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A new approach to persistent traumatic peroneal nerve palsy

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SUMMARY. **Currently used tendon transfers for persistent traumatic paralysis of the common peroneal nerve are based on the transfer of the posterior tibial muscle, an antagonist muscle to the paralytic group of muscles. In order to achieve voluntary active dorsiflexion of the foot and automatic walking we have transposed the lateral head of the gastrocnemius to the anterior side of the lower leg, at the same time suturing the undamaged proximal end of the deep branch of the peroneal nerve to the motor branch of the tibial nerve innervating the lateral head of gastrocnemius muscle. After nerve regeneration and neurotisation the transposed lateral head of gastrocnemius was innervated by the deep branch of the peroneal nerve and thus it took over the function of the paralytic muscles.**

The indications for the operation, the surgical technique, and the results obtained in 6 cases are presented.

Common peroneal nerve palsy is a relatively frequent complication in trauma of the lower extremities. The treatment depends on the mechanism of injury and the type of nerve lesion. In the case of nerve contusion (neuropraxia) a complete nerve recovery can be expected. If the injury involves a complete disruption of the nerve continuity (neurotmesis) or traction lesion (axonotmesis), nerve fibres are damaged. Primary neurorrhaphy, secondary neurorrhaphy, and nerve transplantation are possible methods of treatment in the case of complete nerve lesions.[1,2] In 1960 Clawson reported a 34.7 % recovery after repair of the common peroneal nerve in 72 patients.[1] Wood reported 54.5 % recovery of eleven patients in 1991 as one of the best reported results.[3] These studies are not comparable due to different mechanisms of injury, evolving nerve repair technique, and size of patient samples. In cases where nerve recovery does not occur persistent peroneal palsy develops.

In irreparable paralysis of the peroneal nerve, tendon transposition is one of the methods of functional improvement of a permanently paralysed foot. In 1933 Ober described a transfer of the tibialis posterior tendon to the dorsum of the foot around the medial border of the tibia.[4] If the transposed tendon is passed through the crural interosseus membrane, the method is called Barr's technique.[5,6] Almost all recent work in this area has been based on these two methods of transposition of the tibialis posterior tendon.[7–12]

This report presents a new neurotendinous transposition in cases of persistent traumatic peroneal palsy. The idea is based on the transposition of the lateral head of the gastrocnemius to the tendons of the anterior muscle group, with simultaneous transposition of the intact proximal end of the deep peroneal nerve and suturing to the motor nerve of the lateral head of the gastrocnemius. This restores active voluntary dorsiflexion of the foot and automatic walking.

Materials and method

Adequate selection of the patients is an important prerequisite for the operation. It should be based on the following principles:

1. Viable proximal part of the common peroneal nerve. The lesion of the common peroneal nerve (and thereby its distinct motor deep peroneal nerve component) must be located at or distal to its branching from the tibial nerve. This guarantees intactness of the motor nerve fibres proximal to the site of the lesion (the presence of normal looking axons has to be checked by frozen section histological examination during the operation).
2. Permanent post-traumatic paralysis of the peroneal nerve. This is proven by no recovery of function for at least 18 months post injury or following most recent surgical treatment, with permanent electrodegenerative changes on electromyographic studies as well. However patients with anterior compartment muscle excision following severe compartment syndrome, and patients with nerve lesions at the myoneural junction require primary or early operation using this method (see Table, cases 3 and 5), as there is no chance of nerve recovery and hence no reason to wait 18 months.
3. A good range of passive joint movements. Passive dorsiflexion of the foot of at least 90 degrees.
4. Presence of normal muscles innervated by the tibial nerve.
5. Sufficient soft tissue coverage in the region of tendon transposition.

Surgical technique

The operative procedure consists of three parts.

Table Patients and results

Case & Sex	*Nature of trauma and associated lesion*	*Previous operation on nerve*	*Interval between trauma and tendon transfer*	*Date of tendon transfer and age at transfer*	*Result*
1 M	Struck by car bumper lesion of peroneal nerve	Jan. 1988 primary repair Sept. 1988 neurolysis	19 months	May 21, 1989 21 years	Excellent
2 M	Road traffic accident, compound fracture of tibia and fibula		20 months	July 10, 1990 26 years	Fair
3 M	Road traffic accident, fracture of tibia and unrecognised compartment syndrome	June 1990*	3 months	Sept. 15, 1990 21 years	Excellent
4 M	Iatrogenic (neurinoma of peroneal nerve)		5 years	Jan. 2, 1991 43 years	Good
5 F	Missile injuries		6 months	June 7, 1991† 10 years	Excellent
6 M	Ski-board injury severe ligamentous knee injury	Jan. 1990 neurolysis	28 months	June 19, 1991 26 years	Good

* June 1990, anterior muscle compartment excision and partial excision of peroneal muscle group 7 days after injury.
† Nerve grafting of superficial peroneal branch was performed simultaneously with tendon transfer and lateral head of gastrocnemius reinnervation by deep peroneal nerve.

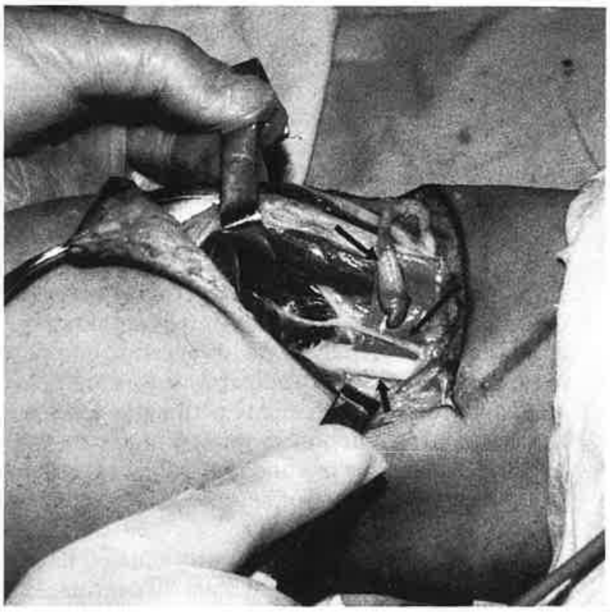

Fig. 1

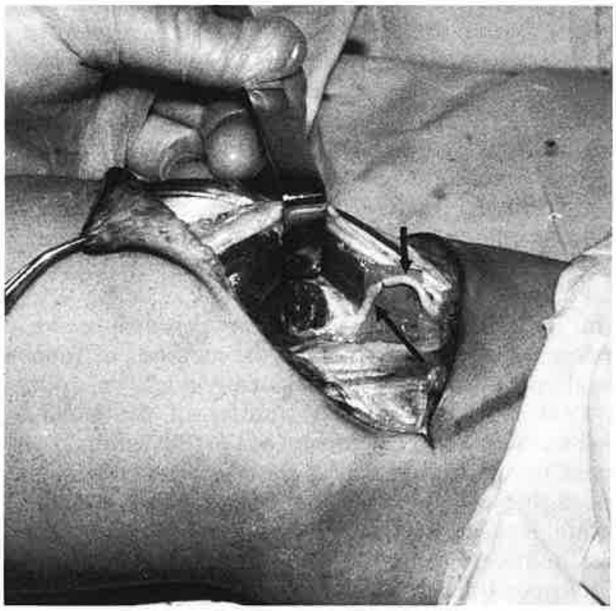

Fig. 2

Figure 1—Intraoperative findings. ——→—the proximal end of the deep branch of the peroneal nerve with neuroma. →—the tibial nerve. ———→—the motor branch of the tibial nerve for the lateral head of the gastrocnemius. **Figure 2**—The nerves prepared for suturing. ——→—the intact proximal end of the deep branch of the peroneal nerve after resection of the neuroma. ———→—resected motor branch of the tibial nerve for the lateral head of the gastrocnemius muscle.

First part. Isolation of the undamaged proximal end of the peroneal nerve and the neurovascular pedicle of the lateral head of the gastrocnemius muscle.

In a bloodless field an incision is made through the popliteal region (Figs 1, 2) to isolate the common peroneal nerve. Under the microscope the deep branch of the peroneal nerve is cut and isolated proximally until the intact nerve fibres are exposed (Fig. 2). The

Fig. 3

Figure 3—The isolated lateral head of the gastrocnemius muscle (Case 4).

deep peroneal nerve is a distinct component of the common peroneal nerve and as such can be separated in continuity from the common peroneal nerve by intraneural dissection as far proximally as the tibial nerve. The length of the intraneural dissection proximal to the site of the lesion depends on the mechanism of the injury and the histological findings. The deep branch of the peroneal nerve is used because it functions almost solely as a motor nerve. The tibial nerve is followed distally (Figs 1, 2) to isolate its motor branch supplying the lateral head of the gastrocnemius together with the lateral sural artery and vein. This motor branch of the tibial nerve is resected thereby denervating the lateral head of the gastrocnemius muscle (Fig. 2).

Second part. Transposition of the lateral head of the gastrocnemius to the anterior side of the lower leg.

The skin incision is extended distally towards the lateral malleolus. The lateral head of the gastrocnemius, together with part of the Achilles tendon, is dissected from the soleus muscle and the medial head of the gastrocnemius. The lateral gastrocnemius is isolated at its origin and at the vascular pedicle, which enables its easy transposition to the anterior side (Fig. 3). The tendons of tibialis anterior, extensor digitorum longus and extensor hallucis longus are isolated anteriorly and prepared for suture to the tendinous transposed lateral head of the gastrocnemius distal to the myotendinous junction.

Third part. Suturing of the nerve and transposed tendon. The nerve suture is the most delicate part of the operation and has to be done precisely, using a microscope and 10/0 sutures. The cross-sectional areas of the nerves are uneven and have to be coapted very carefully and without tension (Fig. 2). The motor branch of the lateral head of the gastrocnemius has to be shortened as close as possible to the muscle's neurovascular hilum to minimise the duration of denervation. The aim of nerve suture is reinnervation of the lateral head of the gastrocnemius by the deep peroneal nerve.

At the end of the operation the foot is brought to maximal dorsiflexion, and the transposed muscle is sutured under moderate tension to the tendons of the anterior muscle group (tibialis anterior, extensor digitorum longus and extensor hallucis longus). A padded above-the-knee plaster cast is applied with the foot maintained in dorsiflexion.

The postoperative period consists of three stages: 1. An immobilisation period, lasting 6 weeks. 2. A controlled immobilisation period lasting at least 6 months. During this time the patient wears a "peroneus apparatus" in order to prevent stretching of the muscles in the phase of nerve regeneration and muscle neurotisation. 3. Unrestricted active movement.

Results

Six patients with persistent post-traumatic paralysis of the peroneal nerve were treated surgically using this method.

Case reports

Case 1. A man, aged 21, was struck by a car. He suffered an isolated "bumper" lesion of the common peroneal nerve of the left lower leg. Primary suturing of the nerve was performed at a department of neurosurgery. Nine months later there were no signs of nerve regeneration either clinically or on electromyographic testing. The neurosurgeon therefore decided to perform another operative procedure (neurolysis). Eighteen months after the injury, however, there were still no positive signs of nerve recovery. After a detailed clinical examination and further electromyographic testing we decided to operate on this patient using the above described method. Our decision was based on the following factors:

1. Eighteen months had elapsed from the injury and nerve transplantation would not yield the desired result because we expected irreversible degeneration of the motor plates before the process of nerve regeneration could prevent it.
2. A strong Tinel's sign at the site of the injury, but not distally, confirmed a viable proximal end of the peroneal nerve (Figs 1, 2) while indicating negligible distal nerve recovery.
3. The patient's age, his high motivation, and the acceptance of all the risks of a new type of operation.

Six months postoperatively muscle contractions became clinically obvious and electromyographic studies showed the reinnervation potentials of the transposed muscle.

Two years after the operation the patient had active dorsiflexion of the foot to 0 degrees (Fig. 4), with active plantar flexion to 50 degrees (Fig. 5). Range of motion (ROM) was 50 degrees without foot inversion. Walking was stable and fully automatic.

Case 2. (See Table, case 5) A 10-year-old girl was accidentally shot in the leg. She was primarily treated in a small hospital. Six months after the accident she was transferred to our department with complete paralysis of the common peroneal nerve. Due to the mechanism of injury and wound site it was not possible to repair the deep branch of the peroneal nerve since the lesion was at the myoneural junction and the distal part of the deep branch of the peroneal nerve was completely destroyed. The proximal deep and superficial branches of the peroneal nerve were viable. Therefore, the lateral head of the gastrocnemius muscle was transposed with nerve suturing of

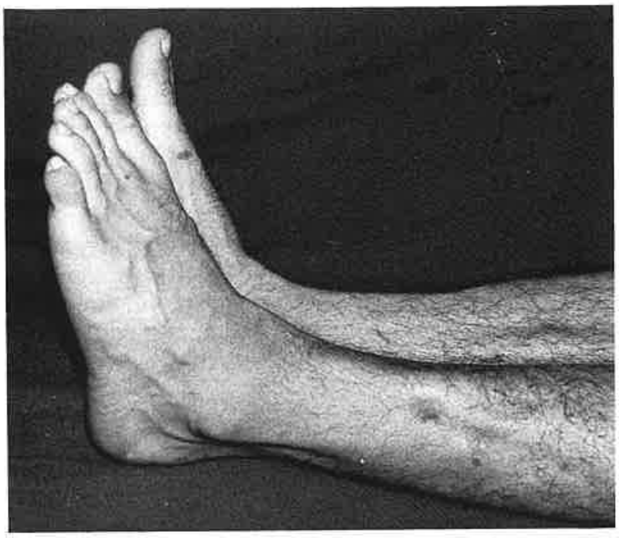

Fig. 4

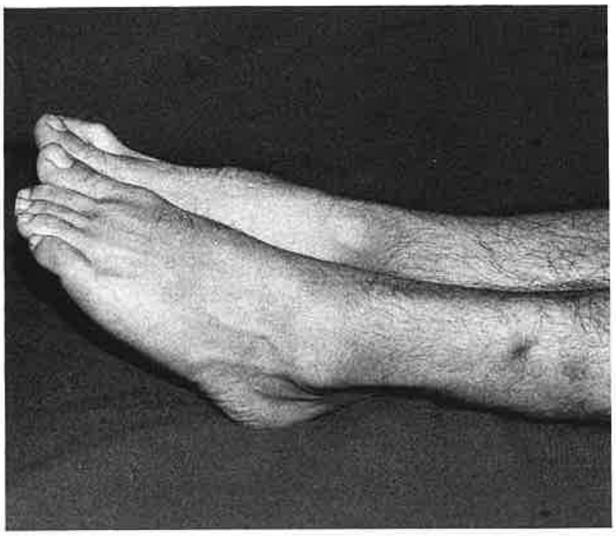

Fig. 5

Figure 4—Dorsiflexion of the foot, Case 1, 2 years postoperatively. **Figure 5**—Plantar flexion of the foot, Case 1, 2 years postoperatively.

the proximal end of the deep branch of the peroneal nerve to the motor branch of the lateral head of the gastrocnemius muscle. The gap between proximal and distal ends of the superficial branch of the peroneal nerve was bridged by a nerve graft.

Eighteen months after the operation the girl had active dorsiflexion to 10°, active plantar flexion to 45°, ROM 55°, without foot inversion, with normal walking.

Electromyographic testing was performed regularly in all patients, preoperatively to confirm absence of reinnervation potentials and postoperatively to determine the reinnervation of transposed muscles.

The results obtained were divided into three groups according to active dorsiflexion and active plantar flexion, range of motion (ROM), the degree of foot inversion and the stability and automatism of walking.

Classification of results

Excellent result. Active dorsiflexion to 0 degrees and more, active plantar flexion to 40° and more, ROM 40° and more, without foot inversion, with stable and fully automatic walking.

Good result. Active dorsiflexion of the foot between −10° and 0°, active plantar flexion to 40° and more, ROM 40° and more, minimal foot inversion, stable walking with minimal dropping of the foot.

Fair result. Active dorsiflexion between −20° and −10°, active plantar flexion to 40° and more, ROM 30° and more, with obvious foot inversion, improved walking, but evident dropping of the foot.

In all excellent and good results there was active dorsiflexion of the toes ranging from 0°–20°. In two cases (cases 3 and 5) with excellent results incomplete recovery of the peroneal superficial branch was noted, and therefore the peroneal muscle prevented foot inversion and improved dorsiflexion of the foot.

Analysis of the fair result showed that it was due to inadequate tension between the transposed muscle and sutured tendons. However, the patient was satisfied with the achieved improvement and was not willing to undertake another operation. There were no significant differences in electromyographic findings between this fair case and the other cases.

In all cases after 18 months postoperatively the electromyographic studies showed reinnervation potentials which were nearly normal in amplitude and duration, which means that there occurred a spatial and temporal compensation.

Discussion

Considering the basic principles of tendon transfer in the leg and foot we realised that in common peroneal nerve paralysis it is not possible to expect a functional synergism between the transposed muscle and the paralytic muscles. Previous methods of tendon transposition in the lower leg in paralysis of the common peroneal nerve were based on the transfer of the tibialis posterior tendon (TP) around the medial side of the tibia[5–7,10] or through the interosseous membrane.[5,6,8,9,12] Sometimes tendon transfer was combined with triple arthrodesis and posterior bone block of the ankle in order to stabilise the foot. In addition to the tibialis posterior tendon Carayon *et al.*[8] also transposed the flexor digitorium longus (FDL) through the interosseous membrane. They sutured the TP to the tendon of the tibialis anterior muscle, while the FDL tendon was sutured to the extensor hallucis longus and extensor digitorum longus. In most cases the transposed tendons were fixed to the bone structures of the foot (head of the third metatarsal, the cuneiform, navicular, or cuboid).

Since all the tendon transfers described in the literature are based on the transposition of an antagonist muscle to a paralytic group of muscles, a long and proper rehabilitation period is necessary to achieve active dorsiflexion of the foot by re-education.

Fig. 6

Figure 6—Voluntary contraction of the transposed lateral head of the gastrocnemius muscle after neurotisation (Case 1).

Unfortunately, active voluntary dorsiflexion is rarely restored satisfactorily by these transfers.[7,12]

Our operative method allows the reinnervation of the transposed muscle and active voluntary muscle contraction (Fig. 6) with active dorsiflexion of the foot and toe. The advantage of this method is a normal muscle balance between the transposed muscle, which is now innervated by the peroneal nerve, and the remaining intact muscles innervated by the tibial nerve. This physiological muscle balance provides fully automatic walking. The standard transfer of the TP does not provide a natural balance of the muscles of the lower leg and is based on the principle of tenodesis. Richard[12] compared the range of active plantar flexion before and after the operation in order to find out the effect of tenodesis on the function of the foot. He reported that the mean range of active plantar flexion before the operation was 26 degrees and after it, 10 degrees, which suggested tenodesis. Our patients, however, did not show limitation in active plantar flexion after the operation since the new procedure excludes tenodesing effects and re-education problems.

In our opinion, the described operative approach offers numerous advantages compared with other methods in the reconstruction of a drop foot secondary to traumatic common peroneal nerve palsy, in a well-selected group of patients.

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