm and then in pronation. If DeQuervain's the pain should not change regardless of position. In Wartenberg's Syndrome the increased tension of the nerve should increase discomfort when test done in pronation.²⁵

Conservative Management:

- A. Restore length of BR and ECRL.²⁵
- B. Neural mobilization²⁵
- C. Orthosis with wrist extension and thumb reposition (in line with second metacarpal or dorsal to it)²⁵ **Care must be taken with application of orthosis to avoid compression over the nerve.¹⁶
- D. Ergonomic modifications:
 - a. Split keyboard²⁵ that eliminates ulnar deviation and is tented (raised in the middle) to reduce pronation.
 - b. Keyboard and mouse at correct height to eliminate wrist flexion.¹
 - c. Vertical mouse²⁵ to minimize pronation.
 - d. Large diameter tools and writing instruments.²⁵
- E. Avoid repetitive pronation and supination (ex: screwdrivers, racquet sports, keyboarding and mouse use with improper positioning that require pronation, ulnar deviation, and wrist flexion).²⁵
- F. Maintain neutral forearm²⁵ and avoid activities that require wrist flexion/extension and rotation.
- G. Avoid anything tight around wrist such as bracelets or watches.²⁵
- H. Corticosteroid injection between tendons of BR and ECRL.²³

Chapter 22 Figures



FIGURE 11
Sustained awkward wrist posture.

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*Surgical Management:*²³

Performed if conservative treatment fails surgical decompression between BR and ECRL can free sites of compression. A portion of BR tendon may be resected if necessary. 85% good or excellent results with surgery.

Post-operative Rehabilitation:

Wrist immobilized in orthosis after release until wound is healed¹⁶

Post-op day 3-5 AROM of all joints initiated.²³

Desensitization of radial sensory nerve distribution.²³

No heavy lifting for 4 weeks.²³

Return to work without restrictions at 6-8 weeks.²³

J. Hand Arm Vibration Syndrome/White Finger Syndrome/Occupational Raynaud's Disease:

A condition that occurs with exposure to vibration from hand-held tools. Cumulative exposure to vibration creates damage to both vessels and nerves.¹⁹

Signs/Symptoms:

- a. Blanching of the fingers¹⁹
- b. Sensory loss¹⁴
- c. Reduced dexterity¹⁹
- d. Diminished grip strength¹⁹
- e. Cold intolerance¹⁹
- f. Wrist and hand pain¹⁹
- g. Numbness & tingling⁴⁴
- h. Muscle cramps¹⁹
- i. Reduced nerve conduction velocities.¹⁴

Prevention is important as the condition can be reversed if caught early but can become chronic. This can be done with anti-vibration gloves, frequent breaks, smoking cessation, limiting exposure to cold to reduce digital vasospasms.¹⁹

i. Double Crush:

Compression of a nerve at one point may increase susceptibility to compression at more proximal or distal sites. Conditions such as obesity, rheumatologic or endocrine disorders, and alcoholism are also known to increase susceptibility of nerve compression and may be considered part of this phenomenon.¹⁴

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Multiple Choice Questions

1. Patient with AIN compression may complain of
 - A. Dropping small items due to decreased sensation in the index and middle fingers
 - B. Decreased ability to complete normal weight training secondary to weak Pronator Teres
 - C. Decreased ability to pick up small items secondary to weak pinch
 - D. Decreased ability to unscrew a bolt secondary to decreased strength of the supinator, wrist extensors, and digital extensors
2. Which orthosis modification may increase effectiveness for manual laborers with carpal tunnel syndrome?
 - A. Blocking supination
 - B. Slight wrist flexion
 - C. 40 degrees of IP flexion block
 - D. 20 degrees of MCP flexion block
3. The best orthosis position for carpal tunnel syndrome is
 - A. 2 degrees wrist flexion and 3 degrees of ulnar deviation
 - B. 20 degrees wrist extension with no deviation
 - C. 20 degrees wrist extension and 5 degrees of ulnar deviation
 - D. 10 degrees wrist flexion with no deviation
4. A patient has reproduction of their symptoms with Finkelstein's test while pronated. Interestingly, the symptoms do not occur when the test is performed with the forearm in neutral. The test can be considered positive for
 - A. DeQuervain's Tenosynovitis
 - B. Wartenberg's Syndrome
 - C. CMC OA
 - D. Pronator Syndrome
5. Risks for Occupational Raynaud's Syndrome include
 - A. Direct pressure
 - B. Sustained postures
 - C. Forceful grip
 - D. Vibration
6. Direct pressure from a bicycle handlebar or steering wheel are risks for
 - A. Ulnar tunnel syndrome
 - B. Hand arm vibration syndrome
 - C. Radial tunnel syndrome
 - D. Wartenberg's syndrome
7. The posterior interosseous nerve may be compressed at the
 - A. Ligament of Struthers
 - B. Arcade of Froese
 - C. Chiasm of camper
 - D. Hook of the hamate

Multiple Choice Questions

8. Numbness in the dorsoulnar hand is indicative of what level of ulnar nerve compression
 - A. At the elbow
 - B. Guyon's canal
 - C. FDS
 - D. Brachioradialis

9. Ulnar neuropathy accompanies which other disorder approximately 50% of the time
 - A. Carpal tunnel syndrome
 - B. DeQuervain's tenosynovitis
 - C. Medial epicondylitis
 - D. Trigger finger

10. Your client complains of a daytime aching, "tired" feeling pain and paresthesias in the volar forearm with no identifiable cause. Name the condition likely involved and the test you could use to confirm this suspicion.
 - A. Carpal tunnel syndrome; Phalen's Test
 - B. Thoracic Outlet Syndrome; Adson's Test
 - C. Pronator Syndrome; Direct pressure on Pronator Teres for 30 seconds
 - D. Anterior Interosseous Nerve Syndrome; Manual muscle test of FPL, FDP of digits 2 and 3, and Pronator Quadratus

11. The pulley most often involved in trigger finger
 - A. A3
 - B. C1
 - C. A1
 - D. C3

12. The median nerve may become compressed in the proximal forearm from repetitive
 - A. Pronation and wrist flexion
 - B. Supination and gripping
 - C. Wrist flexion/extension with thumb movements
 - D. Elbow flexion/extension and pronation

13. The most sensitive test for cubital tunnel syndrome
 - A. Elbow flexion test independently
 - B. Pressure provocation and elbow flexion test
 - C. Elbow extension with pressure provocation
 - D. Ulnar nerve subluxation

Multiple Choice Questions

**Multiple Choice Question Answer Key
Chapter 22**

1-C, 2-D, 3-A, 4-B, 5-D, 6-A, 7-B,
8-A, 9-C, 10-C, 11-C, 12-D, 13-B