CASE REPORT

Surgery of the peripheral nerves

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Abstract

Outcome: **In contrast to the CNS, peripheral nerves have the ability to regenerate. This ability has been utilized for a long time in the therapy of injuries of peripheral nerves. The aim of the present research was to assess the achievements in reconstructive surgery including nerve grafting and peripheral nerve suture repair in our clinic.**
Material and methods: **During the 16-year period from 1986 to 2001 we surgically treated 116 patients with peripheral nerve lesions. The cases of lesions of the brachial plexus, partial peripheral nerve lesions and postoperative revision, as well as the attempts of reconstruction of cervical nerves and neurolysis are not included in this work. We analysed the results of surgery in our patients who where subjected to treatment of peripheral nerves in the arms (95 patients) and legs (21 patients). In 53 patients reconstructive surgery was performed by suture repair of peripheral nerve, which included treatment of 65 nerves, 10 patients were treated by suture repair of 2 nerves and repair of 3 nerves in one patient. In 42 patients we reconstructed 45 peripheral nerves of the hand by autograft. The total number of 42 patients compromised 37 males and five females. The average age was 36 years. Double nerve reconstruction (ulnar and median) was accomplished in three patients. In the remaining 21 patients (14 males and seven females) we performed 21 reconstruction operations of 24 injured nerves in the lower extremities, of which 8 operations of 9 nerves involved suture repair of peripheral nerves and 13 operations of 15 nerves were performed using a nerve graft. Their average age was 39.7 years. The average period between primary treatment and operation was 6.7 months. In five cases the interval exceeded 12 months. Operations were performed by microtechnique. All patients were subject to several postoperational tests aimed at the estimation of the degree of recovery in sensory and motor adaptation. The evaluation was performed according the Seddon classification (1975) [1]. Motor recovery was evaluated according to a five-point scale and the degree of sensory recovery according to a four-point scale. Recovery of grade M4 and S3 (or higher) was considered an excellent or very good result and grades M3 and S2 were considered a good result. Results corresponding to grades M0-M2 and S0-S1 were considered to be insufficient.**
Results and conclusion: **The results of reconstruction operations of peripheral nerves injuries were dependent on the patient's age, the period between the injury and operation, the length of the autograft, the location of the injury, the type of injured nerve and the character of the injury *(Fig. 2, Tab. 7, Ref. 15)*.**
Key words: traumatic lesion of peripheral nerve, nerve graft, suture, reconstruction operations of peripheral nerve.

The first attempts to reconstruct peripheral nerves date back to the 17th century. The first suture repair of a peripheral nerve was performed in 1608 (Ferrara) (2). The first (although unsuccessful) attempt for a reconstructive surgery by autograft was carried out by Albert in 1876. Foerster (1916) introduced the use of nerve grafts to the clinical practice (3). Millesi (1972) pioneered autotransplant surgery by introducing the microtechnique and he restored confidence in autografts in the reconstruction of peripheral nerves (4) (Tab. 1).

Introduction of the surgical microscope in the late sixties significantly improved the outcomes of reconstructive surgery. Good visibility of the operative field, optical magnification of corre-

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Tab. 1. The history of nerve reconstruction.

1608	Ferrara	– suturation of a peripheral nerve
1876	Albert	– fisrt unsuccessful reconstruction by autograft
1916	Foerster	– introduction of nerve grafts to clinical practice
1972	Millesi	– restoration of confidence to autografts

Tab. 2. Number of patients with surgery of peripheral nerves 1986–2001.

	No of patients	No of nerves
Suturation arms and legs	95	110
Suturation by means of autografts	21	24
Total	116	134

sponding structures, perfect illumination and fine microinstrumentation enable delicate and exact procedures.

Surgical reconstruction of peripheral nerves faces several difficulties and the clinical outcome depends on several factors. The knowledge of anatomic variability in peripheral innervation is a prerequisite for successful reconstruction surgery of peripheral nerves. This variability has been only partially described in the literature (5–9), and works concerning the problem of anatomical variability are missing, particularly those that refer to their effect on the final result.

Patient group and methods

During the period of 16 years from 1986 to 2001 we surgically treated 116 patients with peripheral nerve lesions. Operations in 61 patients (53 %) were performed by microtechnique and the nerves were treated with a suture through the epineurium and in 55 cases (47 %) by means of an autograft (Tab. 2).

Not included in the Table are the cases of neurolysis that required the resection of only a fraction of fasciculi followed by a reconstruction by means of autograft, as well as negative revisions of brachial plexus or peripheral nerves, biopsy sampling or post-operative revisions, as well as the attempts at reconstruction of the cranial nerves XII–XI, XII–XII.

Altogether, 134 nerves were reconstructed in 116 patients. Reconstruction procedures of peripheral nerves in the upper limb were dominant in this group and represented treatment of 110 nerves in 95 patients. It is remarkable that only 9 of these patients received primary treatment in our Clinic. The average period between the injury and operation was 8.4 months. Their average age was 38 years.

All patients underwent clinical examination before surgery. In all patients a full neurological deficit was present. The indications for the surgical treatment included total neurological deficit in the absence of spontaneous improvement usually over 2–3 months. Iatrogenic cuts or stab wounds that occurred occasionally were usually handled immediately or in a short time interval. Pre-operative EMG examination showed denervation in all cases of reconstruction surgery.

Tab. 3. Seddon classification of functions.

Motoric	Sensoric
M0 No contractions	S0 Absence of sensitivity in the neural zone
M1 Recovery of tactile contraction in proximal muscles	S1 Recovery of the deep skin pain sensitivity in the nerve zone
M2 Recovery of tactile contraction in proximal and distal muscles	S1+ Recovery of surface skin pain sensitivity
M3 Recovery of functions in proximal and distal muscles in the degree enabling sufficient action against the resistance	S2 Recovery of the surface skin pain sensitivity and partial tactile sensitivity
M4 Recovery to the M3 degree plus possibility of all synergic and independent movements	S3 As S2 with additive moderate response
M5 Complete recovery	S3+ Recovery of surface pain and tactile sensitivity in the nerve zone and disappearance of paresthesias
	S4 As S3 plus partial recovery of two-point discrimination sensitivity Complete recovery

In cases when nerve suture repair was possible after mobilization of nerves or limbs without tension we performed reconstruction surgery as a rule by suture through the epineurium.

We reconstructed 45 peripheral nerves in 42 patients by means of nerve graft. Two nerves (n. ulnaris and n. medianus) were reconstructed in three cases. The n. suralis was used as the autograft in all cases.

All patients were subject to several postoperational tests aimed at estimation of the degree of recovery in sensory and motor adaptation. The evaluation was performed according the Seddon classification (1975) (1) (Tab. 3).

Motor recovery was evaluated according to a five-point scale and the degree of sensory recovery according to a four-point scale. Recovery of degrees M4 and S3 (and higher) was considered as an excellent or very good result, and degrees M3 and S2 were considered a good result. Results corresponding to degrees M0–M2 and S0–S1 were considered to be insufficient.

Repeated post-operational EMG examinations were performed in all patients. The follow-up period was at least three years, however, the majority of patients were monitored for 5 or more years.

Results

The most important factor in reconstruction operations is the result – the final effect in terms of motor and sensory recovery. The recovery may be characterized in several ways. We ana-

Tab. 4. Effect of delay on recovery (upper extremity).

Time (months)	Number of pts	Number of nerves	Suturation	%	Nerve grafts	%
0–3	40	40/36	23/21	91.3	17/15	88

Values are expressed as number of treated cases/number of cases with recovery classified as M3 and better.

Tab. 5. Effect of age on recovery (upper extremity).

Age (years)	Number of pts	Number of nerves	Suturation	%	Neuronal grafts	%
below 20	17	17	11/11	100	6/6	100
over 20	78	93	54/47	87	39/33	85

Values are expressed as number of treated cases/number of cases with recovery classified as M3 and better.

lyzed the results of reconstruction operations of peripheral nerves with respect to general factors affecting functionally the result of operation depending on:

– period between the injury and operation (Tab. 4),
– patient age (Tab. 5),
– length of the autograft (Tab. 6),
– injury location (Tab. 7).

Discussion and conclusion

The principal aim of reconstruction surgery is to achieve maximum motor and sensory recovery in the distal denervated part of the body. The simplest form of peripheral nerve reconstruction is direct suture repair of the epineurium after resection of the stumps of the injured nerve up to the sound fascicles (Fig. 1).

Tab. 6. Nerve grafts (upper extremity).

Length	Number of pts	Number of nerves	Results (Outcome)								
			M0-M1	M2	M3	M4	M5	S0-S1	S2	S3	S4
<5	31	31	1	1	4	10	15	1	8	10	12
6-10	6	8			4	2	2		4	2	2
>10	5	6	4		1	1		4	1	1	

Autografts are used in the cases when the nerve cannot be sutured directly without tension. We have used homotransplants in the past, however, the results were not satisfactory and this technique is currently not used in our operations. We use nerve grafts to bridge the gap between both ends of the injured peripheral nerve that cannot be brought closer without application of even moderate tension (4, 5, 10) (Fig. 2).

These results for mobility and sensitivity in the upper extremities can be satisfactory compared with those achieved in other institutions (4, 6, 9, 11, 12).

Nerve transplants were loosely placed between two nerve endings in such a way that the transplant surpassed the ends of damaged nerve by 5/10 mm. The number of transplants was 2–4. The groups of fascicles were connected by suture size 8.0 usually with 2–3 sutures. These results for the mobility and the sensitivity of the upper extremities can be satisfactorily compared with those achieved in other institutions (4, 6, 9, 11, 12).

A similar situation is noted in the lower limbs. Reconstruction operations of the peripheral nerves of the lower limbs were performed in 21 patients with reconstruction of 24 nerves. These operations included 9 reconstructions by suture repair of a peripheral nerve and 15 operations with nerve grafting.

Tab. 7. Nerve distribution level of lesion result of repair in arm.

Loc.of injury	Nerve	No of nerves	Suturation					Nerve graft				
			M0-M1	M2	M3	M4	M5	M0-M1	M2	M3	M4	M5
Arm												
	median	4					1	1		2		
	ulnaris	3			1		1			1		
	radialis	10	1			2	2	2	1	1		1
Forearm												
	median	8				1	1				3	3
	ulnaris	35		5	4	1	7	1		4	7	6
	radialis	10	1		1		4	1			1	2
Wrist												
	median	24			4	2	12			1	2	3
	ulnaris	16			4	4	6					2
	radialis											
Total		110	2	5	14	10	34	5	1	9	13	17

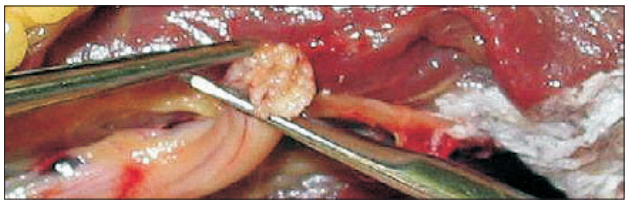

Fig. 1. Direct suture repair of the epineurium after resection of the stumps of the injured nerve up to the sound fascicles.

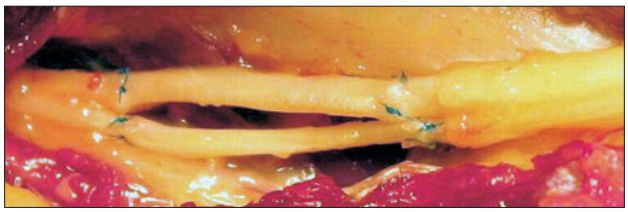

Fig. 2. Nerve grafts to bridge the gap between both ends of the injured peripheral nerve that cannot be brought closer without application of even moderate tension.

Injuries in the proximal and median thirds of the thighs were usually of secondary nature. A broken femur represented one of major reasons of this type of nerve injury.

Injuries were observed most frequently in the distal third of the thigh and the proximal part of shank. As for the character of the injury, lesions of n. fibularis were highly prevalent occurring in 16 patients.

Analysis of the results of post-operative examinations was performed as in the case of upper limb injuries.

The best results were observed for reconstruction procedures in the lower extremities by suture repair of a peripheral nerve (success rate of 70 %). The worst results were obtained with reconstruction operations involving nerve grafts – only 21.4 % success rate (4 patients).

Approximately similar results, though from a smaller group of patients, appear in the works of others (5, 13, 14) dealing with reconstructive operations on the peripheral nerves. We and others describe significantly worse results in the reconstruction of the fibular nerve (3, 5).

A complete recovery of sensory function was not observed in any of the patients over 40 years. Just the protective sensitivity was achieved in these cases.

A crucial factor affecting the results of the surgical reconstruction of peripheral nerves is the time that elapsed between the injury and the reconstructive operation. This factor is especially influential in younger patients.

Worse results were found for reconstructive operations of the lower extremities. Most investigators mention the poor prognosis, both for spontaneous recovery and reconstructive surgery of n. fibularis (4, 6, 11). Sunderland (15) describes several features that make this nerve more vulnerable including the relatively poor blood supply, less protective connective tissue between fascicules, and a reduced number of vegetative filaments. In only 3 out of 14 cases (21.4 %) were the results good or very good. Quite favorable results were observed in reconstruction of the tibial nerve or tibial portion of ischial nerve.

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Received December 30, 2005.
Accepted February 18, 2006.