ORIGINAL ARTICLE • KNEE - TRAUMA

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Short- and long-term results of common peroneal nerve injuries treated by neurolysis, direct suture or nerve graft

C. Horteur[2] · A. Forli[1] · D. Corcella[1] · R. Pailhé[2] · G. Lateur[2] · D. Saragaglia[2]

Abstract

Introduction Damage to the common peroneal nerve is the most frequent nerve injury in lower limb traumas. Our objective was to assess the motor and sensory recovery levels and the functional outcomes after remedial surgery for common peroneal nerve trauma, through either neurolysis, direct suture or nerve graft.

Methods This is a transversal, observational study of a monocentric cohort of 20 patients who underwent surgery between January 2004 and June 2016, which included 16 men and 4 women whose median age was 35 ± 11 years. We assessed the level of sensory and motor nerve recovery and the Kitaoka score. Nine patients benefited from neurolysis, 5 had direct sutures, and 6 received a nerve graft.

Results With 48 months' average follow-up, 7 out of 9 patients underwent neurolysis and 4 out of 5 with direct sutures had good motor recovery ($\geq$ M4), but none for the grafts. Sensory recovery ($\geq$ S3) was satisfactory in 7 out of 9 cases in the neurolysis group, 3 out of 5 in the direct suture group, and 3 out of 6 in the nerve graft group. The average Kitaoka score was 83.7 ± 11.5 for the neurolysis group, 86.8 ± 16 for the direct suture group, and 73 ± 14 for the graft group.

Conclusion Surgical treatment by neurolysis and direct suture yields good results with a motor recovery ratio nearing 80%. When a nerve graft becomes necessary, recovery is poor and resorting to palliative techniques in the shorter run is a strategy which should be evaluated.

Keywords Common peroneal nerve · Suture · Nerve graft · Neurolysis

Introduction

Lower limb nerve injuries are more unusual than in the upper limb and represent 20% of all nerve injuries. Damage to the common peroneal nerve is the most frequent nerve injury when the lower limb is subject to trauma. It is more vulnerable due to its superficial location near the neck of the fibula [1–4].

There are already publications on the subject [5]. In general, surgical treatments have a poorer outcome than repairs to the peripheral nerves in the upper limb [1, 2, 6, 7]. In the literature, the recognized predictive factors for common

peroneal nerve recovery after surgery are injury mechanism and location of trauma, whether or not a graft is required and its length, as well as the time lapse between the accident and the surgery [8, 9].

The main purpose of this study was to evaluate the rates of sensory and motor recovery of the common peroneal nerve after surgical treatment by neurolysis, direct suture or nerve graft. The secondary objectives were to evaluate the time required for nerve recovery, functional results, and complications related to surgical intervention. Our hypothesis, as described in the literature, was that satisfactory motor recovery would be observed in 70% of neurolysis, 50% of sutures, and less than 50% of grafts.

Patients and methods

This is an observational transversal study of a non-randomised monocentric cohort, written in accordance with the principles of the Helsinki Declaration. This study was

✉ C. Horteur
  CHorteur@chu-grenoble.fr

1 Department of Hand and Reconstructive Surgery, Grenoble North University Hospital, 38700 La Tronche, France

2 Department of Orthopaedic Surgery and Sports Traumatology, Grenoble South University Hospital, 38130 Echirolles, France

approved by the ethical committee of our institution, and all subjects included gave their informed consent.

The series

Population characteristics and pre-surgery clinical data are summed up in Table 1.

Thirty-nine patients operated on following an injury to the common peroneal nerve between January 2004 and June 2016 were included in the study. Within this group, 17 underwent emergency surgery for a section of the peroneal nerve, with or without loss of substance, and 22 were operated later on due to a closed injury.

At the final verification, data were available for 20 patients, 4 women and 16 men with an average age of 35.5 ± 11 years (21–59). There were 7 open injuries and 13 closed injuries. Among the 19 patients lost to follow-up, 10 of those who underwent emergency surgery were ski accidents who did not live in the area, and 9 of those operated on at a later stage after the injury were either unavailable or did not wish to have a follow-up consultation.

The circumstances of the injury are summed up in Fig. 1, and the lower limb traumas associated with the nerve injury or responsible for it are detailed in Table 1. Six knee dislocations made up one-third of the mechanical injuries causing a rupture, with loss of nerve substance in 4 cases, and a strain in 2 other cases.

The seven open wounds all had emergency surgery with 5 simple sutures and 2 grafts. The surgeries for the 13 closed wounds were delayed for up to 152 ± 64 days on average (90–250 days, 5 cases < 6 months and 8 cases > 6 months) after status control with an electromyogram. During the recovery time, patients were prescribed a foot-drop orthosis and physiotherapy sessions in order to maintain the ankle range of motion.

Operative procedure

During the intervention, the surgeon noticed 9 (Fig. 2) nerve contusions and sequelae of local compression (grades 2 and 3 of the Sunderland classification), with an indication for simple neurolysis, 5 nerve ruptures without loss of nerve substance treated with sutures (grade 5 of the Sunderland classification) and six ruptures with loss of nerve substance, with damage to the nerve wound area or continuous neuroma (grades 4 and 5 of the Sunderland classification) for which a graft was necessary.

The surgery was done under general anesthesia, and the patient was positioned in either a 3/4 supine position or in ventral decubitus with a pneumatic thigh tourniquet. The post-lateral approach (Fig. 3) was such as described by Masquelet and Tubiana [10].

When a nerve graft was necessary, the sural nerve was removed and interposed with an average of 2 or 3 strands in

Table 1 Population and preoperative data

	N	Average	Median	SD
Sex (men/women)	16/4			
Age at last follow-up (years)	–	35.5	31	11
Age at traumatism (years)	–	30.5	28	12
Age at surgery (years)	–	30.5	29	12
Non-athletic	7			
Athletic	13			
Lesion				
Open	7			
Claused	13			
Associated lesions				
Tibial plateau fracture	1			
Fracture of the fibula	2			
Knee dislocation	6			
Popliteal artery section	1			
Tendon section	6			
Ankle traumatism	0			
Initial complete motor deficit (M0)	19 (1 case M2)			
Initial complete sensory deficit	16			
Interval time between traumatism and surgery (days)	All procedures	99.5	93.5	90
	Neurolysis	150	114	64
	Sutures	0.6	1	0.54
	Nerve grafts	105	93	99

Fig. 1 Traumatic circumstances

■ Number
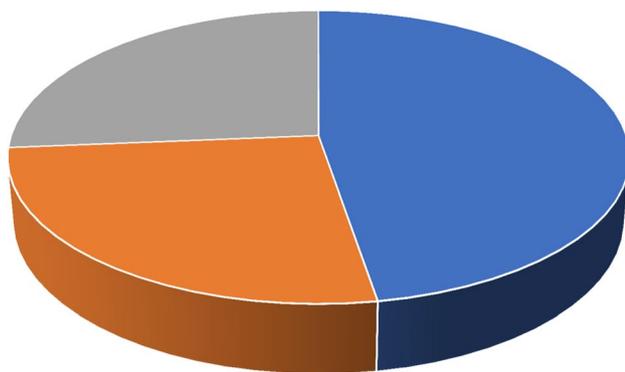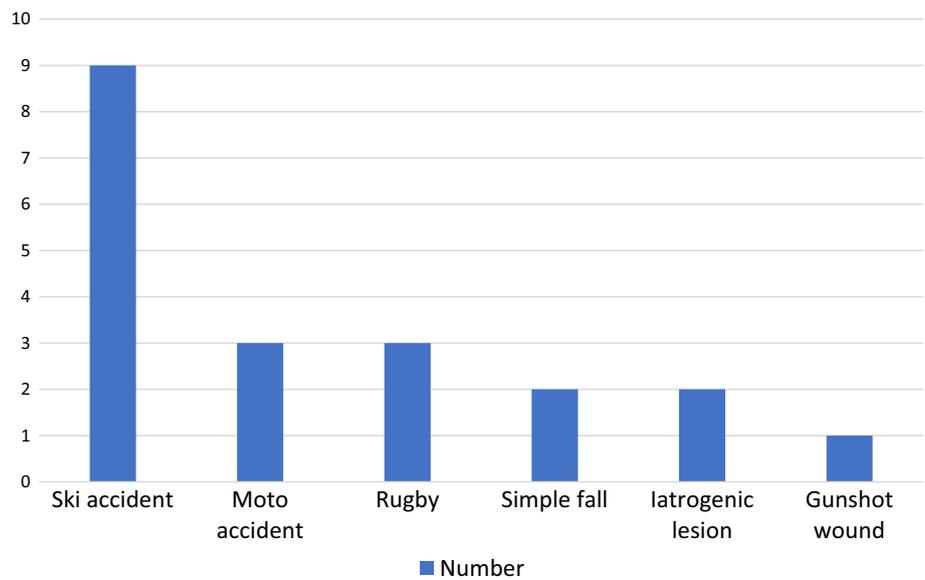
■ Contusion and sequelaa of local compression

■ Nerve rupture without loss of substance

■ Nerve rupture with loss of substance

Fig. 2 Lesion mechanism

Common peroneal nerve   Superficial peroneal nerve

Tendon of Biceps femoris muscle   Deep peroneal nerve

Fig. 3 Common peroneal nerve neurolysis: posterolateral approach and nerve dissection

order to achieve a nerve graft of the same diameter as that of the receiving nerve. The grafts measured 9 ± 4 cm, on average. The nerve sutures were individual stitches under magnifying glass or microscope (Ethilon™, Ethicon, 8/0 or 9/0) and completed with fibrin glue (Tissucol©, Baxter).

Rehabilitation with knee and ankle mobilization began after a 1-month immobilization period post-suture and graft surgery and was implemented immediately after neurolysis.

Evaluation methods

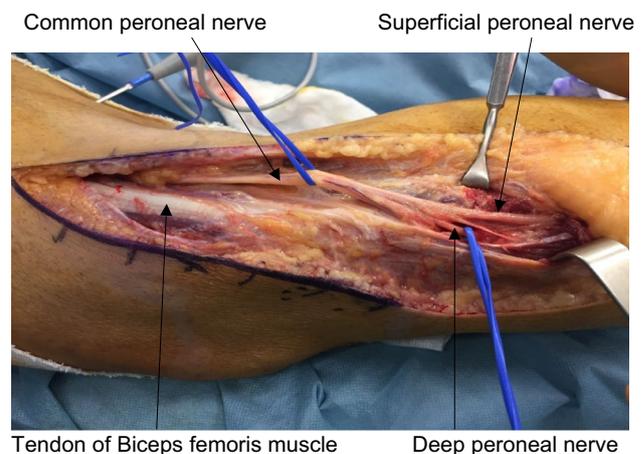Every patient was examined during follow-up. Data collection was performed by an independent investigator, initially based on medical records, and later during the follow-up consultation.

Patient follow-up included measurement of muscle strength according to the British Medical Research Council Scale for Muscle Strength (BMRC) and a comparative, bilateral clinical examination of the lower limbs in order to measure the ankle range of motion, assess the functional outcome according to the Kitaoka scale, and perform a sensitivity test around the common fibular nerve [11]. The investigators also listed possible complications and the need for palliative tendon transfer.

The main evaluation criterion was recovery of muscle strength—results between M4 and M5 were deemed satisfactory. With regard to secondary assessment criteria, sensory recovery was considered satisfactory at S3 or higher

(BMRC) and functional recovery as good or excellent if the Kitaoka score was over 75/100.

Statistical analysis was performed using XL stat 2017 software. The quantitative variables were analyzed using the Student test, and the qualitative variables using the Khi 2 and Fischer tests. All *p* values were compared with a 0.05 alpha value to identify statically significant differences. Subgroup analyses were carried out according to type of surgery, time lapse between injury and surgery, age, and size of graft.

We assessed the quality of the study using the *Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)* checklist.

Results

We recorded 2 complications: 1 hematoma which required draining, and 1 infection which required revision surgery. The recovery results for each intervention are summarized in Table 2.

Average follow-up was 48 ± 46 months (6–144 months) with a median of 25 months (1st and 3rd quartile: 14–61 months). The follow-up was under 12 months for 3 patients treated by neurolysis who showed complete recovery at 6, 7, and 8 months.

Motor recovery was satisfactory (M4–M5) for 11 patients from the total study population: 7 out of 9 in the neurolysis group, 4 out of 5 in the direct suture group, and none in the graft group. In the nerve graft group, the only patient with motor recovery (M3) was the one with the shortest nerve graft (5 cm). Six out of 8 patients operated within 6 months showed satisfactory recovery, versus 2 out of 5 for those who waited more than 6 months ($p = 0.29$). Satisfactory sensory recovery (S3) was found in 7 patients in the neurolysis group, 3 in the direct suture group, and 3 in the nerve graft group. Sensory and motor recovery occurred on average after 6 months (3.9 months for patients with a recovery score $\geq$ M4 and 9.5 months for those with < M4). The final result could usually be confirmed within 12–18 months.

The average Kitaoka score for the limb operated on was 81 ± 14 and 100 for the non-operated limb with a statistically significant difference ($p < 0.001$). The average score was 83.7 ± 11.5 for the neurolysis group, 86.8 ± 16 for the suture group, and 73 ± 14 for the graft group.

The average loss of ankle dorsiflexion range compared with the non-operated limb was 13° ($p < 0.001$). In the group of 9 patients who had poor motor recovery, passive dorsiflexion was $9.5° \pm 9°$ compared with those patients with a good motor recovery at $17.2° \pm 10°$. This difference was very close to the limit for statistical significance ($p = 0.055$).

Thirteen patients described ankle instability on the side operated on without any obvious inversion laxity which could be objectively ascertained through bilateral clinical examination. None of these patients had M5 motor recovery, whereas 4 out of 7 patients who did not describe ankle instability had complete motor recovery (M5). This difference was statistically significant ($p = 0.007$).

In 9 patients, treatment failed (muscle strength $\leq$ M3). Four patients underwent a secondary tendon transfer (1 after neurolysis and 3 after nerve grafts) and recovered partial active dorsiflexion with an average dorsiflexion range of $6.2° \pm 4°$ and a motor strength of M4. The 5 other patients with treatment failure refused surgery: Three had a clinical steppage gait which required the constant use of a foot-drop orthosis, and 2 had an effort induced-steppage gait requiring occasional use of the orthosis.

Discussion

Our results are similar to those found in the literature (Table 3), which reveals good results for neurolysis (7/9) and for direct sutures (4/5), whereas motor recovery is poor in nerve grafts.

The short follow-up for some patients could be a limiting factor. Some of the patients with poor motor recovery had an average follow-up of 42 months versus 52 months for those with good recovery. This difference, however, was not

Table 2 Motor and sensory recovery depending on the type of surgery

	Number	Ratio	Time interval between surgery and recovery start (months)		
			Average	Median	SD
Satisfactory motor recovery ($\geq$ M4)	11	11/20	5.6	3.5	4.1
Neurolysis	7	7/9	3.5	3	2
Suture	4	4/5	7.3	10.7	5.3
Nerve graft	0	0/6	–	–	–
Satisfactory sensory recovery ($\geq$ S3)	13	13/20	5.8	3	6
Neurolysis	7	7/9	7	3.2	5
Suture	3	3/5	4.6	2	4.7
Nerve graft	3	3/6	5.1	4.5	3

Table 3 Published series

Study	Year	Number	Neurolysis (%)	Suture (%)	Nerve graft (%)
George et al.	2014	1254	80	37	36
Kim et al.	2004	278	88	84	41
Birch	2011	150	74	38	–
Matejcik et al.	2001	40	90	75	25
Gosk et al.	2005	43	63	0	56
Seidel et al.	2008	36	72	–	28
Horteur et al.	2017	20	78	80	0

statistically significant ($p = 0.66$) and the average follow-up was higher than the usual recovery time (18 months). Sequelae linked to knee-associated injuries may be a confusion factor in the evaluation of the Kitaoka score for its functional item. None of the associated injuries of the lower limb had an impact on the ankle extensor muscles. Muscle strength therefore was not impacted by the associated injuries.

The first nerve sutures were done by Baudens in 1836. More recently, the common peroneal nerve sutures implemented by Kim et al. and Matejcik et al. described a satisfactory outcome in 75% to 84% of cases [12, 13]. And while Clawson and Seddon, and more recently Wilkinson and Birch, demonstrated that the length of the defect in closed injuries did not influence results, White explains that the longer the defect, the more difficult it is to suture the margins of the lesion precisely, due to a difference in the caliber of the 2 margins [4, 7, 14]. Furthermore a longer defect requires a vast neurolysis and consequently greater damage to the nerve vascularization as well as more tension on the sutures [14]. In order to reduce tension on the nerve suture, Millesi introduced the interfascicular autologous nerve graft in 1972 [15, 16]. The sural nerve is often used as graft [5]. In our study, nerve grafts show poorer results than those described in the literature: The low number of patients in the graft group does not enable us to demonstrate even minimal efficiency for this technique. Moreover, the loss of nerve substance was on average 9 ± 4 cm and acceptable results for nerve grafts in the literature involve loss of substance < 6 cm [8]. In fact, George and Boyce report that over a total of 368 repairs, 64% of the patients with a nerve graft < 6 cm recovered satisfactory muscle strength, whereas patients who underwent a graft between 6 and 12 cm recovered in only 29% of cases, and that number dropped to 11% if the graft was over 12 cm [8]. Furthermore, in our nerve graft group, none of the patients had motor recovery and only half of them had satisfactory sensory recovery. Sensory recovery without motor recovery can be explained among other things by motor plate degeneration after 12 months post-trauma. If we account for nerve regrowth of 1 mm per

day on average, this means early diagnosis and therapeutic care should be recommended.

More recently, nerve transfers from the motor branches of the tibial nerve (including the motor branches of the soleus muscle) were reported in order to compensate for oversized nerve grafts [17, 18]. The benefit of these techniques is to target the muscles to be revived, by performing the transfer on the motor branches of the common peroneal nerve and drawing together the suture and the muscles requiring re-innervation, thus reducing nerve healing time. Nath et al. [19] reported satisfactory results in 11 patients out of 14. Giuffre et al. [17, 18] have less favorable results with only 3 out of 11 patients recovering muscle strength greater than M3. Nerve transfers could be an interesting option when substance loss is over 6 cm, but more conclusive results are necessary. For closed injuries, many authors suggest a 3 month delay before considering surgery [2, 14, 20–22]. Recommendations include prescribing an electromyography and a clinical examination at 3 months, then exploratory surgery if there is no clinical or electrical recovery [22]. This was our approach for the present series.

Subjective lateral ankle instability can be explained by the loss of active stabilisers during an incomplete motor recovery with lack of fibular muscle function. Among the patients who mentioned this instability, none completely recovered their motricity, while those who made no mention of instability had a recovery score of M5 in 4 cases out of 7. Palliative techniques for steppage gait correction include transfer of the posterior tibial tendon through the interosseous membrane, onto the 2nd and 3rd cuneiform bones [23]. Insertion onto the 3rd cuneiform bone provides a decent eversion of the foot according to Werner et al. [24]. Systematically lateralizing the transfer of the posterior tibial tendon onto the mid-foot (on the lateral side of the third cuneiform bone) could be a possible solution, in order to limit the sensation of instability. An interesting strategy in the case of substance losses which require a nerve graft over 10 cm, would be a tendon transfer performed either straight away or 6 months later if there is no sign of recovery. It would be interesting for patients to benefit from early intervention, especially as those who do not recover motricity show a tendency to suffer from ankle stiffness (9° vs. 17° dorsiflexion). In fact, the preservation of the ankle's range of motion is a necessary criterion for the success of the tendon transfer. There is a real chance that the patient might not qualify for palliative treatment in the case of the initial treatment failure, or not achieve the best possible result, if a tendon transfer is undertaken.

George and Boyce [8] in a systematic review (28 studies, 1–5 years of follow-up) reported 80% of good results after 359 neurolysis. Three studies with more than 2 years of follow-up (Kim et al. [12], Matejcik et al. [13] and Kutubidze [25]) showed 78.5% of satisfactory results after 42 nerve

sutures. Comparable outcomes obtained in our study make us highly recommend these procedures when indicated. On the other hand, George and Boyce [8] found only 36% of acceptable results on 431 patients after nerve graft. Results in our study are even worst, thus we suggest evaluation of other strategies when a long nerve graft (over 6 cm) is required.

Conclusion

Surgical treatment of the common peroneal nerve by neurolysis, or direct suture yields good functional results in the long term, with a rate of motor recovery close to 80%. When a nerve graft is necessary, recovery is poor and palliative methods can be considered within a shorter time span after surgery (6 months); if there is no sign of recovery at this stage, or if the patient is not eligible for a nerve transfer, the benefits of which require further evaluation.

Compliance with ethical standards

Conflict of interest The authors hereby declare no conflict of interest.

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