Nerve compression syndromes of the forearm

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EPIDEMIOLOGY

Compression neuropathy can exist anywhere along the course of a nerve, although all reported sites are uncommon compared to the carpal tunnel. The second most common site of upper extremity compression involves the ulnar nerve at the cubital tunnel (Mondelli et al 2005). The ulnar nerve may also be compromised at Guyon’s canal. The annual incidence of cubital tunnel in workers performing repetitive work has been estimated at 0.8% per person-year (Descatha et al 2004). A single large study suggested that the rate of electrophysiological abnormality in the median nerve at the upper extremity is twice that of the ulnar (Pascarelli & Hsu, 2001) nerve, with affected median nerves being twice as likely to be symptomatic, thus resulting in a 4:1 ratio in carpal to cubital tunnel syndromes. (Seror & Nathan 1993).

Entrapment of the median nerve in the proximal forearm is relatively uncommon, but is an important component of differential diagnosis and a potential explanation for failed treatment of carpal tunnel syndrome. The most reported compression syndromes are pronator teres syndrome or anterior interosseous nerve (Kiloh–Nevin) syndrome. In a large series these contributed 1% of the compression syndromes of the upper limb.

The radial nerve has multiple sites of compression in the forearm, with ‘radial tunnel’ the most common. Since there is little agreement on diagnostic approaches or criteria for radial nerve compressions of the forearm, incidence/prevalence rates have not been clearly defined. In a large series of patients with work-related upper extremity disorders, 7% were diagnosed as having radial tunnel syndrome (Pascarelli & Hsu 2001).

Risk factors for developing nerve compression in the forearm are related to both activity and the individual. ‘Holding a tool in position’ was predictive of risk for cubital tunnel (odds ratio (OR): 4.1). Obesity (OR: 4.3) had a similar risk, and the presence of concomitant upper extremity tendinosis also increased the risk (Descatha et al 2004). A gender effect has been established for cubital tunnel syndrome with males at greater risk (Richardson et al 2001). A recent systematic review examined the exposure-response relationships between work-related physical and psychosocial factors including cubital
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---|---|

The work of the hand during the majority of the cycle time is associated with the factor ‘holding a tool in position’ (OR: 3.5), handling loads > 1 kg (OR: 9), static work of the hand during the majority of the cycle time (OR: 5.9) and full extension (0–45°) of the elbow (OR: 4.9) were associated with radial tunnel syndrome. Roquelaure et al (2000) found similar risk factors: Exertion of force of over 1 kg (OR: 9.1), Prolonged static loading of the hand (OR: 6), or working with the elbow extended (OR: 5) (Roquelaure et al 2000).

ANATOMY

Ulnar nerve

The ulnar nerve is vulnerable by its location, its path through the forearm and the effects of position and movement. The C8 and T1 nerve roots give rise to the medial cord of the brachial plexus which branches into the ulnar nerve and the medial component of the median nerve. The ulnar nerve travels on the medial side of the brachial artery in the upper arm, and at mid upper arm pierces the inter-muscular septum to continue on the medial head of the triceps. At the elbow, it passes through the cubital tunnel, a groove between the medial humeral epicodyle and the olecranon. The nerve then travels between the two heads of the flexor carpi ulnaris and down the forearm between the deep and superficial finger flexors. Just below the elbow, it sends branches to the flexor carpi ulnaris and the ulnar half of the flexor digitorum profundus. There are five potential entrapment sites:

1. The arcade of Struthers, a fibrous band from the medial head of the triceps to the medial inter-muscular septum (the fibrous band only occurs in 70% of people)
2. The medial inter-muscular septum
3. The cubital tunnel (most common site) where the medial collateral ligament of the elbow forms the floor and the arcuate ligament (cubital tunnel retinaculum) the roof
4. The aponeurosis between the two heads of the flexor carpi ulnaris (Osborne band)
5. The aponeurotic covering between the flexors digitorum profundus and superficialis is occasionally a site of compression. Anatomic variants are commonly reported in case studies as unusual causes of nerve compression.

An average of 5 mm of ulnar nerve excursion is required at the elbow to accommodate shoulder motion from 30° to 110° of abduction or elbow motion from 10° to 90°. When the wrist is moved from 60° of extension to 65° of flexion, 14 mm excursion of the ulnar nerve is required at the wrist. When all the motions of the wrist, fingers, elbow, and shoulder are combined, 22 mm of ulnar nerve excursion is required at the elbow and 23 mm at the wrist. Ulnar nerve strain of 15% or greater occurs at the elbow with elbow flexion and at the wrist with wrist extension and radial deviation (Wright et al 2001). Ultrasoundography of 200 normal individuals revealed that the ulnar nerve changes its course at the fibrous band region 11.5 mm distal to the medial epicodyle. Dynamic studies showed that during elbow flexion, the nerve moved to the tip of the epicodyle in 27% of individuals whereas it dislocated anteriorly in 20% (Okamoto et al 2000). Some believe that subluxation of the nerve during movement can contribute to cubital tunnel syndrome.

At the wrist, the ulnar nerve runs above the flexor retinaculum lateral to the flexor carpi ulnaris tendon and medial to the ulnar artery. At the proximal carpal bones, it courses between the pisiform and the hook of the hamate at the entrance to the Guyon canal (the roof of the canal is formed by an extension of the transverse carpal ligament that links these two bones). Three zones of the ulnar nerve within the distal ulnar tunnel have been defined as follows:

- **Zone 1 – Ulnar nerve proximal to the bifurcation**
- **Zone 2 – The deep branch**
- **Zone 3 – The superficial branch or branches.**

The deep (motor) branch supplies the abductor digiti minimi (ADM), then crosses under one head of the flexor digiti minimi (FDM), supplies this muscle, and crosses over to supply the opponens digiti minimi (ODM) before rounding the hook of the hamate bone to enter the mid palmar space and supply other hand muscles. These anatomic zones correlate with clinical symptomatology. After Zone 1 nerve bifurcates into superficial and deep branches. These terminal branches include the superficial cutaneous branch to the ulnar portion of palm, and the deep branch that innervates the hypothenar muscles, 3rd and 4th lumbricales, adductor pollicis, all interossei, and deep head of flexor pollicis brevis. Depending on the exact site of compression within the Guyon canal, the ADM or both the ADM and the FDM may be spared. The ODM is always affected, together with the interossei, lumbricals 3 and 4, and the adductor pollicis. Patients with zone 1 compression can present with motor, sensory or mixed lesions; those with zone 2, motor lesions, and zone 3, sensory only. Compression of the deep branch is the most common and usually occurs at the level of the fibrous arch of the hypothenar muscles. The distal canal is also the common site for ganglions arising from the wrist.

Radial nerve

The radial nerve is the largest branch of the brachial plexus (posterior cord) and receives fibres from C6, C7 and C8 (sometimes T1). Its crosses the latissimus dorsi...
The wrist and hand regions

deep to the axillary artery, passes the inferior border of the teres major, winds around the humerus, and then enters the triceps muscle between the long and medial heads. It progresses along the spiral groove of the humerus to pierce the lateral inter-muscular septum and runs between the brachialis and brachioradialis to lie anterior to the lateral condyle of the humerus. Branches to the brachioradialis and extensor carpi radialis longus are given off just proximal to the elbow. The anconeus receives a branch, and the nerve then divides into a superficial branch and a deep branch. The extensor carpi radialis brevis (ECRB) receives its innervation either from the radial nerve proper or from the posterior interosseous nerve. The superficial branch, which is purely sensory, runs under cover of the brachioradialis in the forearm. Eight centimetres proximal to the tip of the radial styloid, the nerve pierces the fascia medial to the brachioradialis to lie dorsal to the extensor tendons. It divides into a medial branch and a lateral branch to innervate the radial wrist (with some variable overlap from the lateral antebrachial cutaneous nerve), dorsal radial hand, and dorsal of the radial 3½ digits to approximately the middle phalanx level.

The deep branch or posterior interosseous nerve (PIN), winds to the dorsum of the forearm, around the lateral side of the radius, and through the muscle fibres of the supinator. It then divides into medial and lateral branches, each of which supplies different extensor muscles. The PIN supplies ECRB and supinator before entering arcade of Frohse. This arcade is a fibrotendinous structure at the proximal origin of supinator and the most common site for entrapment of the radial nerve. In 25% of individuals, the PIN actually touches the dorsal aspect of radius opposite the bicipital tuberosity; thus fracture fixation (plates) placed high on the dorsal surface of radius may trap the nerve underneath. The most common compression site is at the supinator muscle. However, proximal lesions should be suspected with humeral fractures. Radial nerve palsy associated with fracture is more common after the nerve bifurcates, selective paralysis of muscles occurs, depending on which branch is involved. Compression of the medial branch causes paralysis of the ECU, extensor digitorum minimi, and extensor digitorum communis. Compression of the lateral branch causes paralysis of the abductor pollicis longus, extensor pollicis longus, and extensor indices. Other possible aetiologies for posterior interosseous nerve dysfunction include trauma (Monteggia fractures), synovitis (rheumatoid), tumours, and iatrogenic injuries.

Wartenberg syndrome, or RSN entrapment, is unique in that it has isolated sensory symptoms. Insidious onset may occur in association with de Quervain tenosynovitis. Acute onset can occur following post-surgical injury, external compression or trauma on the radial aspect of the wrist. The anatomic site of compression corresponds to the transit of the nerve from its submuscular position beneath the brachioradialis to its subcutaneous position on the ECRL. With pronation, these two muscles can create a scissor-like effect compressing the RSN.

Median nerve

The median nerve arises from both the lateral and medial cords of the brachial plexus and travels with the brachial artery on the medial side of arm between biceps brachii and brachialis. In the upper arm it is lateral to the artery, but then crosses anteriorly to run medial to the artery inside the cubital fossa, in front of the point of insertion of the brachialis muscle and deep to the biceps. The median nerve gives off an articular branch in the upper arm as it passes the elbow joint and then passes between the two heads of pronator teres. It innervates pronator teres (PT), flexor carpi radialis (FCR) and flexor digitorum superficialis (FDS); travels between FDS and flexor digitorum profundus before emerging between FDS and FCR. The median nerve gives off two branches as it courses through the forearm: the anterior interosseous branch courses with the anterior interosseous artery and innervates flexor pollicis longus (FPL). FDP to 2nd and 3rd fingers and pronator quadratus. It ends with its innervation of pronator quadratus. The palmar cutaneous branch of the median nerve arises at the distal part of the forearm and supplies sensory innervation to the lateral aspect of the skin of the palm (but not the digits).
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Compression of the median nerve in the forearm can arise as a result of anatomic variations (supracondylar process, Struthers ligament, lacertus fibrosus) at the biceps brachii, or overuse/tightness of the pronator teres muscle or flexor superficialis. With less frequency, an anomalous accessory head of the flexor pollicis longus (Ganzer’s muscle) or persistent median artery can be found. Rarer causes of extrinsic compression of the median nerve are chronic compartment syndrome or partial rupture of the distal biceps tendon (or bicipital tendon bursitis). The most common site of compression of the median nerve is the tendinous origin of deep head of pronator teres.

**PATHOLOGY**

Nerve compression can occur directly from anatomic structures as highlighted above. Repetitive or acute trauma to a nerve may result in micro-vascular (ischaemic) changes, oedema, or injury to the myelin sheath and structural alterations in membranes in both the myelin sheath and the nerve axon. Wallerian degeneration of the axons and permanent fibrotic changes in the neuromuscular junction may prevent full reinnervation after compression is relieved. Seddon has classified nerve injuries into three categories:

- **Neuropraxia:** a transient episode without disruption of the nerve or its sheath – complete recovery is expected
- **Axonotmesis:** disruption of the axon but maintenance of the Schwann sheath. In this case, motor, sensory and autonomic effects are expected and recovery may be complete or incomplete
- **Neurotmesis:** nerve and sheath damage and incomplete recovery is usual.

Nerve fibres are not affected uniformly but by their proximity to the source of compression. Superficially located fibres tend to bear the brunt of compression, while central fibres are relatively spared. Since large diameter, heavily myelinated fibres are more sensitive to compression than poorly myelinated fibres, they are more affected. This explains the earlier and more pronounced impairment of light touch (vibration) sensibility in nerve compression disorders. Mild compression produces a transient conduction and disruption of axoplasmic flow which may only be evident with provocative manoeuvres. In chronic compression, segmental demyelination results in slowing of conduction and more persistent symptoms. With progression axolysis occurs in compressed segments, and Wallerian degeneration occurs distally. The critical threshold pressure for initiating changes in nerve has been reported to be 30 mmHg (Mackinnon 2002).

**DIAGNOSIS**

Nerve compression presents with loss of sensory and motor function where mixed nerves are involved. Radial tunnel and distal sensory nerve compressions are examples of where these symptoms may occur separately. In general progression of motor symptoms may start with a clumsiness or aching and progress to substantial loss of muscular strength and endurance. By the time patients have identified weakness; substantial loss in grip strength is usually measurable. Muscle atrophy is typically a late finding. Sensory abnormalities tend to progress from positional or activity-based paraesthesia that may be associated with pain to persistent symptoms. In later stages, numbness may be so profound that neither pain nor paraesthesias are as pronounced. Sensory abnormalities are first detected in vibration or touch thresholds and later appear in discriminative touch such as two-point discrimination. Tables 29.1–29.3 show the clinical signs, the special tests and common differential diagnosis depending on the site of nerve entrapment.

**Ulnar nerve**

The presenting symptoms with ulnar nerve are numbness and/or tingling most noted by the patient in the little finger but a loss of sensory function throughout the nerve distribution. Aching pain and loss of hand function are usually reported. Symptoms are aggravated in positions of flexion (and at night). Sensory and motor impairments can be variable, and electrodiagnosis is recommended before proceeding to surgery (Nakazumi & Hamasaki 2001). Patients with an ulnar neuropathy with a gradual non-traumatic onset may report a history of repetitive elbow flexion or prolonged resting of the elbow on a hard surface. Elbow flexion creates narrowing of the cubital tunnel as a result of traction on the arcuate ligament and bulging of the medial collateral ligament. Elbow flexion may also contribute to the injury by increasing the intra-neural pressure. With scarring and adhesion of the epineurium, elongation accentuates the tethering effect on the axons. These effects may be accentuated at night when the patient sleeps with the elbow in flexion.

Sensory and motor examinations of the hand reveal weakness of grip, atrophy of the thenar muscles and weakness of pinch (adductor pollicis muscle). Atrophy of affected muscles is most easily observable in the first dorsal interosseous. Inability to cross fingers may indicate interosseous weakness; although manual muscle testing may also be used. The FCU and FDP to the ring and little finger are usually not affected. Special tests include Foment’s sign where pronounced thumb interphalangeal (IP) flexion is observed when grasping a piece of paper between thumb and index finger, as the FPL is used to
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<tr>
<th></th>
<th>Ulnar nerve</th>
<th>Median nerve</th>
<th>Radial nerve</th>
<th>Posterior interosseous nerve syndrome</th>
<th>Distal sensory radial nerve syndrome (Wartenberg’s syndrome)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area of symptoms</strong></td>
<td>Medial elbow</td>
<td>Palmar aspect of 4th and 5th digits only – sensation should be spared over dorsal aspect</td>
<td>Poorly localized to the volar proximal forearm</td>
<td>Approximately 5 cm (2 inches) distal to the lateral epicondyle</td>
<td>Over Arcade of Frohse</td>
</tr>
<tr>
<td></td>
<td>medial elbow</td>
<td></td>
<td></td>
<td></td>
<td>Dorsal aspect of the radial 3½ digits, as far distally as the proximal interphalangeal joints. The subungual region should be spared</td>
</tr>
<tr>
<td><strong>Nature of symptoms</strong></td>
<td>Pain, numbness or tingling, weakness</td>
<td>Could be any or all of pain, numbness or tingling, weakness</td>
<td>Pain and/or weakness</td>
<td>Pain and fatigue, weakness</td>
<td>Weakness</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pain, numbness or tingling</td>
</tr>
<tr>
<td><strong>Motor signs</strong></td>
<td>Grip and/or pinch weakness.</td>
<td>Froment’s sign(^b)</td>
<td>Weakness of flexor pollicis longus and flexor digitorum profundus of the 2nd digit. Affected individuals will be unable to form a circle by pinching the tips of the thumb and 2nd digit together.</td>
<td>No obvious muscle weakness in early stages(^a)</td>
<td>With complete palsy, patients will be unable to extend the thumb or fingers at the MCP joints. Will also have difficulty or be unable to extend the wrist in neutral or ulnar positions(^f)</td>
</tr>
<tr>
<td></td>
<td>Possible Froment’s sign.</td>
<td>Wartenberg’s sign(^c)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Possible Wartenberg’s sign.</td>
<td>Weakness of the dorsal and palmar interossei and hypothenar muscles(^d)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>May have difficulty crossing 2nd and 3rd digits. Specific weakness of 1st dorsal interosseous, abductor digiti minimi and flexor digitorum profundus of the 4th and 5th digits</td>
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</table>

\(^a\)The region directly under the nail.

\(^b\)Usually tested by asking the patient to pinch a piece of paper between the thumb and index finger, then the examiner pulls it away. Inability to hold the paper, or excessive flexion of the median innervated flexor pollicis longus (flexion of the 1st IP joint) is considered positive for ulnar nerve palsy.

\(^c\)Abduction and extension of the 5th digit.

\(^d\)Opponens digitii minimi, Abductor digiti minimi, Flexor digiti minimi brevis.

\(^e\)Prolonged compression of the radial nerve may lead to weakness of the radially-innervated muscles of the forearm including extensor digitorum, extensor pollicis longus and brevis, and extensor carpi ulnaris. If weakness is present the condition is usually referred to as posterior interosseous nerve syndrome.

\(^f\)Branches supplying ECRB and ECRL usually come off the radial nerve prior to entering the Arcade of Frohse and therefore are spared.
### Table 29.2 Special tests depending on the site of nerve entrapment

<table>
<thead>
<tr>
<th>Ulnar nerve</th>
<th>Median nerve</th>
<th>Radial nerve</th>
<th>Distal sensory radial nerve syndrome (Wartenberg’s syndrome)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cubital tunnel syndrome</td>
<td>Guyon’s tunnel syndrome</td>
<td>Anterior interosseous nerve syndrome</td>
<td>Radial tunnel syndrome</td>
</tr>
<tr>
<td>Positive upper limb neurodynamic testing with ulnar nerve bias</td>
<td>Positive upper limb neurodynamic testing with median nerve bias</td>
<td>Positive upper limb neurodynamic testing with median nerve bias</td>
<td>Positive upper limb neurodynamic testing with radial nerve bias</td>
</tr>
<tr>
<td>Positive Tinel’s sign over Guyon’s tunnel</td>
<td>Posterior Tinel’s sign over the radial tunnel</td>
<td>Pain with resisted extension of the 3rd digit</td>
<td>Pain with resisted extension of the 3rd digit</td>
</tr>
<tr>
<td>Tenderness over the cubital tunnel</td>
<td>Pain may be reproduced with active or resisted forearm supination with wrist flexion</td>
<td>Pain may be reproduced with active or resisted forearm supination with wrist flexion</td>
<td>Pain may be reproduced with active or resisted forearm supination with wrist flexion</td>
</tr>
</tbody>
</table>

*Positive Tinel’s sign at the cubital tunnel is not an uncommon finding in asymptomatic people.*

*Flex elbow past 90°, supinate forearm and extend wrists. Positive test is reproduction of pain or discomfort within 60 seconds. Shoulder abduction can be added to increase the symptoms.*

*Between the medial epicondyle and olecranon.*

*Approximately 5 cm (2 inches) distal to the lateral epicondyle.*

*Between the brachioradialis and extensor carpi radialis tendons, approximately two-thirds of the way down the forearm.*

### Table 29.3 Common differential diagnosis depending on the site of nerve entrapment

<table>
<thead>
<tr>
<th>Ulnar nerve</th>
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<th>Radial nerve</th>
<th>Distal sensory radial nerve syndrome (Wartenberg’s syndrome)</th>
</tr>
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<tbody>
<tr>
<td>Cubital tunnel syndrome</td>
<td>Guyon’s tunnel syndrome</td>
<td>Anterior interosseous nerve syndrome</td>
<td>Radial tunnel syndrome</td>
</tr>
<tr>
<td>C8/T1 root lesions</td>
<td>C8/T1 root lesions</td>
<td>Flexor digitorum profundus avulsion</td>
<td>Lateral epicondylitis</td>
</tr>
<tr>
<td>Guyon’s tunnel syndrome</td>
<td>Carpal tunnel syndrome</td>
<td>Lateral cord lesion</td>
<td>Brachial plexus injury</td>
</tr>
<tr>
<td>Thoracic outlet syndrome</td>
<td>Thoracic outlet syndrome</td>
<td>C8 radiculopathy (rare)</td>
<td>C5–C6 radiculopathy</td>
</tr>
<tr>
<td>Valgus ligament instability</td>
<td>Systemic – diabetes, alcoholism</td>
<td>Parsonage-Turner syndrome</td>
<td>De Quervain’s tenosynovitis</td>
</tr>
<tr>
<td>Systemic – diabetes, alcoholism</td>
<td>Pancoast tumour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pancoast tumour</td>
<td>Medial epicondyle fracture</td>
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</table>
Radial nerve

Radial tunnel syndrome is characterized by pain over the antero-lateral proximal forearm in the region of the radial head and can be aggravated by repetitive elbow extension or forearm rotation. Radial tunnel syndrome can appear similar to symptoms of lateral epicondylitis (Henry & Stutz 2006), although the maximum tenderness is usually located 4 fingerbreadths distal to the lateral epicondyle as opposed to directly over the top of it. Based on a cadaveric study, a clinical test for radial tunnel was proposed that involves constructing nine equal squares on anterior aspect of the forearm, the PIN was confined to the lateral column (crossing two or three of the lateral squares) (Loh et al 2004). Symptoms can be reproduced by extending the elbow and pronating the forearm. In addition, resisted active supination and extension of the long finger cause pain (middle finger test). A compression test where the thumb is used to compress over the radial tunnel (similar to that used for carpal compression) is positive if it reproduces symptoms or aching muscle pain. This has been reported as the most consistent finding radial tunnel syndrome (Rinker et al 2004).

Posterior interosseous nerve syndrome presents with weakness or paralysis of the wrist and digital extensors. Pain may be present, but usually is not a primary symptom. Attempts at active wrist extension often result in weak dorso-radial deviation due to preservation of the radial wrist extensors but involvement of the ECU muscle and extensor digitorum communis. These patients do not have a sensory deficit. Muscle testing should include extension of the metacarpophalangeal joints which will be weak whereas IP extension remains intact because innervation to the lumbricals will be spared (ulnar nerve). Since the EIP and EDM are independent from the EDC innervation to the lumbricals will be spared (ulnar nerve). Patients with compression of the RSN complain of pain over the distal radial forearm associated with paraesthesias over the dorsal radial hand. They frequently report symptom magnification with wrist movement or when tightly pinching the thumb and index digit. These individuals demonstrate a positive Tinel sign over the RSN and local tenderness. Hyperpronation of the forearm can cause a positive Tinel sign. A high percentage of these patients reveal examination findings consistent with de Quervain tenosynovitis, and the synovitis may be a contributing factor in the compression of the nerve. Thus careful examination is required to distinguish isolated diagnosis of either condition versus coexistent pathology. Finkelstein’s test may be positive in both cases, but quantitative sensory testing will reveal deficit when the RSN has been compromised.

Median nerve

Patients with pronator syndrome usually complain of pain in the anterior forearm aggravated by forearm rotation. Unlike carpal tunnel patients symptoms are not...
worse at night. Compression of the median nerve is indicated by sensory motor disturbances affecting the thumb, index and long fingers, and occasionally ‘ring-splitting’ phenomena, where the lateral side of the ring finger is noted as different from the medial side. If the palm is also affected than confidence is increased that compression is proximal to carpal tunnel. Muscle testing should attempt to differentiate potential compressive structures including lacertus fibrosus (resisted supination and flexion), FDS (independent flexion of the middle finger localizes the level of entrapment to the fibrous arcade of the FDS) or pronator teres (pronation and wrist flexion). A compression test where the thumb is used to create pressure over the pronator muscle that reproduces paraesthesia within 30 seconds is diagnostic. A differential diagnosis for C6/C7 radiculopathy can be determined by examining the function of the muscles innervated by the C6/C7 portions of the radial nerve (wrist extensors and the triceps).

Involvement of the anterior interosseous nerve (AIN) can be distinguished from the median nerve proper because it is primarily a motor nerve except for some sensory branches to the distal radio-ulnar and carpal joints. The latter may contribute to pain in the wrist with this syndrome; however paraesthesia is absent. AIN supplies FPL, the lateral half of FDP, and pronator quadratus. A more common misdiagnosis is an FDP avulsion since loss of terminal joint flexion may be interpreted as a loss of tendon integrity. Patients with AIN syndrome primarily complain of weakness, whereas those with pronator syndrome may present with pain and paraesthesia that can be confused with carpal tunnel syndrome.

### PROGNOSIS

The extent of nerve damage affects symptoms and prognosis as discussed above. In general, severe compression detected by electrodiagnosis, atrophy, changes in two-point discrimination and persistent numbness indicate more severe nerve damage and thus poorer prognosis. Dellon et al (1993) followed a cohort of 128 patients treated non-operatively for cubital tunnel syndrome. At 5 years, 89% of patients with symptoms only, 67% of patients with abnormal sensorimotor thresholds, and 38% of patients with abnormal sensorimotor innervations density had not progressed to surgery. A history of elbow injury significantly worsened outcome (P < 0.02), but the results of the pretreatment electrodiagnosis did not. For patients who proceed to cubital tunnel release, outcomes are better if physical therapy is initiated within 3 days rather than if it is delayed for 14 days (Warwick & Seradge 1995).
recovered (Banta 1994). Another trial suggested that in mild to moderate cases, 10 treatments of iontophoresis and ultrasound was effective in reducing symptoms (Dakowicz & Latosiewicz 2005).

The ability of the nerve to glide between different structures in the forearm has been highlighted in the anatomy. More recently there have been suggestions that ‘nerve sliding’ techniques may enhance mobility of the nerve, while producing less strain (Coppieeters & Alshami 2007). An approach that encourages nerve mobility has been suggested as beneficial, but current clinical trials are limited to those using such exercises as an adjunct to splinting and tend to be underpowered (Svernlov et al 2009, Baysal et al 2006, Pinar et al 2005, Coppieeters et al 2004). Readers are referred to Chapter 38 of this textbook for nerve neurodynamic. There is rationale (level 5 evidence) to suggest that a detailed examination of muscle mobility, activation and positional effects on symptoms that are characteristic of physical therapy expertise may identify structures that require specific mobilization, although this will remain inherently difficult to study in clinical trials.

**Ulnar nerve**

The mainstay of treating cubital tunnel syndrome has been night positioning, activity modification (Padua et al 2002), splinting the elbow in extension and nerve gliding exercise. Although custom hard thermoplastic splints are common, compliance can be a problem and soft versions that restrict full flexion may be more acceptable to patients. These can range from inexpensive off-the shelf (neoprene and other materials) or home-made approaches (a pair of socks used to create a sleeve and flexion block) to custom-made individual padded orthoses.

Behavioural changes should include avoiding compression (resting on elbows, elbow flexion, external pressure on elbows) and repetitive flexion or any activity in extremes of position. Office workers may need work station evaluation, postural and ergonomic training.

Nerve mobilization slowly progressed may be useful, but care should be taken to avoid over aggressive mobilization that contributes to the problem through tractioning the ulnar nerve. There is empirical evidence that ‘sliding techniques’ result in a substantially larger excursion of the ulnar nerve at the elbow than ‘tensioning techniques’ (8.3 mm versus 3.8 mm), and that this larger excursion is associated with a much smaller change in strain (Coppieeters & Butler 2008). Differential stretching of specific muscles (FDS) may also increase mobility. While strength may be compromised, and functional goals may suggest the need for improved strength, therapists should exercise caution as strengthening has the potential to increase compressive factors.

The evidence on conservative management is sparse and inconclusive. A recent small trial suggested that 75% of patients with mild to moderate ulnar neuropathy improve within 6 months but that splinting and nerve gliding provide no additional benefit over activity modification (Svernlov et al 2009). The potential for lack of power in a trial of 70 patients is substantial but indicates the need for more evidence. The potential for natural history of recovery with minor changes (Szabo & Kwak 2007) suggests that activity modification and evaluation of a recovery pathway should be implemented as a first approach. Failure to respond to a more comprehensive physical therapy programme indicates a need for surgical release (Lund & Amadio 2006, Robertson & Saratsiotis 2005).

**Radial nerve**

Evidence for the effectiveness of conservative management and radial tunnel is lacking (Huisstede et al 2008). Mobilization of the potential compressive structures and differential movement of both muscle and tendon may be useful. Ergonomic changes to workstations may include tilting/split or modified keyboards to reduce excessive rotation or extreme wrist positioning. Tissue pressures suggest that positions of elbow flexion, supination, and wrist extension place the least stress and strain on the radial tunnel. This is not functional, but patients may benefit from a wrist support that places the wrist in moderate wrist extension and advice on avoiding forearm rotation and elbow extended positions during activity. Given that radial nerve symptoms can be confused with lateral epicondylitis patients whose symptoms are improved or worsened by a tennis elbow counterforce bracing should be re-evaluated for potential radial tunnel syndrome and switched to a wrist extension splint.

**Median nerve**

Changes in activity to reduce median nerve irritation include preventing repetitive forearm rotation and excessive forceful grip. A rest splint that maintains mid-rotation is sometimes used for a short period; although the necessity of this has not been proven (Lee & LaStayo 2004). The natural history of compressive disorders would suggest that activity modification is more important. Stretching of pronator teres and nerve gliding may be useful.

**CONCLUSION**

Nerves can be compromised in the forearm as a result of anatomic, biomechanical or external forces. Muscle testing and sensory examination should reveal the nerve affected and the most likely site of compression. Quantitative measures of muscle strength and sensory detection threshold are imperative for accurate diagnosis and
monitoring progress in treatment. A treatment programme that mitigates the compressive forces, facilitates nerve healing, restores normal gliding, uses postural and cortical retraining to normalize anatomic balance and interpretation of nerve responses, and teaches patients to be proactive in identifying potential sources of compression in their work and behaviour (and how to modify these appropriately) should be successful for mild to moderate cases of nerve compression. Advanced compression may require surgical release, with early physical therapy being indicated. Both the quality and quantity of evidence on physical therapy techniques or programmes is insufficient and studies that look at the immediate impact of specific interventions on nerve function and the more global functional impacts of physical therapy programmes over the longer term are needed.

REFERENCES


