Neovascularization and Other Histopathologic Findings in an Autogenous Saphenous Vein Wrap Used for Recalcitrant Carpal Tunnel Syndrome: A Case Report

Kent H. Chou, MD, Nikolaos G. Papadimitriou, MD, PhD, Ioannis Sarris, MD, PhD, Dean G. Sotereanos, MD, *Pittsburgh, PA*

A patient suffering from recalcitrant carpal tunnel syndrome despite 4 surgical decompressions was treated successfully with revision carpal tunnel release, neurolysis, and autogenous saphenous vein wrapping of the median nerve. When he subsequently developed compression of the common digital nerve to the middle finger his carpal tunnel was re-explored and the previously applied vein graft underwent a biopsy examination. Histopathologic analysis of the biopsy specimen was remarkable for neovascularization of the vein graft and structural transformation of the vein endothelium, neither of which has been reported in vein wrapping of the upper extremity. (J Hand Surg 2003;28A:262–266. Copyright © 2003 by the American Society for Surgery of the Hand.)

Key words: Vein wrapping, compressive neuropathy, carpal tunnel.

Several investigators have proposed vein wrapping for the treatment for recurrent compressive peripheral neuropathy.[1–7] The mechanism by which vein wrapping protects chronically compressed nerves remains the subject of debate, however, largely because histopathologic data on vein tissue used to wrap nerves are almost entirely absent from the literature. We describe a case in which a patient with recalcitrant carpal tunnel syndrome despite 4 surgical decompressions was treated successfully with revision carpal tunnel release, neurolysis, and autogenous saphenous vein wrapping of the median nerve. When he subsequently developed compression of the common digital nerve to the middle finger documented on electrophysiologic studies, we had the unique opportunity to re-explore his carpal tunnel and to inspect and take a biopsy specimen of the previously applied vein graft.

Case Report

A 44-year-old steel worker presented to us after having undergone 3 failed left carpal tunnel releases over a period of 9 months. Subjectively the patient complained of persistent and incapacitating numbness, tingling, and pain in the index and middle fingers. Physical examination was remarkable for 2-point discrimination of greater than 15 mm in the index and middle fingers, a positive Tinel's sign over the carpal tunnel, and exquisite tenderness to palpation at the distal wrist crease. Because the patient continued to be debilitated and unemployed because

From the Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA.

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Reprint requests: Dean G. Sotereanos, MD, 490 East North Ave, Suite 500, Pittsburgh, PA 15212-4740.

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of his symptoms the decision was made to proceed with revision carpal tunnel release and internal neurolysis of the median nerve.

At the time of surgery the median nerve was identified beneath the flexor digitorum superficialis and noted to bifurcate into radial and ulnar branches within the distal forearm. Thorough microscopic neurolysis was performed from the distal forearm through the carpal canal. A piece of anomalous flexor digitorum superficialis muscle lying between the radial and ulnar branches of the bifid median nerve was resected. A radial forearm flap consisting of fascia and subcutaneous fat was then raised and laid over the median nerve in the distal forearm to provide better soft-tissue coverage. The tourniquet was let down and abundant punctate bleeding noted within the transplanted flap. Routine closure was performed without difficulty.

After this procedure the patient experienced 2 months of symptomatic improvement; this was followed, however, by recurrence of his pain at the distal wrist crease and radiating digital paresthesias. It was felt that the timing of this recurrence was consistent with that of postoperative adhesion formation. After 7 months of failed desensitization and conservative treatment modalities the decision was made to proceed with revision carpal tunnel release, neurolysis, and vein wrapping of the median nerve to prevent extrinsic scar formation and recurrence of his symptoms.

Abundant scar was encountered during this procedure and meticulous dissection was necessary to identify and neurolyse both branches of the anomalous median nerve. The radial branch of the bifid nerve was noted to be tightly adherent to the overlying scar, particularly at the distal wrist crease. A 24-cm segment of ipsilateral saphenous vein was then harvested, split longitudinally, and wrapped circumferentially around a 6-cm segment of the radial branch of the median nerve with the intimal side facing the epineurium. The vein wrap was sutured to itself and tacked to the surrounding soft tissue proximally and distally to prevent slippage or segmental dehiscence. The previously transplanted radial forearm flap was inspected and noted to be viable.

Desensitization and range of motion exercises were begun immediately. At 3 weeks the patient reported a dramatic decrease in his pain at the distal wrist crease. Physical examination revealed nearly symmetric wrist and digital range of motion, substantial reduction in his sensitivity to palpation, and normalization of his 2-point discrimination with the exception of his middle finger, in which discrimination remained greater than 14 mm. Despite this apparent deficit the patient considered himself almost completely improved and returned to work in his previous capacity shortly thereafter.

The patient returned to the senior author (D.G.S.) almost 4 years later complaining of recurrent left wrist pain as well as persistent numbness in his left middle finger. The patient had been treated with anti-inflammatory medications, gabapentin, and even diuretics, without relief. Surprisingly he had worked continuously in his regular capacity at the steel mill until approximately 1 week before this presentation when he was placed on temporary disability pending medical re-evaluation. Physical examination showed 2-point discrimination of between 4 and 7 mm in all fingers except the middle finger, in which discrimination remained greater than 14 mm. He had an equivocal Tinel's sign at the distal wrist crease and a negative Phalen's test. Electrophysiologic studies performed within the next several weeks showed prolongation of sensory and motor latencies to the middle finger distal to the carpal tunnel. Conduction through the carpal tunnel itself was within normal limits. Magnetic resonance imaging had been ordered by the patient's primary care provider and was unremarkable except for some flattening of the median nerve. Plain radiographs of the wrist similarly were unremarkable.

At this point it was believed that the patient had formed scar at the level of the common digital nerve to the middle finger. Despite repeated warnings that surgery was unlikely to improve his symptoms the patient requested and subsequently underwent revision left carpal tunnel release and neurolysis of the common digital nerves.

Painstaking dissection was required again to identify and isolate the median nerve. The vein wrap was identified in its entirety (Fig. 1) and noted to be lifted easily off the nerve with only minimal blunt dissection (Fig. 2). Furthermore the vein graft was noted to be pink and well perfused despite prior limb exsanguination and elevation of a pneumatic tourniquet. When a small portion of the graft was excised sharply, punctate capillary bleeding was noted from within the wall of the vein. This piece of tissue was saved and sent to pathology for histologic analysis. Neurolysis of the ulnar branch of the bifid median nerve as well as each of the common digital nerves was then performed. The tourniquet was let down and the vein wrap was re-inspected. Brisk capillary bleeding from the biopsy site requiring bipolar elec-

trocautery was noted. Routine closure was performed without difficulty.

Multiplanar histopathologic sections of the biopsy specimen were fixed and stained with hematoxylin-eosin. Abundant collagenous stroma was noted adjacent to the adventitial surface of the vein and many patent venules and arterioles were noted within the adventitia itself (Fig. 3). Even more remarkable, however, was the appearance of the intimal surface of the vein where the endothelium was noted to be hyperproliferative and elevated into multiple papillary projections lined by endothelial cells and supported by loose connective tissue (Fig. 4). Notably absent was any evidence of inflammation, degeneration, or necrosis.

Clinically the patient experienced a dramatic reduction in his wrist pain and improvement in his 2-point discrimination from 14 to 6 mm. He returned to full-time work at the steel mill without any restrictions or limitations 4 months after surgery.

Discussion

Xu et al[4] showed that chronically compressed rat sciatic nerves that were wrapped with autogenous contralateral femoral vein exhibited more axons, less degeneration, and less demyelination when com-

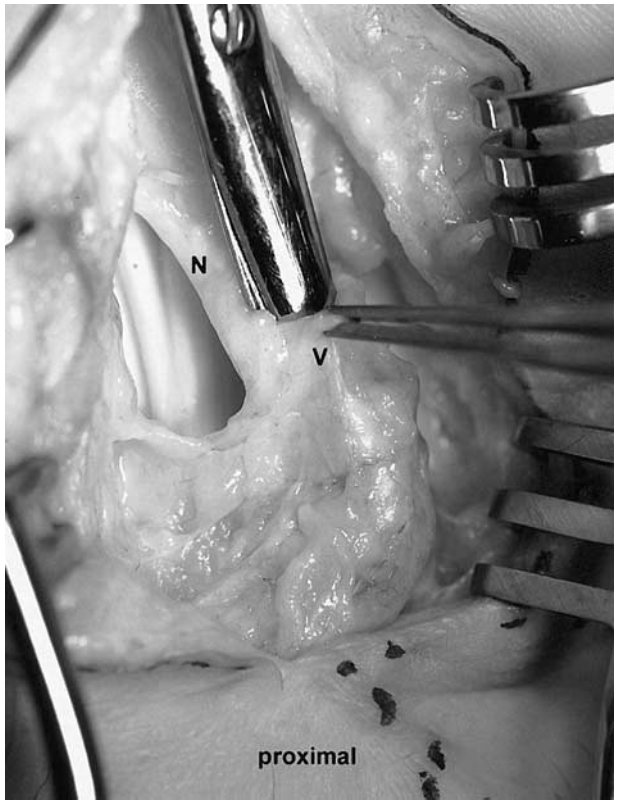

Figure 2. The vein wrap (V) is lifted easily off the underlying nerve (N).

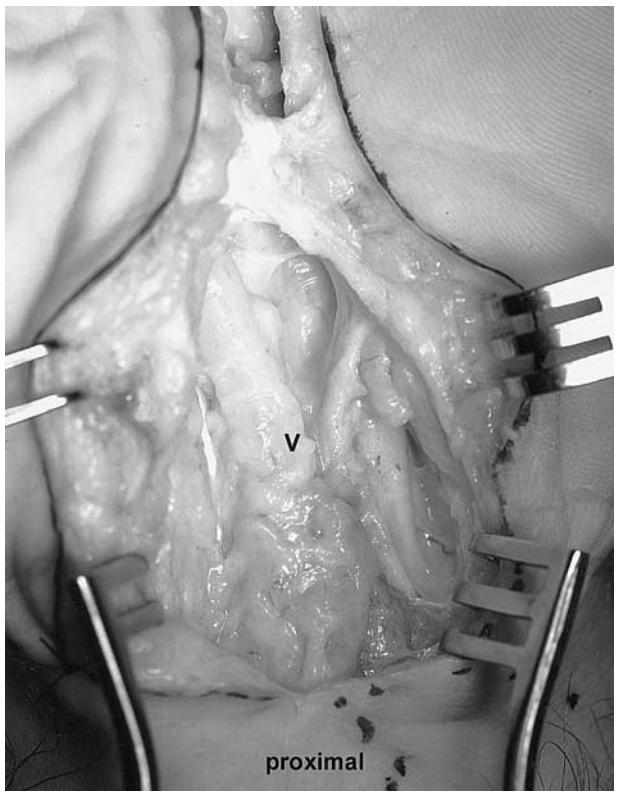

Figure 1. Intraoperative appearance of the vein wrap (V).

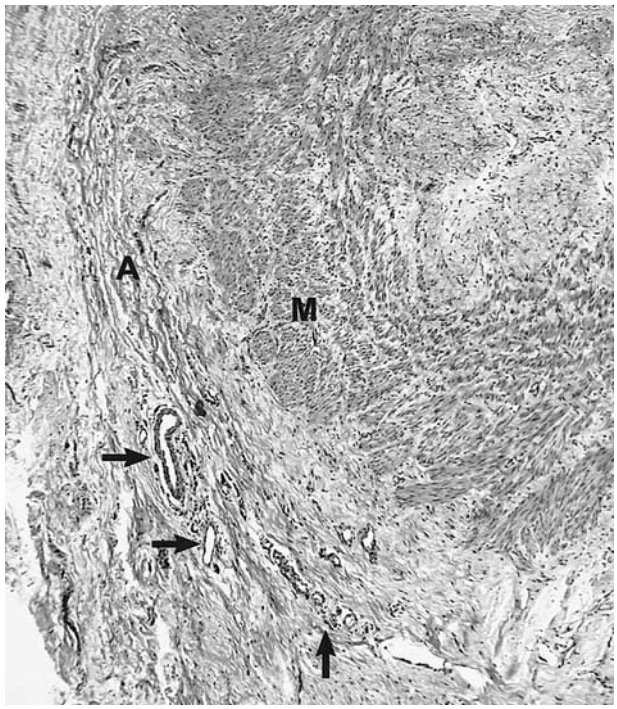

Figure 3. A low-power cross-section through the media (M) and adventitia (A) of the vein wrap. Note the patent adventitial vessels (arrows).

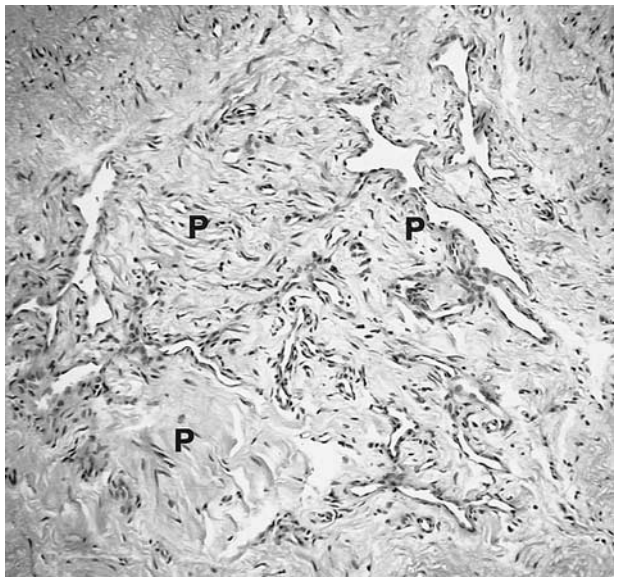

Figure 4. A high-power cross-section through papillary projections (P) found on the intimal surface of the vein wrap.

pared with chronically compressed unwrapped sciatic nerves. In addition the epineurium in vein-wrapped nerves remained free of adhesions histologically whereas in unwrapped nerves the epineurium was thickened grossly and encased in scar. The vein grafts themselves appeared to have revascularized and were viable with no histologic evidence of degradation or inflammation. Functionally the animals that had undergone the vein wrapping procedure showed greater improvement in motor function as measured electrophysiologically and by walking track analysis. Xu et al[4] proposed that autogenous vein wrapping preserved nerve function and organization by preventing epineurial adhesion formation, maintaining or restoring intrinsic epineurial vascularity, and forming a gliding interface between the nerve and the surrounding tissue.

In the only human histopathologic analysis performed to date Campbell et al[5] showed that autogenous saphenous vein wrapping of the tibial nerve in the setting of recalcitrant tarsal tunnel syndrome effectively protected the nerve from intrinsic and extrinsic scar formation because there was no fibrous reaction noted within or around the wrapped nerve microscopically. The vein graft itself clearly was viable and well vascularized with numerous intact, patent vessels noted in the adventitia. The patient in whom the vein wrapping procedure had been performed experienced significant relief of his pain at the tarsal tunnel and was subsequently re-explored for irritability of nerve branches distal to the tarsal tunnel. Campbell et al[5] suggested that the vein wrap had promoted normalization of nerve function by serving as a barrier to extrinsic scar invasion, thereby optimizing the local vascular environment.

Our analysis of a previously applied vein wrap, like that of Campbell et al,[5] revealed complete viability and obvious neovascularization of the autogenous saphenous vein graft with no histologic evidence of inflammation, degeneration, or necrosis. In addition there was no evidence of adhesion formation between the nerve and the intimal surface of the vein, suggesting that the vein wrap mechanically had shielded the nerve from extrinsic scar invasion. This was consistent with our intraoperative finding that the vein graft was lifted easily off the underlying nerve.

Additionally, however, our histopathologic analysis revealed that the vein endothelium had assumed a papillary morphology not typical of normal venous histology. We believe that this structural transformation as well as the neovascularization of the vein graft may have been induced by biologic interactions between the vein graft and the neighboring nerve. Of note, neuropilin-1, a transmembrane protein expressed both by adult sensory neurons and by endothelial cells, has been shown to bind vascular endothelial growth factor, a powerful stimulator of angiogenesis,[8,9] as well as semaphorin-3A, a protein that modulates the development, maintenance, and regeneration of adult sensory neurons.[10,11] In addition to its role in angiogenesis, vascular endothelial growth factor also has been found to promote Schwann cell invasion and neovascularization when applied to nerve grafts in rats.[12]

Our gross and histologic observations support the hypothesis that vein wrapping of chronically compressed nerves mechanically inhibits extrinsic epineurial scar formation, which may in turn promote normalization of nerve function. Additionally we propose that local factors originating from either the nerve, the vein graft, or both may be responsible for the neovascularization of the transplanted vein graft and structural transformation of the vein endothelium and may even act on the injured nerve directly to restore or optimize its function. Whether these events are mediated by interactions among neuropilin-1, vascular endothelial growth factor, and semaphorin-3A, or by some other mechanism is unclear and should be investigated further.

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