Entrapment neuropathies:

1. Upper limb

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Accurate diagnosis of nerve entrapment requires a sound knowledge of anatomy and careful examination of the patient. Diagnosis is aided by specific clinical tests and neurophysiological investigation. This article reviews clinical presentation, relevant anatomical detail and appropriate investigations in the management of entrapment neuropathies of the upper limb.

Entrapment neuropathy is a specific form of compression neuropathy. The term "nerve entrapment" refers to a pathological condition arising from a discrepancy between the volume of a peripheral nerve structure and the anatomical space available. Such a situation may occur where a nerve trunk passes through a fibrous or fibro-osseous tunnel or under a constricting fibrous band, fascial edge or blood vessel. *Table 1* shows the most common entrapment neuropathies of the upper limb.

Table 1. Common entrapment neuropathies of the upper limb

Nerve	Syndrome
Median nerve	Carpal tunnel syndrome
Ulnar nerve	Cubital tunnel syndrome
	Ulnar nerve entrapment at the wrist
Radial nerve	Posterior interosseous nerve entrapment

Pathology

The degree of nerve damage depends not only on the nature of the injury but also on the intraneural anatomy. Peripheral fibres are more susceptible to damage than those placed more centrally, and this leads to pressure on a nerve producing selective damage to certain fascicles only. As a result, different degrees of involvement of the fascicles within the trunk may make it difficult to localize a lesion accurately. This is further compounded by anomalous motor or cutaneous innervation, which is common in the hand.

Clinical diagnosis

History

It is important to obtain an accurate description of the symptoms. In entrapment neuropathy, pain is typically localized, often worse at rest and at night, and may radiate or be referred to distant parts. However, the symptoms of tingling, numbness and burning are confined to the cutaneous distribution of the affected nerve.

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Examination

The course of the affected peripheral nerve should be examined, looking for localized areas of thickening. The nerve should be percussed along its length to elicit Tinel's sign (localized pain and paraesthesiae in the cutaneous distribution of the nerve). Specific nerve provocation tests should be attempted, e.g. Phalen's test at the wrist (Phalen, 1951). Examination of the innervated areas may show trophic changes in the cutaneous distribution of the nerve arid weakness and wasting in the motor distribution. *Table 2* summarizes the overall effect of damage to nerves supplying the forearm.

Special investigations

Nerve conduction studies

Nerve conduction studies are useful for confirming the nature of the lesion, localizing the site of compression and assessing severity. After treatment they are also useful for assessing the results of therapy. In nerve compression, focal demyelination tends to lead to slowing of nerve conduction through the abnormal area. There is a decrease in the amplitude of the sensory action potential and also of the compound muscle action potential *(Fig. 1)*.

Radiographs

Plain radiographs of the affected part may be useful for demonstrating abnormal anatomy, e.g. the ligament of Struthers compressing the median nerve in the distal humerus.

Double crush lesions

The concept of a double crush injury to a nerve was first suggested in 1973 by Upton and McComas. A crush injury to a nerve is said to increase the likelihood of nerve entrapment at a more distal level in the same nerve. Interference in the axonal transport of the nerve concerned, with resultant swelling of distal segments, is thought to be the aetiology. The concept of a reverse double crush injury (Csenz et al, 1966) has also been suggested. This again causes interference in the axonal transport mechanism, rendering a further entrapment at a proximal level more likely. It is thought to explain persistent symptoms in sonic patients after carpal tunnel syndrome.

Table 2 A summary of neurological deficits occurring in the forearm

	Motor deficit	Sensory supply	Sensory loss	Area of pain	Reflex arc
Median nerve	Wrist flexors, long finger flexors (thumb, index and middle), pronators of forearm, abductor pollicis brevis	Lateral palm and lateral fingers	Lateral palm and lateral fingers	Thumb, index and middle fingers; often spreads up forearm	Finger jerks (flexor digitorum superficialis)
Ulnar nerve	All the small muscles of the hand (excluding the abductor pollicis brevis), flexor carpi ulnaris, long flexors of ring and little finger	Medial palm, little finger medial half of ring finger	Medial palm, little finger and medial half of ring finger, but often none at all	Ulnar-supplied fingers and palm distal to wrist; occasionally along course of nerve	Nil
Radial nerve	Triceps, wrist extensors, finger extensors, brachialis, supinator of forearm	Lateral dorsal forearm and back of thumb and index finger	Dorsum of thumb and index finger (if any)	Dorsum of thumb and index finger	Triceps jerk and supinator

Data from Patten (1977)

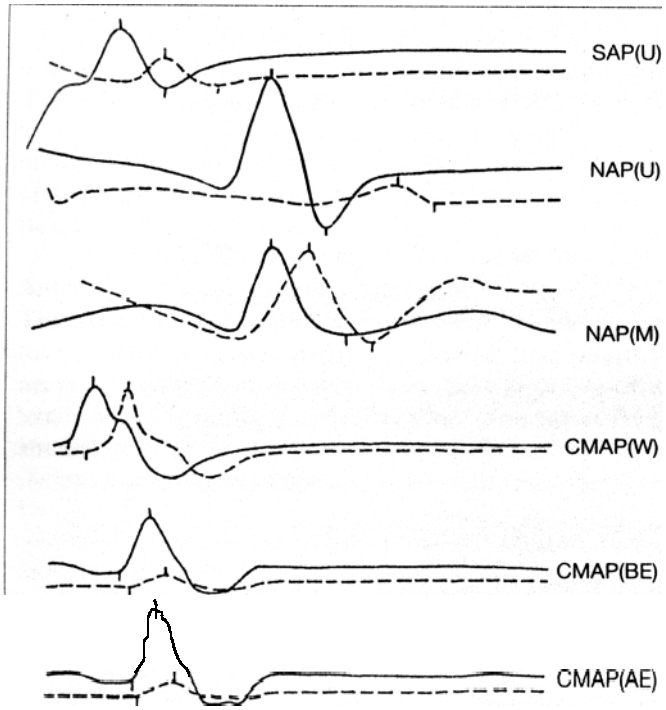

Fig. 1. Nerve conduction studies. Dotted line shows abormal conduction. SAP(U)=ulnar nerve sensory action potential; NAP(U)=ulnar nerve action potential; NAP(M)=median nerve action potential; CMAP(W)=combined muscle action potential at the wrist; CMAP(BE) =combined muscle action potential below the elbow; CMAP(AE)=combined muscle action potential above the elbow.

Upper limb entrapment neuropathies

Motor signs are more reliable than sensory signs due to the complex central representation of the arm and the overlapping of peripheral sensory territories. The two commonest entrapments are, first, the median nerve at the wrist, followed by the ulnar nerve at the elbow.

Median nerve entrapment

Carpal tunnel syndrome

Entrapment of the median nerve beneath the flexor retinaculum of the carpal tunnel is the most common entrapment neuropathy. It presents with symptoms of nocturnal paraesthesiae, usually in women between the ages of 40 and 60 years. Later, symptoms progress to loss of sensation and muscular weakness in the distribution of the median nerve within the hand. Specific aetiologies include the presence of callus or ganglia, or synovial disorders such as rheumatoid arthritis, at the carpal tunnel. Temporary carpal tunnel syndrome may occur in pregnancy or in medical disorders such as hypothyroidism.

Diagnosis: The symptomatology is often strongly suggestive of carpal tunnel syndrome. Examination may reveal wasting of the thenar muscles or diminution of two-point discrimination in the radial three fingers of the hand. The patient may also complain of clumsiness in the affected hand. Phalen's test (Phalen, 1951) of wrist flexion for 60 s will reproduce the symptoms in 80% of patients with carpal tunnel syndrome. Similarly, Tinel's sign is positive in 45% (Phalen, 1970). Other possible sites of compression of the median nerve at the neck and the axilla should be excluded. Neurophysiological testing will supply supportive evidence in doubtful cases.

Treatment: Conservative treatment is indicated in temporary cases (e.g. pregnancy) or those which might respond to medical treatment such as hypothyroidism. Night splinting of the wrist in a position of slight extension minimizes the carpal tunnel pressure and reduces the symptoms. Steroid injections may relieve the symptoms, but this alleviation is generally only temporary, lasting 4-6 months (Gelberman et al, 1980).

Operative treatment of carpal tunnel syndrome involving division of the flexor retinaculum provides prompt relief from pain and paraesthesiae. Sensory loss and muscle weakness may take longer to disappear. Internal neurolysis (division of the epineurium of the nerve) does not significantly improve results in those patients with a severely scarred median nerve (Rhoades et al, 1985). Failure to improve following operation suggests either incomplete section of the ligament, erroneous diagnosis or double crush syndrome. Late recurrence may occur as maturing scar tissue further compresses the median nerve.

Pronator syndrome

Compression of the median nerve in the elbow region occurs as the nerve passes between the two heads of the pronator teres muscle or through fibrous arches of the flexor digitorum superficialis muscle *(Fig. 2)*. Patients commonly present

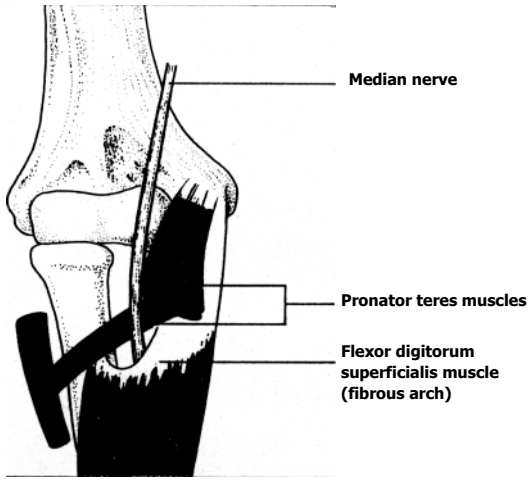

Fig. 2. Course of the median nerve at the elbow.

complaining of pain around the elbow and forearm in the distribution of the median nerve, although in more severe cases muscle weakness may be noted (Kopell and Thompson, 1958). Symptoms are most commonly elicited by repetitive pronation-supination movements, which may relate to the patient's occupation.

Diagnosis: Patients complain of pain in the forearm and further symptoms are precipitated by exercise. The objective findings are local tenderness with a positive Tinel's sign at the front of the elbow and weak and painful pronation of the forearm against resistance. Weakness of the flexor digitorum superficialis muscle to the middle finger may also be revealed. Weakness in the thenar muscles may be noted in severe cases. The diagnosis may be differentiated from carpal tunnel syndrome by the presence of pain at the elbow and a negative Phalen's test at the site of the carpal tunnel.

Treatment: The majority of cases resolve on resting the forearm in a splint and reducing pronation-supination movements. Persistent cases may require surgical decompression of the median nerve at the level of the pronator teres or flexor digitorum superficialis muscle.

Anterior interosseous nerve syndrome

This is a pure motor syndrome. It is a specific variant of the pronator syndrome where only the anterior interosseous nerve is involved. The nerve may be trapped by fibrous bands of the flexor digitorum superficialis muscle or by other anomalous fibrous bands within the flexor muscle mass (Schmidt and Eiken, 1971).

Diagnosis: The anterior interosseous nerve innervates three muscles: the flexor pollicis longus, flexor digitorum profundus and pronator quadratus. Patients present with a clinically abnormal pinch and a history of a blow or prolonged compression over the forearm. Tinel's sign may be positive 5-8 cm from the front of the elbow. Patients may have a pointing finger sign. Inability to perform the circle test, in which patients are asked to oppose the tips of the thumb and index finger, indicates nerve damage *(Fig. 3)*. This test exposes the weakness in flexion of both the interphalangeal joints of the thumb and the distal interphalangeal joint of the index finger. Weakness of the pronator quadratus muscle may be revealed when the elbow is flexed to reduce the effect of the pronator teres muscle and only weak resistance against supination is noted.

Treatment: Following a definite history of injury, treatment should produce resolution of the neurapraxia within 8-12 weeks. If no recovery follows, the diagnosis should be verified by neurophysiological testing. Surgical relief of fibrous bands within the flexor muscle mass is beneficial.

Fig. 3. The circle test. This patient has a median nerve palsy following a supracondylar fracture of the humerus.

Ligament of Struthers

A rare cause of entrapment at the elbow is the presence of a supracondylar bony spur and an accessory ligament of Struthers arising from the tip of the spur which passes to the medial epicondyle of the humerus. The median nerve passes beneath this ligament and may be symptomatically compressed. A plain radiograph will clearly demonstrate the bony spur and surgical treatment is directed at releasing the ligament.

Ulnar nerve entrapment

At the elbow

Ulnar nerve compression at the elbow is the second most common entrapment neuropathy. The nerve may be affected as it lies in the condylar groove behind the medial epicondyle or as it enters the body of the flexor carpi ulnaris muscle through a fibrous arch (the cubital tunnel) *(Fig. 4)*. Trauma to the nerve may arise from repeated movement. As a result of chronic irritation, gliding around the elbow may be restricted by oedema and subsequent scar formation. Chronic irritation may also occur in those patients who have a nerve that subluxes from the ulnar groove. The so-called “tardy” ulnar palsy is thought to be a result of increasing valgus deformity of the elbow from a previous injury.

Diagnosis: Early ulnar nerve entrapment of the elbow presents as pain and paraesthesiae in the ulnar two fingers. Initially this is intermittent but it may become persistent. Later it may be complicated by muscle weakness. Patients may complain of weakness of grip and pinching in the hand. Unlike the carpal tunnel syndrome, ulnar nerve entrapment in the elbow is much more common in men than in women.

Examination of the patient may reveal weakness and a positive Tinel's sign at the elbow. Wasting of the hypothenar eminence and guttering of the interossei may also be observed. Weakness of the first dorsal interosseous, abductor digiti minimi, and flexor profundus muscles to the little finger is

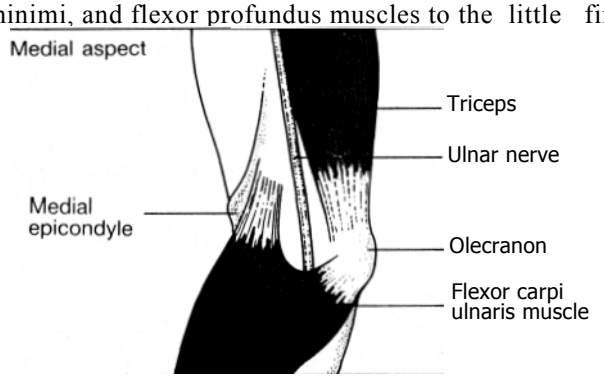

Fig. 4. Course of the ulnar nerve at the elbow.

Fig. 5. Froment's sign.

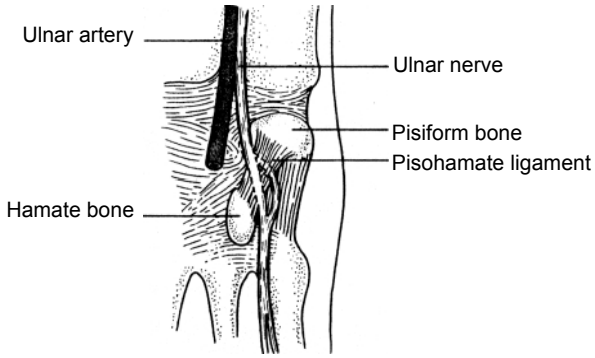

Fig. 6. Course of the ulnar nerve at the wrist.

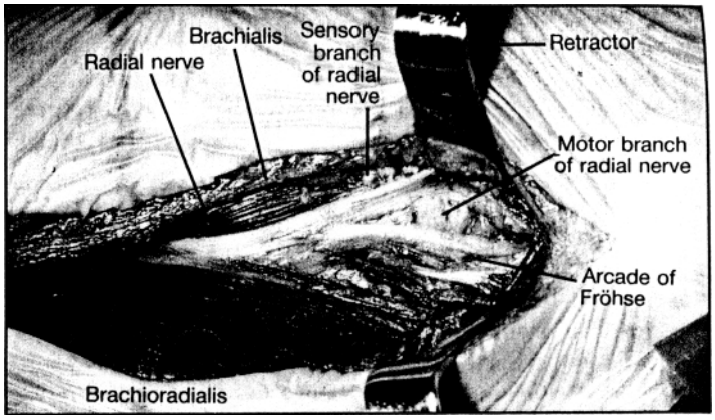

Fig. 7. The arcade of Fröhse.

observed. Provocation of the nerve may be achieved by elbow flexion with the wrists in neutral, a test similar to Phalen's sign at the wrist. Most cases are positive within 3 min, with paraesthesiae in the medial two fingers. Young patients who are unable to cooperate may be examined by their ability to cross their fingers, which utilizes the intrinsic musculature (Earle and Vlaston, 1980).

Intrinsic weakness is also indicated when the thumb flexes in an effort to grip in Froment's test *(Fig. 5)*. Long-standing cases of severe ulnar neuropathy may exhibit ulnar claw hand. The little and ring fingers are hyperextended at the metacarpophalangeal joints and flexed at the interphalangeal joints due to the unopposed action of the long flexors and extensors.

Treatment: The mainstay of conservative management is to tell patients to avoid leaning on their elbows. If this fails, simple ulnar neurolysis is most effective. Ulnar nerve transposition should be reserved for cases of bony abnormality in the ulnar groove of the elbow, e.g. from osteophytes in osteoarthritis.

At the wrist

As the ulnar nerve passes into the wrist it is at risk of compression in Guyon's canal. It may be compressed by the pisohamate ligament or the superficial volar carpal ligament of Guyon's canal itself (Fig. 6). Compressive injuries in this area may relate to a single traumatic incident, to repeated trauma such as using a hammer or to occupations involving heavy gripping. Additionally osteoarthritis of the pisohamate joint may cause compression. Differing patterns of sensory and muscle weakness may be observed depending on the level at which the ulnar nerve is compressed, because it divides into sensory and motor branches within Guyon's canal. Symptoms may be entirely sensory or present as an isolated motor weakness. The differential diagnosis between compression at the wrist or elbow may be made by involvement of the flexor profundus to the little finger, as this is only involved in ulnar nerve compression at the elbow. The elbow flexion test will also differentiate the two conditions (Wadsworth, 1976).

Treatment: In isolated cases of trauma, conservative management is indicated. However, surgical decompression of Guyon's canal may be necessary before true resolution of the neuropathy is observed.

Radial nerve entrapment

Posterior interosseous nerve palsy

The motor branch of the radial nerve is at risk of entrapment as it enters the supinator muscle at a fibrous arch named the arcade of Fröhse just below the elbow (Moss and Switzer, 1983). This may occur in patients with rheumatoid arthritis as synovial proliferation expands the capsule of the elbow joint and so compresses the nerve against the arcade *(Fig. 7)*.

Diagnosis: Compression of the posterior interosseous nerve primarily presents with pain. Although this is a motor branch of the radial nerve, pain-conducting fibres from receptors within the muscles, ligaments and joint capsules run with the motor fibres. Pain is most commonly felt 3-4 cm distally from the elbow and is associated with repetitive supination and pronation. Electromyographic (EMG) analysis may be normal in the resting limb, and thus a provocation test of active supination and pronation must be carried out beforehand. Posterior interosseous nerve palsy must be distinguished from tennis elbow. The latter has a point of maximal tenderness over the lateral epicondyle which is well circumscribed, whereas the pain arising from nerve compression is often more diffuse and may only occur at night.

Severe cases may present with weakness of wrist, finger and thumb extensors which may be tested by assessing the extensor carpi ulnaris muscle.

Treatment: The majority of cases respond to conservative management with rest, splinting, and avoidance of pronation and supination. However, in the face of good EMG evidence, or if external compression is present, decompression of the arcade of Fröhse will resolve the symptoms.

Conclusion

Symptoms of entrapment neuropathy are often ill-defined and variable. However, careful history taking and examination will allow accurate diagnosis. Specific treatment is effective in relieving these, often distressing, symptoms.

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Entrapment neuropathies: 2. Lower limb

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Entrapment neuropathy is a form of compression neuropathy (see previous article). It is rare in the lower limb. Fibular tunnel syndrome, meralgia paraesthetica and tarsal tunnel syndrome are reviewed here.

The peripheral nerves of the leg are less vulnerable to everyday trauma than those of the arm (Patten, 1977). The exception is the common peroneal nerve at the fibular neck. There are very few true entrapment neuropathies of the lower limb (Stewart and Aguayo, 1984). Entrapment of the common peroneal nerve at the fibular tunnel, entrapment of the lateral cutaneous nerve of the thigh (meralgia paraesthetica) and tarsal tunnel syndrome are generally recognized *(Table 1)*. Important data on the peripheral nerves of the lower limb are summarized in *Table 2*.

Table 1: Entrapment syndromes in the lower limb

Nerve	Syndrome
Lateral cutaneous nerve of thigh	Meralgia paraesthetica
Common peroneal nerve	Fibular tunnel syndrome
Tibial nerve	Tarsal tunnel syndrome

Common peroneal nerve palsy

Fibular tunnel syndrome

The common peroneal nerve is a branch of the sciatic nerve and follows a course around the fibular neck. It passes through the attachment of the superficial head of the peroneus longus muscle and this is known as the fibular tunnel *(Fig. 1)*.

Common peroneal neuropathy from diabetes and collagen vascular diseases, such as rheumatoid arthritis, is the most frequent nerve lesion in the leg. However, entrapment in the fibular tunnel is very rare. Otherwise a history of trauma is common, especially iatrogenic trauma following general anaesthesia during which the fibular neck has not been protected. Ganglia, cysts from the knee and fracture callus are more usual causes of entrapment. Plaster casts and braces as well as prolonged squatting and sitting cross-legged have also been implicated.

Diagnosis: Lesions of the nerve cause foot drop with weakness of ankle dorsiflexion or eversion. There may be little or no sensory impairment in the compression neuropathies, but paraesthesiae over the dorsum of the foot may be present in the fibular tunnel syndrome. It can be difficult to distinguish this from an LS root lesion (Saal et al, 1988). Electromyographic (EMG) studies can be helpful if there is doubt.

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Treatment: In a true entrapment, surgical release of the tendinous arch of the peroneus longus muscle leads to relief of symptoms. Usually the treatment is expectant, with resolution of symptoms if the precipitating causes are removed. Surgical exploration is rarely required.

Superficial peroneal nerve entrapment

The common peroneal nerve divides into a superficial and deep branch. The superficial branch can be trapped at its fascial opening in the anterolateral compartment of the calf, 10 cm above the lateral malleolus. Styf (1989) reported on 19 patients treated by fasciotomy and neurolysis. The symptoms were anterolateral calf pain and sensory disturbance over the dorsum of the foot. He described three provocation tests:

1. Pressure over the nerve as it emerges from the deep fascia with active dorsiflexion and inversion of the ankle
2. Passive plantar flexion of the ankle alone
3. Tinel's test over the fascial opening.

One or more of these tests elicited the symptoms. All patients showed slowing of nerve conduction electrophysiologically. Nine out of 19 were cured by operation.

Tibial nerve entrapment

Tarsal tunnel syndrome

The tibial nerve may be trapped in the tarsal tunnel *(Fig. 2)*. It lies behind the medial malleolus of the ankle, deep to the flexor retinaculum. The nerve lies between the tendons of the flexor digitorum longus and flexor hallucis longus muscles. Tarsal tunnel syndrome is usually caused by tight footwear, rheumatoid arthritis, tendon sheath cysts, or posttraumatic fibrosis. It is rarely caused by a tight retinaculum.

Diagnosis: The clinical symptoms are variable but include vague paraesthesiae on the plantar surface of the foot and toes, or over the medial half of the lower calf. Pain may be present. The symptoms may be worse at night, or made worse by exercise or rest, and by raising and lowering the leg.

Examination may show that the bulk of the abductor hallucis muscle is decreased. Sensory impairment may be present. Tinel's test may be positive behind the medial malleolus. In view of the vague symptoms, neurophysiological studies are necessary to confirm the diagnosis.

The nerve to the abductor digiti minimi muscle, which is a branch of the tibial nerve distal to the tarsal tunnel, is said to be trapped by a calcaneal spur (Baxter and Thigpen, 1984). It has been proposed that this is the cause of heel

Table 2. Important data on the peripheral nerves of the lower limb

Nerve	Motor deficit	Sensory supply	Sensory loss	Area of pain	Reflex arc
Sciatic	Peroneal: Dorsiflexion, inversion and eversion of foot	Anterior of leg and dorsum of foot	Often just dorsum of foot	Often painless	None
	Tibial: Plantar flexion and inversion of foot	Posterior leg, sole and lateral border of foot	Sole of foot	Often painless	Ankle jerk
Femoral	Extension of knee	Anteromedial thigh and leg to ankle	Usually anatomical	Anterior thigh and medial leg	Knee jerk
Obturator	Adduction of thigh	Medial surface of thigh	Often none	Medial thigh	Adductor reflex

After Patten (1977)

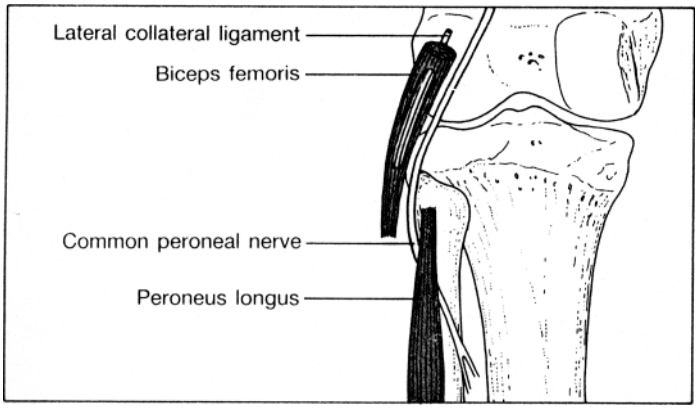


Fig. 1. The common peroneal nerve.

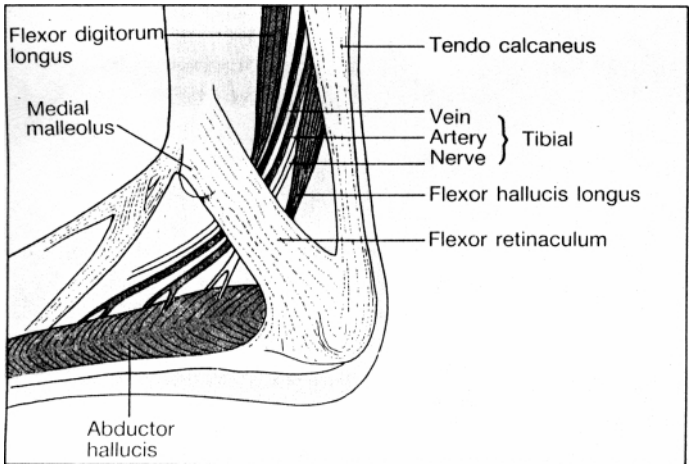


Fig. 2. The structure and content of the tarsal tunnel.

pain in what is usually termed plantar fasciitis. Baxter and Thigpen (1984) advocate release of the nerve as their treatment for heel pain.

Treatment: A trial of 2-3 weeks of a non-steroidal anti-inflammatory drug or a below-knee walking cast may relieve the symptoms. In pregnancy, rest and elevation of the leg may help, and the syndrome should resolve within a few months after delivery (as in carpal tunnel syndrome). Surgical release of the tibial nerve and all its branches is indicated in resistant cases (Richardson, 1987).

Lateral cutaneous nerve entrapment

Micralgia paraesthetica

This is a fairly common condition which is thought to be due to entrapment or kinking of the lateral cutaneous nerve of the thigh as it leaves the pelvis under the inguinal ligament just medial to the anterior superior iliac spine. *(Fig. 3).* It can also be produced by repeated pressure, such as leaning against a table, or by wearing tight clothes such as corsets. It is most common in obese individuals, especially if they have recently lost weight, due to the sagging abdominal wall pulling on the nerve. It also occurs in pregnancy.

Diagnosis: Meralgia paraesthetica presents as numbness, tingling or burning in the upper outer thigh. The lateral cutaneous nerve of the thigh does not supply the skin across the midline. In true cases of meralgia paraesthetica the symptoms are confined to the cutaneous distribution of the nerve. Men notice it when they place their hands in their pockets and find one side numb.

The diagnosis may be confirmed by injecting local anaesthetic into the hiatus of the nerve by the anterior superior iliac spine. This should abolish the symptoms.

Treatment: Most patients symptoms resolve spontaneously over 2-3 months. Steroids added to the local anaesthetic injection may hasten a cure, but should not be used on more than two occasions. In resistant cases where the clinical findings are definite, release of the nerve under the inguinal ligament can bring relief.

Sciatic nerve entrapment

Piriformis syndrome

The sciatic nerve can be compressed as it passes in front of the piriformis muscle. This presents as pain in the buttock which radiates down the leg like sciatica. Abnormal leashes of blood vessels have been found at operation (Adams, 1980). However, piriformis syndrome is usually thought to be due to scarring or spasm in the muscle. There is no significant damage to the nerve (Robinson, 1947).

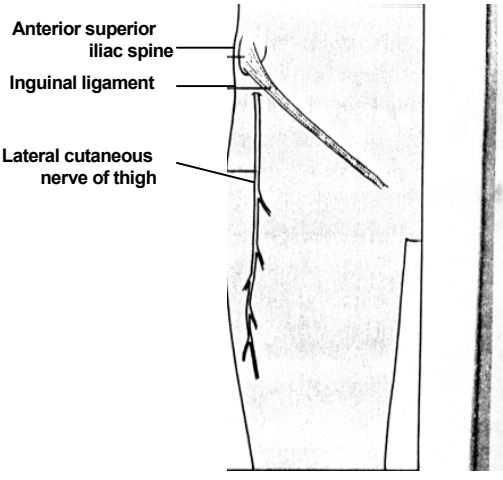
Saphenous nerve entrapment

Mozes et al (1975) have reported entrapment of the saphenous nerve as it pierces the subsartorial fascia. Patients have pain in the thigh and lower leg on walking, mimicking claudication. The nerve is locally tender. Relief is obtained by local injection or neurolysis.

Pseudoradicular syndrome

Lower limb nerve entrapment may mimic lumbar pain syndromes. Saal et al (1988) reported on 36 patients sent for neurophysiological studies whose true diagnosis was a peripheral nerve lesion. Of these lesions 20 were in the common peroneal nerve, 7 were in the saphenous nerve, 9 were in

Fig. 3. The lateral cutaneous nerve of the thigh.



the tibial nerve in the popliteal space and 9 were in the femoral nerve above the inguinal ligament. Most of these cases were not true entrapments but compressions. Tenderness and a positive Tinel's test often gave a clue to the diagnosis.

Conclusions

Entrapment neuropathies in the lower limb are rare. Many compression neuropathies have been described in the literature, but have not been reviewed here. In the main, nerve entrapment causes pain and local tenderness with sensory disturbance in the cutaneous distribution of the nerve. Conservative treatment will usually settle the problem. Neurophysiological studies are useful in persistent cases. Surgical decompression can be beneficial.

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