Vascularized Nerve Bypass Graft: A Case Report of an Additional Treatment for Poor Sensory Recovery

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Summary: End-to-side neurorrhaphy has proven effective in basic research and in clinical application. One of the methods of end-to-side neurorrhaphy, nerve bypass technique, has been reported and axon regeneration has been proven. In clinical application, the utility of the nerve bypass technique has been revealed in some cases; however, these bypasses were performed using nonvascularized nerves. We initially used the vascularized nerve bypass graft technique with the sural nerve as a secondary clinical procedure after median nerve injury in a 61-year-old patient and achieved motor and sensory nerve regeneration, as supported by a nerve conduction study and clinical sensory test. This technique has the potential to become one of the choices for salvage procedure of severe nerve injury. *(Plast Reconstr Surg Glob Open 2016;4:e686; doi: 10.1097/GOX.0000000000000673; Published online 21 April 2016.)*

Sensory nerve recovery after median nerve repair tends to heal relatively well, and the outcome is generally acceptable.[1] However, in some cases, the postoperative result can be unacceptable, that is, severe crush injury, proximal site injury, elderly patient, and long denervation time before primary repair.[1,2] If sensory recovery is not expected to improve favorably after primary repair, reneurorrhaphy or nerve graft with end-to-end nerve coaptation is considered for secondary operation. While severing the nerve in the process of healing can provide an unbearable strain for the patient, there is no assurance that the outcome after secondary repair will improve beyond the primary repair. Indeed, there is no established additional treatment for severe nerve injuries that do not exhibit acceptable recovery.

In recent years, the availability of end-to-side neurorrhaphy has been demonstrated in basic research,[3,4] and the clinical application in the hand region has spread.[5,6] Among the applications of end-to-side neurorrhaphy, nerve bypass graft techniques have been reported and axonal regeneration has generally been proven.[7,8] In this report, we describe a new clinical application for vascularized nerve bypass graft as a salvage treatment for poor sensory recovery after median nerve repair. The purpose of this procedure was to establish the nerve axon from the proximal to distal site via the bypass route.

CASE REPORT

The patient was a 61-year-old man who was injured as a result of deep laceration at his right forearm by a broken window. His median nerve and flexor tendons were injured 8 cm proximal to the wrist crease. He urgently underwent primary repair of the median nerve (complete tear), flexor tendons, and

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Table 1. Improvement on Clinical Sensory Test and Nerve Conduction Study after Vascularized Nerve Bypass

		Clinical Sensory Test				Nerve Conduction Study				
						Median Motor (APB)			Median Sensory (Index)	
		Thumb	Index Finger	Middle Finger	Ring Finger*	MCV (m/s)	CMAP amp (mV)	DL (ms)	SCV (m/s)	SNAP amp (μV)
Before nerve bypass (18 months after primary repair)	s2PD (mm)	20<	20<	20<	20<					
	m2PD (mm)	12	20<	20<	20<	—	NE	—	—	NE
	SW	Purple	Purple	Purple	Purple					
7 months after bypass						30.7	0.19	5.2	37.2	2.6
18 months after bypass	s2PD (mm)	14	20	20	20					
	m2PD (mm)	9	8	12	12	28.3	0.68	8.7	34.6	5.6
	SW	Purple	Purple	Purple	Purple					

*Radial side of finger.
APB, abductor pollicis brevis; CMAP amp, amplitude of compound muscle action potential; m2PD, moving 2-point discrimination; MCV, motor nerve conduction velocity; NE, not evoked; s2PD, static 2-point discrimination; SCV, sensory nerve conduction velocity; SNAP amp, amplitude of sensory nerve action potential; SW, Semmes Weinstein monofilament test.

ulnar artery. The injured median nerve was initially repaired with an epineural suture.

Eighteen months after primary median nerve repair, he acquired full finger grip, but sensory recovery was poor. In the nerve conduction study, we detected compound muscle action potential (CMAP) of abductor pollicis brevis muscle and sensory nerve action potential (SNAP) of index finger over the primary repair site by the stimulations with anterograde pathway. But neither CMAP nor SNAP was evoked (Table 1). Therefore, we planned an additional procedure involving the vascularized nerve graft. In this operation, we initially performed neurolysis of the median nerve. There was no neuroma at the primary repair site, which was wrapped with a thin scar (Fig. 1). Next, we harvested the peroneal perforator flap from the posterior-lateral aspect of left leg together with 7 cm of the vascularized sural nerve and a 6-cm × 3-cm skin paddle (Fig. 2). The involved sural nerve was divided distally within the flap, and the flap pedicle was ligated at the perforator level. We generated epineurial windows in the median nerve at the proximal and distal position over the primary repair site and sutured the sural nerve to these windows in an end-to-side fashion (Figs. 3, 4). The pedicle artery and vein were then anastomosed to the

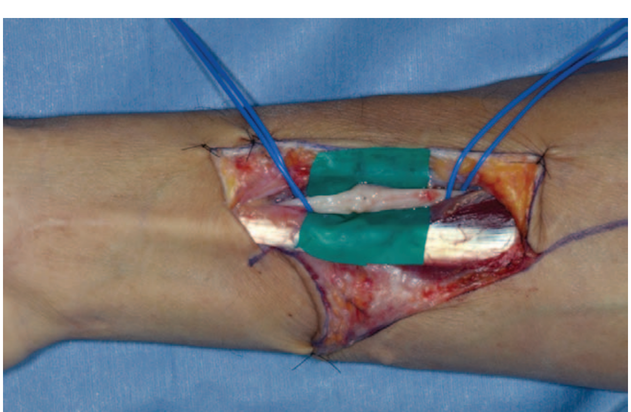

Fig. 1. Primary repair site of the median nerve after neurolysis during nerve bypass operation, which was wrapped with a thin scar.

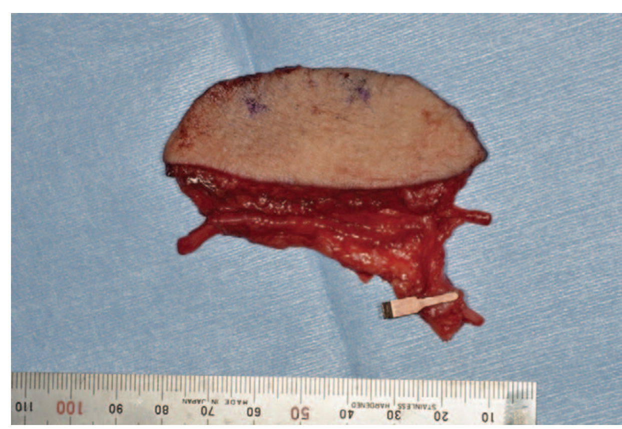

Fig. 2. A harvested peroneal true perforator flap together with 7-cm vascularized sural nerve and skin paddle.

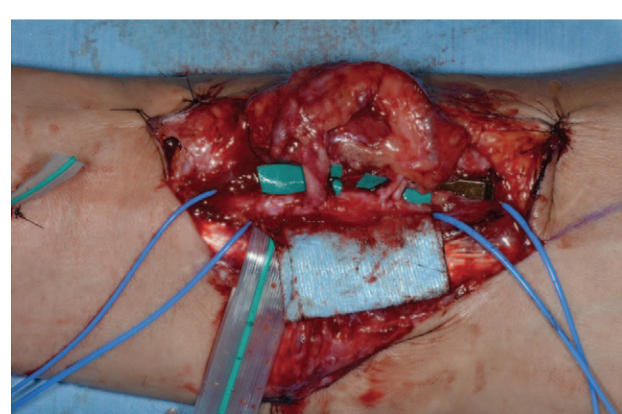

Fig. 3. The vascularized sural nerve was sutured with an epineurial window above the primary repair site.

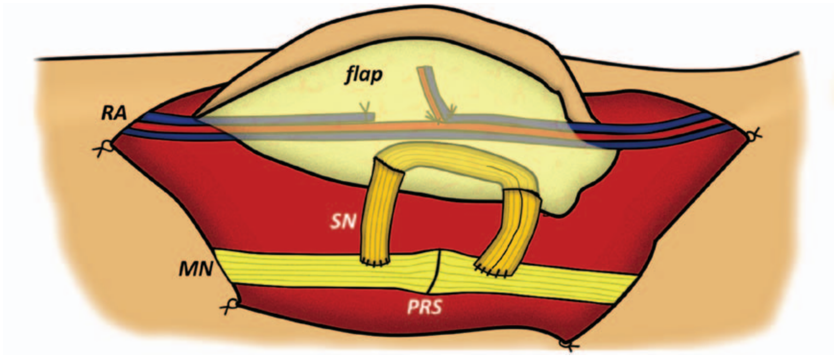

Fig. 4. The schema of the vascularized nerve bypass procedure. MN indicates median nerve; RA, radial artery; PRS, primary repair site; SN, sural nerve.

radial artery and one of the comitant veins. The initial forearm wound site could be closed directly. Therefore, we removed the skin paddle and left the residual vascularized nerve and subcutaneous fat to cover the median nerve after neurolysis.

As of 7 months postoperatively, CMAP and SNAP could be detected. At 18 months postoperatively, the CMAP and SNAP amplitudes were greater than those at 7 months postoperative. In the clinical sensory evaluation, static and moving 2-point discrimination were improved relative to the values obtained preoperatively (Table 1).

DISCUSSION

The potential for end-to-side neurorrhaphy in the hand region has been reported in both basic studies[3,4] and clinical reports.[5,6] The application of end-to-side neurorrhaphy has been reported as both direct neurorrhaphy[3,4,6] and a nerve graft procedure.[7,9] Among the nerve graft procedures, nerve bypass[5,6,8,10] has been used as one of the applied reconstruction concepts. In their basic research, Ulkür et al[7] reported the effectiveness of end-to-side neurorrhaphy by the nerve graft procedure in their rat model. In the clinical practice of nerve bypass, the effectiveness of bypass between the median and the ulnar nerves has been reported in some cases.[5,6] Kasabian et al[10] reported one case of free sural nerve bypass grafts for the treatment of neuroma-in-continuity of the peroneal nerve. In this case, nerve bypass was placed over the neuroma, after which functional motor and sensory return was acquired. In our case, the amplitudes of CMAP and SNAP were detected clinically 7 months after the nerve bypass. From this result, axon regeneration occurred in both the motor and the sensory fibers by simple end-to-side neurorrhaphy with an epineural window.

As a limitation of this case, there is no way to establish that this nerve regeneration occurred via either bypass route or the primary repair route or both. However, at 18 months after the primary repair, CMAP and SNAP were not completely detected, that is, regeneration of median nerve did not occur adequately via the primary repair site, although these action potentials improved 7 months after the vascularized nerve bypass. Based on these facts, we considered that both motor and sensory nerve conduction had occurred through the bypass route even if bypass nerve sprouting was weak. The biggest advantage of this procedure is to avoid damage and reset the primary nerve repair site. This bypass method only adds collateral axonal fibers; therefore, the patient did not lose function without flap donor site morbidity.

The advantages of the vascularized nerve graft have been reported for clinical cases, including the necessity for a long graft over 6 to 7 cm[2,9] or transference to a poorly vascularized bed.[9] Furthermore, the result of the vascularized nerve graft is superior compared with conventional nonvascularized nerve graft in terms of the rate of axonal regeneration and the rate of electromyogram return.[9] We believe that the vascularized nerve graft has the potential to establish greater axon regeneration in a shorter period of time than conventional nerve graft in end-to-side neurorrhaphy.

In summary, the nerve bypass graft procedure has the potential to improve sensory recovery. Thus, we encourage the selection of a vascularized nerve to produce a maximum result in end-to-side neurorrhaphy. This procedure could be one of the salvage choices for cases with poor sensory recovery.

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