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ORIGINAL ARTICLE

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Common peroneal nerve injuries

Results with one-stage nerve repair and tendon transfer

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Abstract The authors report their experience in the treatment of common peroneal nerve (CPN) injuries using a one-stage procedure of nerve repair and tibialis posterior tendon transfer. A series of 45 patients with traumatic injury and graft repair of the CPN is presented. From 1988 to 1991, the six patients elected for surgery had only nerve repair: five ultimately did not recover, while muscle contraction in the remaining patient was graded M1-2. Since 1991, nerve surgery in our clinic was associated with tendon transfer procedures (39 cases) which were followed by a satisfactory reinnervation rate. Nerve transection and iatrogenic injuries, torsion/dislocation of the knee, complex biosseous fractures of the leg, and gunshot wounds showed excellent to fair results in decreasing order: in nerve sections, muscle recovery scored M3 or M4+ in all the patients, and in nerve ruptures due to severe dislocation of the knee, it was M3 or M4+ in 85% of cases. The association of microsurgical nerve repair and tendon transfer has changed the course of CPN injuries.

Keywords Common peroneal nerve palsy · Foot drop · Nerve graft · Tibialis posterior tendon transfer

Introduction

The common peroneal nerve (CPN) can be damaged in the course of complex biosseous fractures of the leg, sharp injuries or lacerations (Fig. 1), severe adduction injuries and dislocations of the knee [1, 12], and gunshot wounds. The CPN can also be inadvertently injured during knee surgery such as removal of ganglions or benign tumours.

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Nerve regeneration following CPN repair is poorer than with any other peripheral nerve [3, 6, 8, 11] and still considered a great challenge, in spite of the unusually high rates of recovery (60–65% classified as good or fair) declared by Birch et al. [2] and Kline and Hudson [7].

Several factors have been advocated to explain this poor prognosis, including excessive nerve length and abundance of connective tissue [12]. Millesi [9] postulated that the main causative factor might be imbalance between the normal function of plantar flexor muscles and the passively stretched foot and finger extensors, which are inactive because paralyzed. In spite of weight bearing and the use of a kick-up brace, the foot tends to become fixed in a short time in the equinovarus position. The excessive contracture of the active muscles and shortening of the heel cord may also represent a severe obstacle to reinnervation. Therefore, Millesi suggested that early correction of these forces might favour nerve recovery.

Fig. 1 Foot drop due to a sharp laceration injury in the popliteal fossa. *SPE* common peroneal nerve

Table 1 Group A primary nerve repair (1988–1991)

Causative mechanisms	No. of patients (5M, 1F, mean age 21 years)	Graft repair
Sharp injuries and lacerations	2	2
Iatrogenic	1	1
Torsion/dislocation of the knee	2	2
Gunshots	1	1
Total	6	6

Fig. 2 Surgical findings in sharp injury. *SPE* common peroneal nerve

Patients and methods

From 1988 to 1991, six patients with CPN injury were treated with graft repair of the nerve (group A). Table 1 presents the data on these patients. From 1991 on, in all other patients we associated prodorsiflexion transfer of the tibialis posterior tendon with nerve repair in the same surgical session (group B). These patients' clinical features are listed in Table 2. In both series, surgery was generally performed 6 to 9 months after the trauma, due to late
referral.

Surgical technique

During the surgical procedure, the patient lies prone, the leg slightly flexed. A bayonet-shaped skin incision centered on the popliteal fossa allows exposure of the peroneal nerve from its division at the sciatic trunk to the neck of the fibula. In a nerve rupture (Fig. 2, Fig. 3b) and a neuroma in continuity (Fig. 4), where no nerve action potentials (NAP) or compound muscle action potential (CMAP) can be elicited, cable graft repair (8–20 cm) is performed. In 85% of the patients, the grafts were longer than 10 cm, and in one third of the cases, good fascicular architecture at the proximal stump was reached after microsurgical division of the lateral sciatic nerve upwards in the common trunk.

The distal peroneal canal was opened according to the general rules of nerve surgery. The patient is turned supine and the tendon procedure begun. A preoperative test of passive dorsiflexion indicates the opportunity of a Z-elongation of the Achilles tendon, although such decisions are ultimately taken intraoperatively. This became necessary in 25/39 patients (60%).

The tendon of the tibialis posterior muscle (which is spared in isolated CPN injuries) is then harvested through a retromalleolar incision prolonged towards the scaphoid and first cuneiform bones (Fig. 5). As its length is crucial, thorough subperiostal dissection is required. The tendon is then passed through the interosseous membrane, taking care to avoid sharp angles. After emergence in the anterior compartment, preferably medial to the extensor digitorum communis (EDC) (Fig. 6), it is tunneled subcutaneously and anchored to the third cuneiform bone. The foot is maintained at 90°. More dorsiflexion is not advisable because of the risk of toe clawing and retraction due to tension in the flexor digitorum longus.

Cast immobilization is maintained for 6 weeks. After removal of the cast, patients are taught to activate the transfer and immediately encouraged to practise unrestricted walking.

Results

Muscle reinnervation was evaluated after electromyography (EMG) and clinical examination according to the British Medical Research Council Guidelines, in which M4+ is considered the best score obtainable after nerve repair, M5 being completely normal strength. Clinical testing was done with the patient supine and asking him/her to neglect the effect of the transfer and concentrate on normal foot dorsiflexion. The ratings were: good (M3 or higher) for full function against gravity, which allows complete ease in walking, fair (M1-2), and poor (M0). The best scores were observed for the tibialis anterior, peroneal muscles, and common extensor of the toes. The extensor hallucis proprius had poor or no recovery, even with good reinnervation of the other muscles in half of the cases.

Group A results (Table 3) confirm the old view [10] that nerve repair alone is rarely worthwhile in CPN injuries. The only "fair" result is probably due to the patch-

Table 2 Group B combined nerve repair and muscle transfer (1991–2000)

Causative mechanisms	No. of patients (36M, 3F, mean age 23 years)	Graft repair
Sharp injuries and lacerations	9	9[a]
Iatrogenic	4	4 (two split repair)
Torsion/dislocation of the knee	20	20
Compound crush fractures (femoral, tibio/peroneal)	3	3
Gunshots	3	3 (one split repair)
Total	39	39

[a] None had a direct suture, not even in a sharp clean cut repaired in emergency

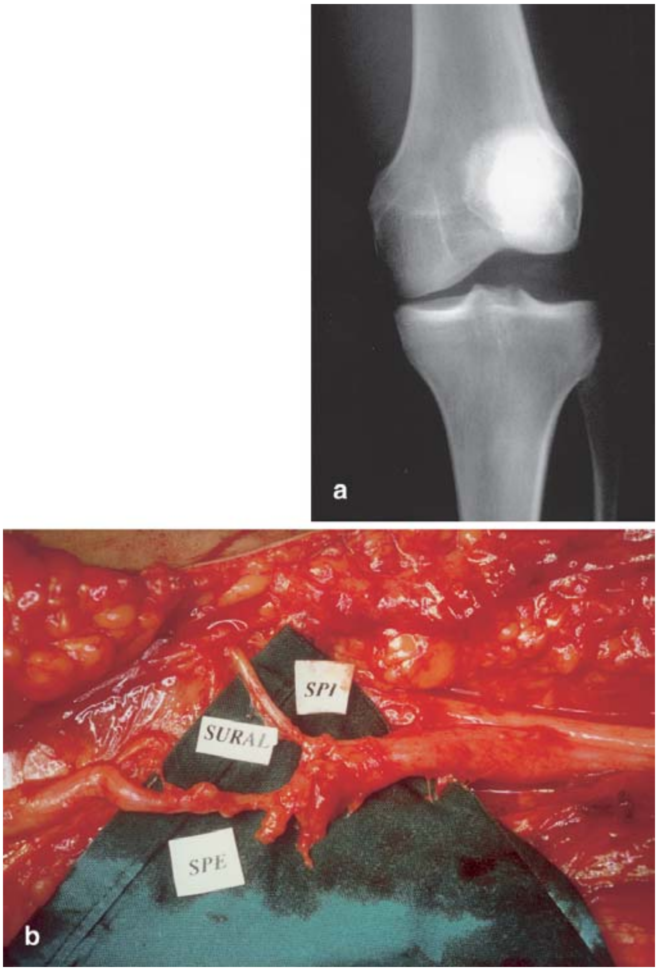

Fig. 3a,b Severe knee injury. **a** Radiological appearance. **b** Nerve rupture. *SPE* common peroneal nerve, *SPI* posterior tibial nerve, *Sural* sural nerve

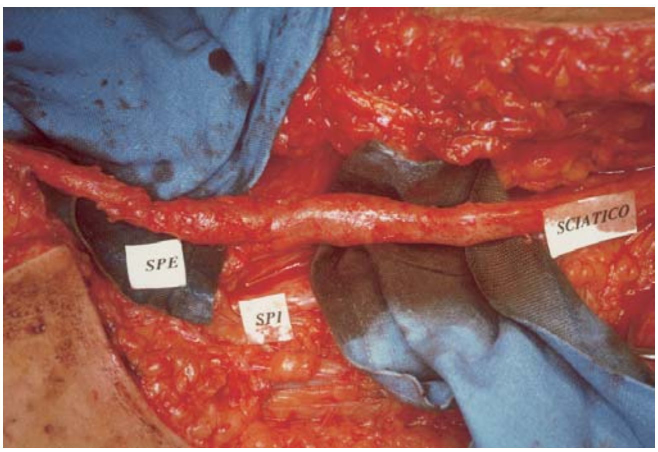

Fig. 4 Severe knee injury: neuroma in continuity. *SPE* common peroneal nerve, *SPI* posterior tibial nerve

Fig. 5 Tibialis transfer: identification of the tendon

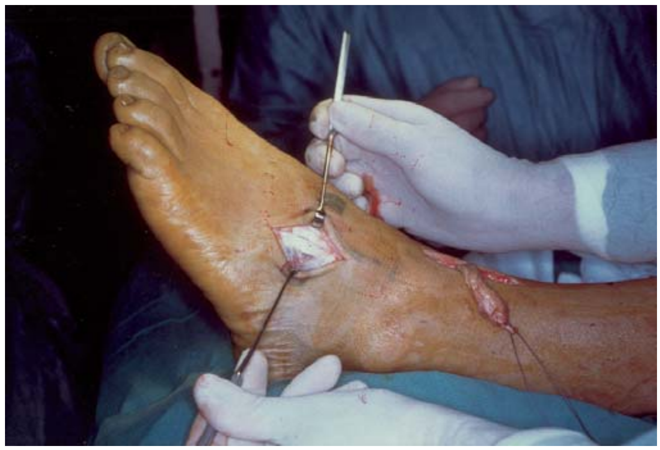

Fig. 6 Tibialis transfer: site of insertion of the tunneled tendon

Table 3 Group A results in muscle recovery

Causative mechanisms	No. of patients	Good	Fair	Poor
Sharp injuries and lacerations	2	0	0	2
Iatrogenic	1	0	0	1
Torsion/dislocation of the knee	2	0	0	2
Gunshots	1	0	1	0
Total	6	0	1	5

work nature of the nerve damage typical of gunshot injuries. Some of these patients had late transfer prodorsiflexion, but none ultimately recovered muscle function.

Every patient in group B (Table 4) regained independent walking without an orthotic device immediately after operation, thanks to the tendon transfer (Fig. 7). This method is a distinct advantage, since patients can rapidly return to active life and face rehabilitation therapy opti-

Table 4 Group B results in muscle recovery

Causative mechanisms	No. of patients	Good	Fair	Poor
Sharp injuries and lacerations	9	9	0	0
Iatrogenic	4	1	2	1
Torsion/dislocation of the knee	20	17	2	1
Compound crush fractures (femoral, tibio/peroneal)	3	1	1	1
Gunshots	3	0	2	1
Total	39	28	7	4

Fig. 7 Tibialis transfer: result activating the sole transfer

Fig. 8 Two-year follow-up: good recovery of common and big toe extensors. Same case as Fig. 1

mistically. None of them had long-term complications [5, 13]. At 2-year follow-up, neural regeneration was evident in 35 of the 39 patients (90%).

In sharp injuries and severe dislocations of the knee joint (Fig. 3a), the results were outstanding: the patients showed 100% and 95% of documented reinnervation. When other causative mechanisms (less represented in this series) were involved, outcome was definitely worse (Table 4). The results after split graft repair (M0 in the course of a perineurioma removal, M1 for repairing a nerve inadvertently damaged after an operation for osteoma of the fibular head, and M2 following a gunshot injury) were also below our expectations.

Discussion

In sharp injuries and severe dislocations of the knee, nerve repair associated with the tendon procedure is highly rewarding, while in the presence of different causative mechanisms (crush fractures, gunshot injuries), good recovery is less common; this is probably due to damage of the vasa nervorum and to total or partial muscle necrosis (some had compartment syndrome). Full recovery also appeared rarely following split graft repair, apparently due to unknown axonal damage in the neighbouring nerve fascicles.

Surgery is recommended in open wounds with immediate nerve palsy or in closed injuries, if no signs of recovery either clinically or on EMG occur within 2 or 3 months (the time needed for neuroapraxic damage to heal). Undue delay favours irreversible changes in the ankle joint and extensor muscles, which may severely impair final results. Birch et al. [2] reported good recovery in 48% of cases when the nerve was repaired 0 to 6 months after injury, compared to 9% when surgery was performed after 12 months. However, with the one-stage procedure, we obtained M4 muscle recovery in a patient grafted 13 months after injury and M3 recovery in another operated upon 18 months after injury.

The fate of CPN palsy due to closed injuries of the knee joint is of particular interest. These injuries are generally expected to have spontaneous recovery and therefore treated conservatively by the majority of physicians. Yet the nerve damage may often be so severe as to require graft repair (87% of cases in our series) [4].

Results of M4+ (Fig. 8) were achieved in spite of the graft length (up to 20 cm), in contrast to those reported by Kline and Hudson [7], who had poor results with grafts exceeding 13 cm.

Neural regeneration is significantly different between patients having nerve repair alone and those who also receive one-stage tendon transfer. Since no other difference in timing or surgical technique is evident, it appears that when the muscles remain anatomically sound although denervated, the early correction and rebalancing of flexion and extension forces favours neural regeneration. An additional factor may be that the rapid resumption of walking allowed by the transfer acts as a continuous 'internal' rehabilitation. One circumstance may render passive stimulation of the denervated muscles extremely easy: the majority of our patients, especially in the younger group, rapidly regained foot dorsiflexion simply by thinking of the same movement as before, in spite of the transfer of a muscle with a different function.

On the other hand, none of the patients submitted late to tendon transfer presented muscle recovery at the end (most had been operated on elsewhere and showed no nerve regeneration). This would suggest that the different success rates may not be due to the redistribution of forces per se, but that only a rebalancing before muscular fibrosis ensues can create better conditions for neural regeneration.

Neural regeneration does not affect CPN-dependent muscles in the same way. The tibialis anterior and peroneal muscles recover sooner, while the EDC is slower and less consistent. Recovery of the extensor hallucis longus is often unpredictable: a patient may appear to have an overall good result but fail to regain big toe dorsiflexion. We have no explanation for that.

Conclusion

In CPN injuries, nerve repair has better prognosis if it is associated with a tendon transfer procedure to regain foot dorsiflexion. Early correction of the imbalance between the activity of the plantar flexors and the paralyzed dorsiflexors not only prevents irreversible soft tissue and joint changes but also appears to enhance neural regeneration. With this technique, a highly satisfactory return of function can be expected, even in very severe injuries of the CPN.

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