Carpal tunnel syndrome

Scott D Middleton, 1  Raymond E Anakwe 2

Carpal tunnel syndrome is the most commonly diagnosed compression neuropathy of the upper limb. Patients may present to general practitioners, physiotherapists, hand therapists, or surgeons with a variety of symptoms. Several studies have examined the epidemiology, diagnosis, and treatment of carpal tunnel syndrome. We review these resources to provide an evidence based guide to the diagnosis and treatment of carpal tunnel syndrome.

What is carpal tunnel syndrome and who gets it?
Carpal tunnel syndrome encompasses a collection of symptoms: patients often mention altered sensation or pain in the hand, wrist, or forearm. The reported prevalence of carpal tunnel syndrome is between 1% and 7% in European population studies, and most studies cite a figure of around 5%. 1, 2 It has been found to be three times more common in women than in men. 2

The pathology is believed to relate to compression, entrapment, or irritation of the median nerve within the carpal tunnel at the wrist: an anatomical space bounded by the carpal bones dorsally and the fibrous flexor retinaculum volarly. In effect, anything that causes a reduction in the volume of this compartment or increases the pressure within the compartment may precipitate or cause the symptoms of carpal tunnel syndrome.

Most cases of carpal tunnel syndrome are idiopathic. The symptoms of carpal tunnel syndrome have been estimated to be bilateral in up to 73% of cases, although they may not manifest concurrently. 1, 2 Other causes or associations have been identified with pregnancy, overuse of the hand or wrist, wrist trauma, obesity, hypothyroidism, renal failure, diabetes, and inflammatory arthropathy. 3 Evidence also suggests a genetic component for carpal tunnel syndrome, although the exact basis of this has not yet been established. 4

Patients often report that symptoms are worse at night or wake them from sleep. They may report aggravation of symptoms with overuse of or heavy activities involving the hand or wrist. Despite this, the evidence for occupation as a causative factor for carpal tunnel syndrome is weak. 5, 6 Worsening of symptoms is not the obligatory clinical course of the condition. 2 How to identify those patients who will experience progressively worsening symptoms without treatment has not been satisfactorily resolved.

How is it diagnosed?
The diagnosis of carpal tunnel syndrome is a clinical one that may be supported by specific tests and electrophysiological studies. The diagnosis should be suspected in patients of any age, although it is much less common among children and the diagnosis is less likely to be idiopathic. 7 Patients commonly report intermittent tingling, pain, or altered sensation of the fingers in the distribution of the median nerve: the thumb, index finger, middle finger, and radial half of the ring finger (box 1). These symptoms may extend atypically to include the little finger or may manifest as less well localised symptoms in the forearm, radiating as far proximally as the shoulder. Where symptoms are isolated to the ring and little fingers, a diagnosis of carpal tunnel syndrome is less likely.

Permanent sensory change as well as motor signs and symptoms are late manifestations of carpal tunnel syndrome. More severe disease may also present with unremitting sensory symptoms, thenar muscle wasting (fig 2), or weakness. Patients may become aware of reduced dexterity with fine tasks such as doing up buttons or become clumsy and drop items. Patients may

Box 1 | Symptoms and signs of carpal tunnel syndrome

- Tingling or numbness in the hand especially in the thumb, index finger, and middle finger
- Pain in hand, wrist, or forearm, possibly radiating as far proximally as the shoulder
- Reduced grip strength
- Increased 2 point sensory discrimination on testing in the median nerve distribution
- Clumsiness or reduced manual dexterity
- Wasting of the thenar eminence musculature
- Reduced thumb abduction strength (fig 1)
- Trophic ulcers at the tips of thumb, index finger, or middle finger

THE BOTTOM LINE

Carpal tunnel syndrome is extremely common and is seen in both community and hospital practice. A diagnosis of carpal tunnel syndrome should be suspected in patients with intermittent tingling, pain, or altered sensation affecting the fingers in the distribution of the median nerve: the thumb, index finger, middle finger, and radial half of the ring finger. Non-operative strategies may be successful for early or mild disease or where advanced disease is associated with minimal symptoms. Where non-operative strategies fail, open carpal tunnel decompression provides good results and high levels of reported satisfaction for most patients.

**Sources and Selection Criteria**
We searched PubMed, the Cochrane Library, and the Cumulative Index to Nursing and Allied Health Literature to identify source material for this review. We examined available evidence published in the English language for the diagnosis and treatment of carpal tunnel syndrome. The search terms used were “carpal tunnel”, “carpal tunnel syndrome”, “tingling fingers”, “median nerve compression”, and “compression neuropathy”. There were no well conducted large randomised trials. We selected and examined smaller randomised trials as well as case series, cohort studies, and observational reports where these provided the only evidence.

**Correspondence to:** R E Anakwe
raymundis@doctors.org.uk
Box 2 | Differential diagnoses for carpal tunnel syndrome

- Cervical radiculopathy—suggested by exacerbation of symptoms on neck movement, neck pain, and atypical patterns of neurological involvement
- Diabetes mellitus—the resulting polyneuropathy should be suspected where symptoms relate to both the arms and the legs or reflexes are lost or diminished, or both
- Hypothyroidism—the resulting polyneuropathy should be suspected where symptoms relate to both the arms and the legs or reflexes are lost or diminished, or both
- Osteoarthritis of the small joints of the hand—painful and stiff small joints of the hand may coexist with carpal tunnel syndrome
- Inflammatory arthropathy of the small joints of the hand—this may coexist with carpal tunnel syndrome. Look for features of systemic disease as well as joint specific symptoms
- Vibration white finger or hand-arm vibration syndrome—use of vibrating tools can be established from the history
- Other peripheral neuropathies—these should be suspected where symptoms relate to both the arms and the legs or reflexes are lost or diminished, or both
- Raynaud’s phenomenon—a relation should be sort between symptoms and exposure to cold
- Motor neurone disease—will not usually have a sensory component
- Ulnar nerve compression—usually presents in the distribution of the ulnar nerve

is often carpal tunnel syndrome because of its considerable prevalence; however, the condition can be confused with other diseases (box 2). These should be considered as alternative or additional diagnoses depending on the presentation and age of the patient.

The median nerve can be the object of focal compression or irritation at more than one site along its anatomical course. The second nerve lesion occurs most commonly in the cervical spine. Clinical examination of the cervical spine is usually enough to establish whether there is any important degenerative change at a relevant spinal level in patients who do not have any neck symptoms or signs. Patients with degenerative changes of the cervical spine may report pain, altered sensation, or motor signs in an atypical distribution for carpal tunnel syndrome and localised neck pain or stiffness, or both, as well as variation in their symptoms depending on cervical position or movement. Where there is diagnostic doubt or concern

relate their symptoms to their occupation, particularly where this involves heavy manual or repetitive hand and wrist actions. Examination may identify trophic ulceration to the pulps or tips of affected fingers, representing loss of protective sensation.

Weakness of thumb abduction is tested by assessing the abductor pollicis brevis muscle. Tinel’s sign (fig 3), the modified Phalen’s test (fig 4), and Durkan’s compression test (fig 5) are provocative tests commonly used to support a diagnosis of carpal tunnel syndrome. These tests are considered to be more supportive of the diagnosis where two or all of them show abnormal results, but they are less reliable when used individually, with wide variation in their reported sensitivity and specificity.

The combination of the history, examination, and results of these specific tests will lead clinicians to a subjective impression of the likelihood of carpal tunnel syndrome as a clinical diagnosis. The most likely diagnosis

The median nerve can be the object of focal compression or irritation at more than one site along its anatomical course. The second nerve lesion occurs most commonly in the cervical spine. Clinical examination of the cervical spine is usually enough to establish whether there is any important degenerative change at a relevant spinal level in patients who do not have any neck symptoms or signs. Patients with degenerative changes of the cervical spine may report pain, altered sensation, or motor signs in an atypical distribution for carpal tunnel syndrome and localised neck pain or stiffness, or both, as well as variation in their symptoms depending on cervical position or movement. Where there is diagnostic doubt or concern

relate their symptoms to their occupation, particularly where this involves heavy manual or repetitive hand and wrist actions. Examination may identify trophic ulceration to the pulps or tips of affected fingers, representing loss of protective sensation.

Weakness of thumb abduction is tested by assessing the abductor pollicis brevis muscle. Tinel’s sign (fig 3), the modified Phalen’s test (fig 4), and Durkan’s compression test (fig 5) are provocative tests commonly used to support a diagnosis of carpal tunnel syndrome. These tests are considered to be more supportive of the diagnosis where two or all of them show abnormal results, but they are less reliable when used individually, with wide variation in their reported sensitivity and specificity.

The combination of the history, examination, and results of these specific tests will lead clinicians to a subjective impression of the likelihood of carpal tunnel syndrome as a clinical diagnosis. The most likely diagnosis

The median nerve can be the object of focal compression or irritation at more than one site along its anatomical course. The second nerve lesion occurs most commonly in the cervical spine. Clinical examination of the cervical spine is usually enough to establish whether there is any important degenerative change at a relevant spinal level in patients who do not have any neck symptoms or signs. Patients with degenerative changes of the cervical spine may report pain, altered sensation, or motor signs in an atypical distribution for carpal tunnel syndrome and localised neck pain or stiffness, or both, as well as variation in their symptoms depending on cervical position or movement. Where there is diagnostic doubt or concern

relate their symptoms to their occupation, particularly where this involves heavy manual or repetitive hand and wrist actions. Examination may identify trophic ulceration to the pulps or tips of affected fingers, representing loss of protective sensation.

Weakness of thumb abduction is tested by assessing the abductor pollicis brevis muscle. Tinel’s sign (fig 3), the modified Phalen’s test (fig 4), and Durkan’s compression test (fig 5) are provocative tests commonly used to support a diagnosis of carpal tunnel syndrome. These tests are considered to be more supportive of the diagnosis where two or all of them show abnormal results, but they are less reliable when used individually, with wide variation in their reported sensitivity and specificity.

The combination of the history, examination, and results of these specific tests will lead clinicians to a subjective impression of the likelihood of carpal tunnel syndrome as a clinical diagnosis. The most likely diagnosis

The median nerve can be the object of focal compression or irritation at more than one site along its anatomical course. The second nerve lesion occurs most commonly in the cervical spine. Clinical examination of the cervical spine is usually enough to establish whether there is any important degenerative change at a relevant spinal level in patients who do not have any neck symptoms or signs. Patients with degenerative changes of the cervical spine may report pain, altered sensation, or motor signs in an atypical distribution for carpal tunnel syndrome and localised neck pain or stiffness, or both, as well as variation in their symptoms depending on cervical position or movement. Where there is diagnostic doubt or concern
that degenerative changes in the cervical spine may be the cause of symptoms, these patients should be referred to a specialist clinic. Cervical spondylosis is not a bar to investigation or treatment for carpal tunnel syndrome, although patients should be counselled that they may experience incomplete relief of symptoms or no improvement at all depending on the balance of cervical versus carpal tunnel involvement.

**How is it investigated?**

Once a diagnosis of carpal tunnel syndrome has been made, clinicians should attempt to identify a specific cause for the symptoms. Any reversible or transient causes dealt with may contribute to an improvement or resolution of the carpal tunnel symptoms. Secondary causes of carpal tunnel syndrome include hypothyroidism; pregnancy; bleeding into the carpal tunnel, associated with haemophilia or minor trauma; and space occupying lesions within the carpal tunnel itself, causing local nerve compression, such as ganglions or cysts.

Although rheumatoid arthritis, diabetes, and hypothyroidism are thought to be associated, it is neither useful nor cost effective to screen patients presenting with carpal tunnel symptoms with radiography or glucose or thyroid function tests in the absence of other clinical evidence of the disease.

There is debate about the place of electrophysiological testing in carpal tunnel syndrome. The American Academy of Orthopaedic Surgeons recommends the routine use of electrophysiological testing to confirm a diagnosis of carpal tunnel syndrome. Guidelines by the British Society for Surgery of the Hand, which are currently being reviewed, recommend that electrophysiological testing should be used to substantiate the diagnosis only in specific situations or where there is diagnostic doubt. Guidelines for healthcare commissioning by the British Society for Surgery of the Hand, the British Orthopaedic Association, and the Royal College of Surgeons recommend that electrophysiological testing should be reserved for situations where there is diagnostic doubt, complex cases, or where there are recurrent symptoms after initial surgery, and that testing is best undertaken in a specialist centre.

The techniques used in the electrodiagnostic studies vary and the false negative rate is estimated to be in the order of 5%. Debate therefore centres on cost effectiveness. One well organised prospective study found that electrophysiological testing significantly influenced patient selection for surgery and the surgical plan.

Although electrophysiological studies are useful, we suggest that they are not required to make an initial diagnosis of carpal tunnel syndrome or to initiate management in the primary care environment. Their use is better suited to assessment in a specialist environment, for patient selection for surgery, and for evaluation of complex cases, relapse of symptoms, or recurrence. Their usefulness is to confirm a median nerve lesion, localise the lesion to the carpal tunnel rather than to another site such as the cervical spine, exclude other causes of neuropathy, and form a baseline for nerve function before treatment. This baseline assessment of nerve function can be particularly useful should patients fail to improve after surgery.

**How is it managed?**

Several treatments for carpal tunnel syndrome have been advanced, recommended, and studied, although evidence to support these is of variable quality. Treatments are directed at both the relief of symptoms and the prevention of future deterioration.

**Wrist splinting**

A large volume of low level evidence suggests that wrist splinting in a neutral position (0° of extension) can alleviate the symptoms of carpal tunnel syndrome. These studies are generally poorly randomised or blinded but
do report symptomatic improvements in several small studies with four weeks of wrist splinting, resulting in few complications.18

Good evidence suggests that carpal tunnel syndrome is not necessarily progressive and that the simple method of splinting is all that is sometimes required to control symptoms. One small randomised controlled trial of 176 patients compared patient satisfaction and outcomes in patients with a confirmed diagnosis of carpal tunnel syndrome who were randomised to splinting or to surgery. Splinting provided adequate relief of symptoms and avoided surgery for 37% of patients.19

Corticosteroid injection
Injection of steroid into the carpal tunnel is commonly used for the treatment of carpal tunnel syndrome and as a diagnostic tool. It is widely thought to offer good relief of symptoms for patients with mild to moderate disease, particularly for pain.20 21 Evidence also supports the use of oral steroids in the treatment of carpal tunnel syndrome,22 although the systemic effects of these drugs generally preclude their regular use in modern practice. Several small cohort studies examining corticosteroid injection into the carpal tunnel have had mixed results. One such study of 23 patients reported sustained relief of symptoms in 11% of patients after 18 months.23 A recent randomised controlled trial compared three groups (37 patients each) receiving 80 mg methylprednisolone steroid injection, 40 mg methylprednisolone steroid injection, and placebo and found that steroid injections improved symptom scores at 10 weeks but that there was no difference with placebo at one year.24 Overall, 75% of the patients had surgery within one year. The results of carpal tunnel injection are reported to be worse for patients with more clinically severe disease, those with diabetes, older people, and where symptoms are permanent or unremitting.16

Injection into the carpal tunnel is safe25; however, there is a small risk of injury to or even injection within the nerve.20 21 A good response to carpal tunnel injection is often thought to indicate the potential for a good response to surgery, although the evidence for this is poor and there is no consensus on dose or preparation of steroid injection.25 The practice of treating relapse after carpal tunnel injection with a further injection is not supported by good evidence.20

Therapy
Carpal tunnel syndrome is often treated using rest or modification of activity, physiotherapy, tendon and nerve gliding regimens, mobilisation of the carpal bones, or stretching programmes. However, the evidence to support these regimens is poor.

There is no good evidence to support the use of diuretics, magnets, vitamins, or acupuncture in the treatment of carpal tunnel syndrome. A small but well organised randomised and double blinded study in 45 people with bilateral carpal tunnel syndrome confirmed by electromyography did show evidence that ultrasound treatments may provide short to medium term relief of mild to moderate symptoms.26

Surgery
Carpal tunnel decompression is a well established surgical treatment for carpal tunnel syndrome. It is usually undertaken as a day case procedure under local anaesthesia. Several large retrospective cohort studies have reported good outcomes and high levels of patient satisfaction after decompression surgery; however, there are potential complications. These include a potentially tender scar, persistent symptoms, neurovascular injury, wound complications, bleeding, pillar pain (a deep aching pain at the base of the thenar eminence and across the wrist), and reduced grip strength. Of these, most are rare and of the order of <1%; however, scar tenderness and pillar pain are reported in 7% and 18% of patients, respectively and may persist for up to two years.27

As with most surgical interventions, the technical procedure for carpal tunnel decompression varies. Release of the flexor retinaculum may be combined with a tenosynovectomy, neurolysis of the median nerve, or lengthening of the flexor tendons.
ening or reconstruction of the flexor retinaculum. There is no good evidence of additional benefit for any of these specific variations for the treatment of idiopathic carpal tunnel syndrome.\textsuperscript{17}

Between 70% and 90% of patients undergoing carpal tunnel decompression are estimated to obtain a good long term result and report high levels of satisfaction.\textsuperscript{27, 28} One survey found that most patients reported being satisfied and free from symptoms of carpal tunnel syndrome at an average of 13 years after open carpal tunnel decompression.\textsuperscript{29}

One well constructed systematic review identified that poor outcomes were associated with diabetes mellitus, poor health status, thoracic outlet syndrome, double crush nerve injury, alcohol misuse, smoking, workers’ compensation cases with outstanding litigation, normal preoperative nerve conduction studies, and noticeable preoperative wasting of the abductor pollicis brevis muscle.\textsuperscript{28} Patient age, weight, and sex were not found to be relevant predictors of outcome, although patient satisfaction was more unpredictable for elderly patients (aged 70 years or more).\textsuperscript{29} The improvement of symptoms in very elderly patients has often been reported to be incomplete. Despite this, elderly patients (aged 80 years or more) with advanced disease do report considerable relief of pain and high levels of satisfaction after carpal tunnel decompression, although grip strength may not improve.\textsuperscript{30, 31}

The carpal tunnel can also be decompressed using an endoscopic technique. The published results for this technique are equivalent to those for standard open decompression, although these results relate to procedures undertaken by experts. Endoscopic surgery remains a specialist technique and has not been shown to provide superior outcomes. One stated advantage is the avoidance of a palmar wound, which may be more comfortable for patients. One well structured randomised controlled trial confirmed this benefit for endoscopic surgery. However, the improvement was marginal at best compared with patients undergoing standard open carpal tunnel decompression.\textsuperscript{32}

There has been considerable debate as to whether patients with bilateral carpal tunnel symptoms selected for surgery should undergo staged or concurrent surgery. The concern is that concurrent surgery may leave them exposed to major functional limitations and should they experience a complication, this could be particularly disabling. One small but well structured patient cohort study followed up separate cohorts of patients with bilateral symptoms selected for staged (33 patients) and concurrent surgery (30 patients). Both groups reported high levels of satisfaction and good outcomes; however, patients treated with concurrent surgery showed greater functional impairment postoperatively. Far fewer of the patients selected for concurrent surgery reported that they would be happy to repeat this choice given the chance.\textsuperscript{34}

**What is the approach to management in primary care?**

Once a diagnosis of carpal tunnel syndrome is made, wrist splinting in a neutral position is a reasonable first step in management. This can be particularly effective for symptoms at night.

**Box 3 | When should I refer?**

- Diagnostic uncertainty
- Failed conservative treatments
- Severe symptoms or noticeable functional limitation
- Relapse after successful carpal tunnel injection
- Recurrence after carpal tunnel surgery
- Request by patient

Steroid injection of the carpal tunnel is a practical option in the primary care environment but should be undertaken by an appropriately trained clinician. The available evidence suggests that patients who will obtain benefit from wrist splinting or carpal tunnel injection are able to report this within four weeks.\textsuperscript{18, 20} Failure to respond by this time should prompt reassessment and consideration for referral. Box 3 outlines when to consider patients for referral.

Some general practitioners in the community or general practitioners with a specialist interest in hand surgery have training and experience in carpal tunnel surgery. Where surgery is offered outside specialist hand centres this should be supported with access to electrophysiological testing and specialist hand surgeons.

**What is the approach to management in hand surgery centres?**

All of the options for management available in the community remain options for treatment. Electrophysiological testing is useful for localising the disease to the carpal tunnel, quantifying the severity of disease, and providing a baseline for assessment of recovery. Electrophysiological testing is also useful where there has been no improvement in symptoms after surgery or where symptoms recur after an initial period of relief.

The evidence for repeated steroid injection after relapse is limited.\textsuperscript{14} Suitable patients should be offered surgical decompression, which can usually be achieved under local anaesthesia.

**Contributors:** REA and SDM contributed equally to the design, literature review, and production of the paper. REA will act as guarantor.

**Competing interests:** We have read and understood the BMJ policy on declaration of interests and declare the following interests: none.

**Provenance and peer review:** Not commissioned; externally peer reviewed.

**Patient consent:** Obtained.

ANSWERS TO ENDGAMES, p 38
For long answers go to the Education channel on thebmj.com

STATISTICAL
QUESTION
Sample size: how many participants are needed in a cohort study?
Statements a, b, and c are all true.

ANATOMY QUIZ
Sagittal computed tomography angiogram of the abdomen with contrast
A: Right deep inferior epigastric artery
B: Right deep inferior epigastric artery perforator
C: Right rectus abdominis muscle
D: Right external iliac artery
E: Right kidney

PICTURE QUIZ
A 16 year old boy with chest pain
1 Sinus rhythm at 58 beats/min, normal axis, ST elevation in leads II, III, and aVF, with reciprocal ST depression in leads I and aVL. Appearances are consistent with an inferior ST elevation myocardial infarction (STEMI).
2 Causes of ST elevation in young people include "high take off," myopericarditis, and acute STEMI. Causes of myocardial infarction in young people include coronary thrombosis or embolus, accelerated atherosclerotic disease (for example, in familial hypercholesterolaemia), coronary or aortic vasculitis, coronary spasm, congenital coronary abnormalities, and cardiac abnormalities such as a patent foramen ovale and aortic or coronary dissection.
3 Antiplatelet treatment with aspirin and an ADP receptor blocker such as ticagrelor, prasugrel, or clopidogrel should be started provided there are no contraindications. Opiate pain relief with antiemetic cover and nitrates for vasodilation should also be given. Any hypoxia should be corrected with oxygen therapy.
4 Urgent transfer to a tertiary centre for coronary angiography. Subsequent treatment will depend on the confirmed diagnosis and the condition responsible.