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COMMON PERONEAL NERVE INJURIES AT THE KNEE: OUTCOMES OF NERVE REPAIR

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Summary

Background. Common peroneal nerve (CPn) lesion at the knee is one of the most frequent neurologic injury of the lower limb. Among the etiologies there are also open and closed trauma. If direct nerve repair is not possible, nerve grafting is indicated as a primary or delayed procedure. Nerve and tendon transfer are other possible therapeutic options.

Material and methods. In this retrospective double center study, 35 patients with post-traumatic CPn lesion at the knee, that underwent surgical repair, were analyzed. Exclusion criteria were severe concomitant neurological pathologies, complex injury of the lower leg including major vessels lesion and or tibial nerve injury. The objective of the study is to demonstrate the degree of foot dorsiflexion recovery based on the type of trauma and the corresponding performed surgery: the Medical Research Council classification (M0-M5) was used as rating scale.

Results. There were 23 closed and 12 open injuries. Time of surgery varied from 6 to 11 months after closed trauma, whereas 2 open traumas were explored at emergency and the remaining 10 patients were explored 3 to 9 months after injury. Neurolysis was performed in 12 cases. Neurorraphy was performed in 2 cases. Sural nerve grafting was performed in 21 patients, with a length range of 6-10,5 cm and 4-9 cm for closed and open trauma respectively.

Conclusions. Our series confirms that repairs of traumatic CPn injuries have an unfavorable outcome. Motor recovery score ≥ M3 was obtained in only 10 cases (28,57%). Neurolysis and nerve suture show better results than nerve graft alone, although no statistically significant differences emerged; CPn reconstructions with grafts show unsatisfactory results, particularly if the length of the grafts exceeds 6 cm and when patients are treated over 6 months after the trauma. Patients with closed trauma achieve less satisfactory results than those with open injury (13 *vs* 58%) and this was statistically significant ($p < 0.05$), so palliative surgery may be indicated as the first surgical approach for these patients to achieve good foot dorsiflexion.

Key words: peroneal nerve injury, nerve graft, neurolisis

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INTRODUCTION

Common peroneal nerve (CPn) lesion at the knee is one of the most frequent neurologic injury of the lower limb [1,2].

There are several etiologies for CPn palsy. The most common cause remains the compressive etiology: intra- and extraneural compressive masses (such as lipomas, venous ectasias, schwannomas or scars), peripheral neuropathies with CPn entrapment, habitual leg crossing, prolonged bed rest, positioning during surgery or anesthesia, compressive bandage. Traumatic etiology includes open and closed injuries: CPn palsy can derive from knee dislocation, fracture of the fibula, penetrating shot or cut injuries. Iatrogenic injuries generally follow hip, knee or ankle surgery, for example during knee arthroscopy and safenectomy.

CPn injuries are more frequent at the lateral aspect of the knee, as it passes around the fibular neck [2].

Naill et al. reports a CPn palsy rate from 25 to 40% after knee dislocation or luxation [3]; similar rates are confirmed by other studies [4,5].

Another frequent cause of common peroneal nerve lesion is an acute trauma of the ligamentous apparatus at the knee, with a nerve injury rate from 4.5 to 40% [6]. This frequency can increase up to 75% in case of multiligamentous injuries, particularly in postero-lateral knee dislocations [7].

Immerman et al. reports a CPn palsy incidence ranging from 1.2 to 3% in case of fibular head and/or tibial plateau fractures [8].

Traumatic etiology is most common in young athletic and adult patients following high energy trauma, whereas low energy injuries are more frequent in obese patients. Traumatic injuries are associated with poorer outcomes [9,10].

Clinical presentation varies based on the location and severity of the injury and the presence of anatomic variations. Most commonly, the patient reports the classic foot drop, resulting in weakness of ankle dorsiflexion or catching the toes during deambulation [11].

Numbness or dysesthesia may also be present along the antero-lateral leg, dorsal foot, and the first toe web space. Pain is not so common, but it may be present in traumatic wounds or compressive lesions.

Physical examination should primarily rule out neurovascular deficits that may compromise the affected limb. Subsequently, the motor involvement of the superficial peroneal nerve and deep peroneal nerve can be evaluated by the examination foot eversion and foot/toe dorsiflexion.

The classification proposed by the Medical Research Council [12] remains fundamental for the assessment of muscle function:

- M0 = no contraction;
- M1 = contraction without movement;
- M2 = contraction with movement possible in the absence of gravity;
- M3 = contraction with movement possible against gravity;
- M4 = contraction with possible movement against resistance with force less than normal;
- M5 = contraction with normal force.

Tinel's sign is localized in the area of nerve irritation or entrapment. Radiography, CT, MRI and ultrasound are used to understand the etiology.

Electrodiagnostic studies, including nerve conduction velocity (NCV) and electromyography (EMG) tests, help in the evaluation of the motor and sensory axons of the peroneal nerve and its branches. They are also useful for the localization of the nerve injury.

Surgical exploration and decompression of CPn closed trauma should be considered when a rapidly deteriorating lesion is present or there are no signs of improvement within 3 months. For open injuries with a suspected nerve laceration, the nerve should be explored within 72 hours and primary repaired, if possible.

If direct nerve repair is not possible, due to large gapping or severe nerve damage, nerve grafting is indicated as a primary procedure but more often as a delayed procedure [13].

Neurotization or nerve transfer is an emerging surgical option when there is a long or segmental nerve loss and in case of irreparable CPn injuries [14]. In refractory cases, tendon transfer allows to restore foot and ankle function: in particular, Posterior Tibial tendon (PTT) transfer to the lateral cuneiform or cuboid restores the ankle dorsiflexion [15].

The aim of this study is to evaluate the results obtained by repairing Common Peroneal nerve injuries at the knee.

MATERIAL AND METHODS

This is a retrospective bicentric study. The population analyzed includes 35 patients with post-traumatic Common Peroneal nerve lesion at the knee, that underwent surgical repair between 2004 and 2018.

Each patient was evaluated for injury mechanism, pre and postoperative neurological status, electrophysiological studies, lesion characteristics, type of surgery and length of the gap/nerve graft.

Patients with CPn injury at the knee were included in the study. Exclusion criteria were severe concomitant neurological pathologies, complex injury of the lower leg including major vessels lesion and or tibial nerve injury.

In open cut wounds, when a nerve section was suspected, surgery was performed at emergency. In closed injuries, operative treatment was advised when no spontaneous regeneration occurred 4-6 months after the injury.
The foot dorsiflexion evaluation was performed with the Medical Research Council classification (M0-M5): a score ≥ M3 was considered a good result. The sensory recovery was evaluated with the Semmes-Weinstein monofilament test. Fisher exact test was used for statistic analysis and a p-value < 0.05 was considered statistically significant.
All the procedures were performed by the same surgeon (one for each Center). The sural nerve was used as donor nerve, when necessary.

RESULTS

The study group is represented by 35 patients with post-traumatic CPn palsy at the knee, 9 women and 26 men, with an average age of 43 years old.
There were 23 closed and 12 open injuries: among the first, there were 11 varus knee distortion injuries (Fig. 1), 5 knee dislocation (Fig. 2) and 7 fractures of the fibular head and of the proximal tibia. Time of surgery varied from 6 to 11 months after injury. Open injuries consisted of 2 gunshots, 8 cut injuries (Fig. 3) and 2 iatrogenic:

Figure 1. X-ray with knee sprain trauma and ligamentous rupture.

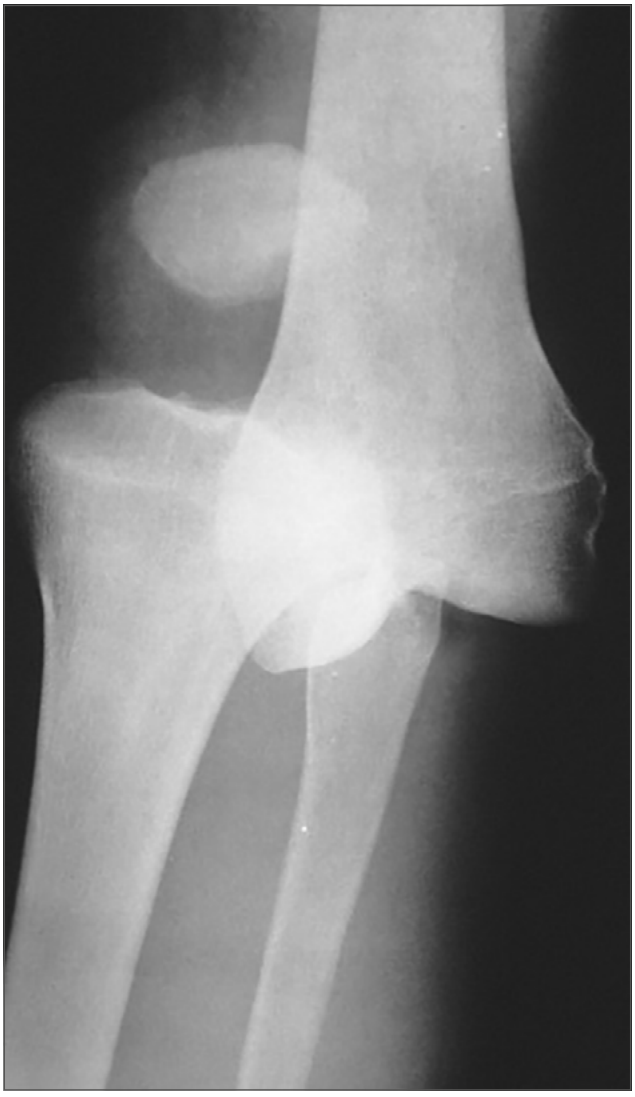


Figure 2. X-ray with knee dislocation.

only 2 of these injuries were explored at emergency, while 10 patients arrived on late referral and time of surgery was 3 to 9 months after injury (Figs. 4-5).
Neurolysis was performed when the nerve was in continuity and the intraoperative stimulation was positive in 12 cases of closed injury. Direct coaptation of nerve stumps was performed in 2 cases of cut lesion. Neuroma resection and CPn reconstruction with multicable sural nerve grafts were performed in 21 cases (11 closed injuries and 10 open injuries), with an average graft length of 9 cm (range 6-10.5 cm) in closed injuries and 6 cm (range 4-9 cm) in open injuries.
Motor recovery was evaluated at 3-6-12-24 months. At the final follow-up only 10 (28.57%) patients reported a score ≥ M3 (Tab. I); in particular, 2 neurorrhaphies, 5 nerve grafting and 3 neurolysis showed a score ≥ M3.

Table I. Demographic data and results.

Patient	Gender	Age y.o.	Type of trauma	Type of surgery	M Score
1	M	35	Close	Nerve graft	0
2	M	60	Open	Nerve graft	3
3	F	56	Close	Nerve graft	2
4	M	40	Open	Neurorrhaphy	4
5	F	45	Close	Neurolysis	1
6	F	32	Close	Neurolysis	0
7	M	21	Close	Nerve graft	1
8	M	43	Close	Nerve graft	1
9	M	18	Open	Nerve graft	3
10	F	25	Close	Neurolysis	4
11	M	55	Open	Nerve graft	1
12	M	52	Close	Neurolysis	0
13	M	48	Close	Nerve graft	0
14	F	45	Open	Nerve graft	0
15	F	28	Close	Neurolysis	2
16	M	32	Close	Neurolysis	4
17	M	59	Close	Nerve graft	0
18	M	62	Open	Nerve graft	3
19	M	72	Close	Neurolysis	0
20	M	55	Close	Nerve graft	0
21	M	31	Open	Nerve graft	4
22	M	25	Close	Nerve graft	2
23	M	44	Close	Nerve graft	1
24	M	66	Open	Nerve graft	2
25	M	53	Close	Nerve graft	1
26	F	43	Close	Neurolysis	3
27	F	21	Open	Nerve graft	0
28	M	55	Close	Neurolysis	2
29	M	67	Open	Neurorraphy	5
30	M	43	Open	Nerve graft	0
31	M	25	Close	Neurolysis	1
32	M	31	Open	Nerve graft	4
33	F	22	Close	Neurolysis	2
34	M	45	Close	Neurolysis	2
35	M	44	Close	Nerve graft	1

There were no statistically significant differences between the outcomes and the various surgical procedures (Fig. 6).

Only 3/23 (13%) patients with closed trauma reported a score ≥ M3, while 7/12 (58%) patients with open trauma showed a score ≥ M3, and this was statistically significant ($p = 0.014$). Twenty-five (71%) patients showed no recovery of Anterior Tibialis muscle and were addressed to palliative tendon transfer.

DISCUSSION

The Peroneal nerve is the most commonly involved nerve among traumatic nerve lesions of the lower limb, in particular at the knee-level.

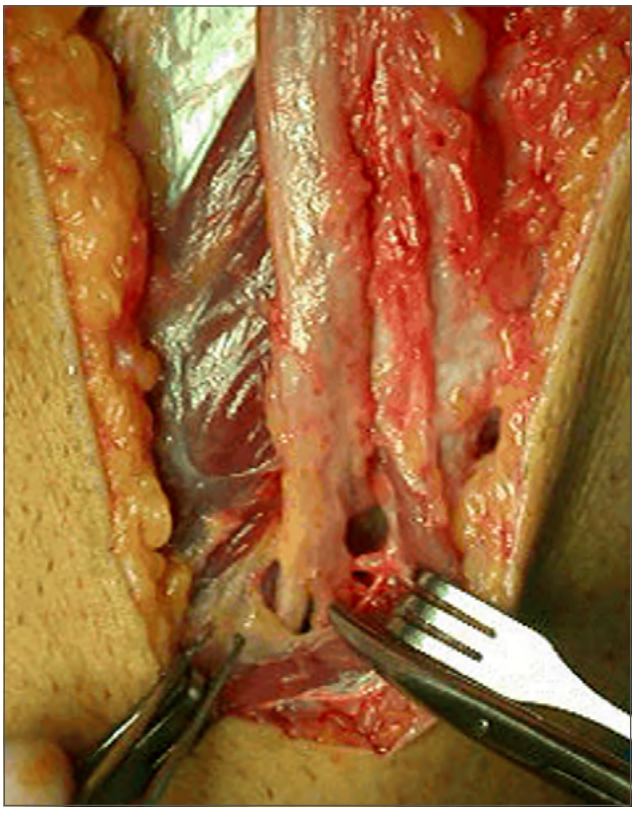
Surgical exploration and decompression of CPn closed trauma should be considered when a rapidly deteriorating lesion is present or there are no signs of improvement within 3-4 months [16-18]. For open injuries with a suspected nerve laceration, the nerve should be explored within 72 hours.

If direct nerve repair is not possible, due to large gapping or severe nerve damage, nerve grafting is indicated as a primary procedure but more often as a delayed procedure [13].

In the last 30 years, in literature there are numerous series that report conflicting results regarding CPn repairs:

Figure 3. CPn injury following stub wound.

it results from the fact that the repair technique (nerve decompression, neurolysis, endo-to-end suture and grafts) and the level of injury are analyzed together.
Demuynck (1987) [19], Wood (1991) [20] and Sedel (1993) [21] reported a good functional recovery respectively in 75, 54.5 and 37.5% of patients after CPn repairs.
The outcome varies according to different parameters such as the injury mechanism (open or closed trauma), the level of the nerve injury (buttock-, thigh-, knee-, ankle-level), the interval between trauma and surgery, graft length and patient age [22,23].
In 1994 Trumble et al showed useful recovery (≥ M3) in 3 patients (50%) treated with < 6 cm sural graft on CPn injuries [24]; in 1995 they confirmed their previous results [25].
Kim et al. [26] showed their results on 86 patients treated with sural grafting: a score ≥ M3 was obtained in 75% of patients who received a graft < 6 cm, in 35% of those with a 6-12 cm long graft, in 14% of those with grafts > 13 cm. In 2004 Kim [27] presented a study with 138 patients with CPn lesions at the knee and treated with nerve grafts: good recovery was obtained in 75% of patients with grafts < 6 cm, 38% of those with 6-12 cm long grafts, 16% of those with grafts > 13 cm. Excellent outcome was achieved in 88% of neurolysis and 84% of end-to-end sutures.



Figures 4-5. Intra-operative view.

Matejcik et al. [28] obtained a score ≥ M3 in 100% of the < 6 cm long grafts, in 25% of those < 12 cm and in none of those > 12 cm. In contrast, 90% of the neurolysis and 75% of the sutures showed an excellent outcome.
The results by Roganovic et al. [29] showed a useful recovery in 15.2% of Peroneal nerve repairs with grafts, concluding that motor recovery following the CPn reconstruction is worse than the one obtained from other peripheral nerves repairs.
The study by Seidel et al. [22] showed a good overall result for CPn repairs: however, a score ≥ 4M was achieved in 73% of external neurolyses, 71% of internal neurolyses,

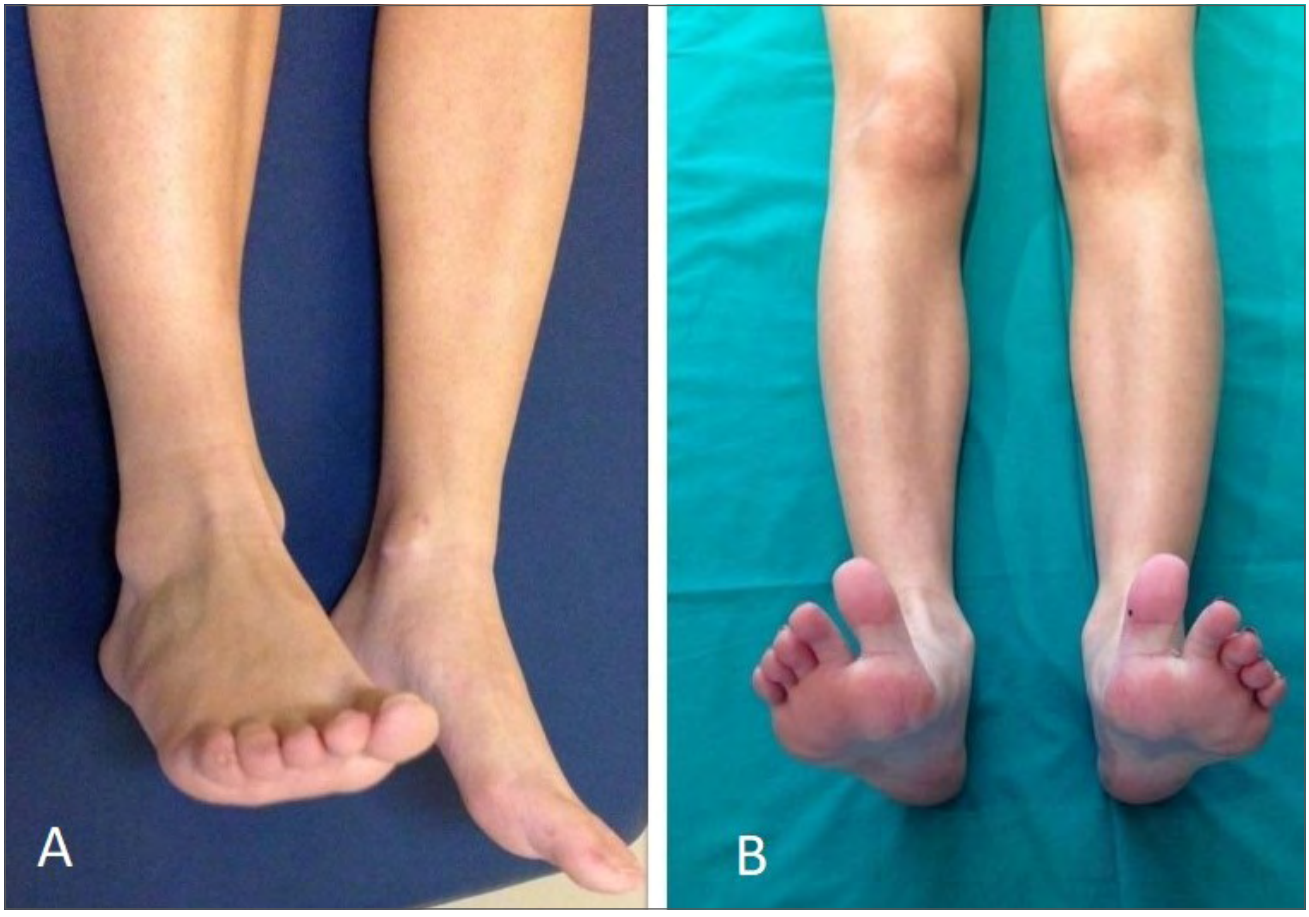


Figure 6. A) pre-operative foot drop; B) 24 months after surgery with restored anterior tibialis muscle function.

but only in 28% of nerve grafts (44% for grafts < 6 cm and 11% for grafts > 6 cm).

In 2008 Murovic et al. [23] published their series of 806 patients with lower-extremity peripheral nerve injuries. Peroneal nerve reconstructions with grafts showed good outcome in 24% of buttock-level peroneal divisions repairs and 45% of thigh-level divisions; good recovery was achieved in 40% of knee-level CPn injuries. As shown in the literature [9,10], our series confirms that repairs of traumatic CPn injuries have an unfavorable outcome.

Among the 35 patients, only 10 achieved a satisfactory outcome (> M3): 2 end to end sutures (100%), 3 neurolysis (25%) and 5 grafts (23.8%). Among the 23 closed injuries, only 3 (13%) repairs (neurolysis) achieved good results, compared with 7 (58%) good results after open lesions. No grafting for closed lesions gave good results: in these cases the length of the grafts varied from 6 to 10.5 cm (9 cm on average). No recovery was achieved in 71% of patients.

Our study shows a good outcome rate in 28.57% of CPn knee injury repair cases: Murovic describes a 40% rate for the same knee injuries. The results in the literature vary greatly, especially for some variables such as the length of the nerve grafts, the time elapsed between trauma and repair, the level of the injury.

It is clear that neurolysis and nerve suture show better results than nerve graft alone: considering only the latter, the literature shows that useful recovery is achieved in less than 30% of repairs, especially with long grafts (> 6 cm) [28,29].

Furthermore, our study shows that patients with closed trauma achieve less satisfactory results than those with open injury (13 *vs* 58%, $p < 0.05$).

The results of deferred CPn repairs are very unsatisfactory, particularly in closed and undiagnosed open injuries, treated with grafts. CPn reconstructions with grafts lead to unsatisfactory results, particularly if the length of the grafts exceeds 6 cm and when patients are treated over 6 months after the trauma. Closed CPn stretch lesions also have a very low success rate and palliative surgery may be indicated as the first surgical approach for these patients to achieve good foot dorsiflexion.

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Conflict of interest statement

The Authors declare no conflict of interest.

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Authors' contributions

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Abbreviations

A: conceived and designed the analysis
D: collected the data
DT: contributed data or analysis tool
S: performed the analysis
W: wrote the paper
O: other contribution (specify contribution in more detail)

Ethical consideration

The present paper doesn't required a specific Institutional ethics approvement.
The research was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki.
Written informed consent was obtained from each participant/patient for study participation and data publication.

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