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CLINICS

Vein Wrapping for Recurrent Compression Neuropathies

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[Q4] Vein wrapping is a technique used to treat cicatrix formation around peripheral nerves by creating a barrier to adhesion in-growth from the surrounding tissues. Scarring of peripheral nerves is encountered most commonly after failed surgical decompression for entrapment neuropathies but also can be seen after trauma.

Carpal tunnel syndrome and cubital tunnel syndrome are the most common entrapment neuropathies of the upper extremity. Although surgical decompression generally is considered effective in both of these conditions, recurrence of symptoms is not uncommon. Rates of treatment failures or recurrence have been reported to be as high as 30% [1–12]. [Q5]

There are several reasons for persisting or recurrent pain following surgical decompression: incomplete release, injury to the nerve trunk or its branches resulting in neuromas, reflex sympathetic dystrophy, and scarring of an intact nerve. Incomplete release can be addressed with repeated decompression. Neuromas may be partial or complete nerve injuries and are treated accordingly. The treatment of reflex sympathetic dystrophy must be individualized.

Results of revision surgery for entrapment neuropathies are not always rewarding [1–4,13]. Even after repeated decompression and neurolysis or transposition of the nerve, symptoms can recur because of scarring. Scarring of the nerve is by far the most difficult condition to treat, because attempts at repeated decompression and internal neurolysis further enhance scar tissue formation and recurrence is inevitable [13].

Pain resulting from postoperative epineural scarring is caused by mechanical constriction, nerve ischemia, and impairment of nerve gliding on the adjacent tissues. Intraneural scarring also develops and aggravates symptoms. The term traction neuropathy was used to describe the resultant chronic neuropathy [7]. Although this term is clinically relevant (pain usually is exacerbated with motion of the adjacent joints), it describes only one of the mechanisms (lack of gliding) that lead to pain.

In the setting of a scarred nerve most investigators agree that soft tissue coverage is necessary. The ulnar nerve at the elbow is easier to cover by anterior transposition in the flexor–pronator musculature, but failures with this technique are not uncommon [1,2,4] and it cannot be applied if submuscular transposition was used as the primary procedure. Soft tissue coverage for the median nerve at the wrist is not readily available and the surgeon has to resort to flaps in revision surgery. The hypothenar fat pad flap can produce good results and is uncomplicated in most cases [14]. Pedicle or free flaps, including the groin flap, lateral arm flap, and posterior interosseous flap, provide excellent protection of the nerve, but the technique is complex and the result is not always satisfying [14,15]. Small local flaps, such as the abductor digiti minimi, the palmaris brevis, and the pronator quadratus, also have been used [16–18]. The dissection of these flaps, however, is not always easy, nerve coverage is sometimes inadequate, and skin closure problems

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may occur. A more conservative approach using implanted nerve stimulators or anesthetic reservoirs [19,20] has failed to produce pain relief consistently for these patients and has been associated with complications.

Basic science

The first clinical report of vein wrapping of a scarred peripheral nerve is attributed to Masear [21]. The effect of wrapping scarred nerves with autogenous vein graft was studied by the authors' group in the late 1990s [22,23] in an experimental chronic nerve compression model. The sciatic nerve of rats first was constricted with a silicone tube and nerve deficits were confirmed at 8 months. Animals then were allocated randomly to a vein wrapping or a control group. Functionally, using the sciatic function index (SFI), the sciatic nerves in the vein-wrapped group showed greater improvement than those in the non–vein-wrapped group. In electrophysiologic testing the latency was significantly shorter in the vein-wrapped group. Histologic evaluation showed marked nerve degeneration and scar tissue formation around the nerves in the non–vein-wrapped group but not in the vein-wrapped group. These studies showed that autologous vein wrapping in a chronic nerve compression model could improve the functional recovery of the nerve and prevent scar in-growth.

Allograft vein wrapping also has been tried clinically [24,25] with the use of allograft umbilical veins. Ruch et al [26] compared the femoral vein autografts with glutaraldehyde-preserved allografts in an animal study and found a significant increase in inflammatory cells and scar tissue associated with the allograft. Autologous vein grafts seem to create fewer adhesions between the vein and the nerve compared with vein allografts. If the allograft vein adheres to the nerve the gliding between the nerve and vein might be impaired, which may have a negative effect on recovery.

The inhibition of scar formation with this technique has been verified by clinical observations from re-exploration of vein-grafted nerves [25,27–29]. Biopsies obtained from re-explored vein grafts [28,29] showed few adhesions between the adventitia of the vein and surrounding tissues and no adhesions between the intimal surface of the vein and the nerve. Neovascularization of the vein graft and structural transformation of the vein endothelium, which is elevated into multiple papillary projections, also was observed.

Vein wrapping seems to prevent extrinsic and intrinsic scar formation. Although the exact mechanism is still unclear, recent basic research has shown that prevention of epineurial adhesions, preservation or restoration of intrinsic epineurial vascularity, and formation of a gliding surface between the nerve and the surrounding tissues contribute to the good clinical results. It is hypothesized that locally produced bioactive molecules could play a significant role in the structural changes observed [29].

Indications

The primary indication for vein wrapping is significant epineurial scarring, and although it can be suspected preoperatively, it is verified intraoperatively. The authors usually reserve vein wrapping for the multiply operated patients and the ones with unrelenting symptoms following surgical decompression of entrapment neuropathies. Patients who present for their first reoperation with moderate pain and moderate scarring of the nerve on inspection can be treated effectively with other soft tissue coverage procedures. Anterior transposition of the ulnar nerve with minimal medial epicondylectomy (if the nerve has not been transposed already) and hypothenar fat flap coverage for the median nerve are the authors' choices in such instances. Vein wrapping also can be applied in recurrent radial tunnel and tarsal tunnel surgery and in cases of severe posttraumatic scarring of peripheral nerves, but recurrent carpal and cubital tunnel are by far the most common indications. Small neuromas in continuity sometimes are found in association with scarring of the nerve. If the complaint is simply pain without motor or sensory deficit, vein wrapping may be indicated. If the neuroma is considerable in size or the patient's functional deficit is significant, the neuroma should be excised and the nerve repaired with nerve grafts or conduits.

Patients usually present with recurrent symptoms after an adequate primary decompression. The history of initial temporary relief after the primary decompression or a subsequent neurolysis is highly indicative of scar formation. The absence of even transient symptomatic relief after the initial surgery could signify inadequate decompression. With scar formation the patient's

complaints are usually that of pain worsening with activities and paresthesias. Severe pain (5 or greater in a visual analog scale) is their chief complaint. A positive Tinel sign is the rule and in the authors' experience most patients have abnormal two-point discrimination. Muscular atrophies are not common and when present they indicate more severe intrinsic scarring of the nerve. Electrodiagnostic testing often shows decreased electrical amplitude and sensory conduction after stimulation of the nerve; muscle denervation is seen less often. Nerve scarring can be present in the absence of two-point discrimination abnormalities and electrodiagnostic findings, but in that setting worker's compensation and litigation issues should be taken into consideration carefully.

An initial period of nonoperative treatment to reduce pain (especially in patients without a measurable sensory or motor deficit) is advisable. This can include splinting, injections, desensitization, scar massage, and nerve stimulation. Narcotic analgesics are avoided, because these patients can become dependent easily.

The greater saphenus vein is harvested for this procedure. The length of vein graft taken is usually four times the length of the compressed segment of the nerve. Although this is well tolerated in most individuals, a vascular surgeon must be consulted in patients with peripheral vascular disease or deep venous thrombosis history. In patients with coronary heart disease the saphenous vein is a major source of vein grafts for reconstruction and that also should be taken into consideration.

Operative technique

General anesthesia is used for this procedure because of the need to have two operating fields (in the upper extremity and in the lower extremity). No special instrumentation is needed for the procedure if the saphenous vein is to be harvested with a long incision. A vein stripper (Codman, Johnson & Johnson; Raynham, Massachusetts) is used for a less invasive vein harvesting through two small incisions; this has been the authors' preference in recent years. The authors do not routinely use nerve stimulation for recurrent compression neuropathies.

The procedure is initiated with surgical exploration of the affected nerve. Vein harvesting is initiated only after the affected nerve is dissected and found to be severely scarred. The incision used for the former procedures usually is used and is extended proximally and distally to virgin tissues. The affected nerve should be identified in healthy tissues proximally and distally and then dissected toward the scarred section. Dissection is painstaking and is performed under loop or microscope magnification. All potential sites of nerve compression must be re-explored and their release should be confirmed. If the structural continuity of the nerve is in doubt, the operating microscope is used to dissect fascicles from proximal to distal through the scarred segment. Internal neurolysis under the operating microscope is performed as necessary. Indications for internal neurolysis include severe compression and thinning of the nerve, lack of epineural vascularity, and muscle wasting. The length of the nerve that has to be vein-wrapped then is measured. It is advisable to vein wrap a 0.5–1.0-cm zone of healthy-appearing nerve at both ends of the scarred segment if the length of the graft is adequate.

The ipsilateral or contralateral lower extremity is used for harvesting of the greater saphenous vein. The required length of the vein is three to four times the scarred length of the nerve. The length taken is usually 20–30 cm. The position of the greater saphenous vein usually can be palpated and is marked on the skin before tourniquet inflation. An incision is made 1 cm anterior to the medial malleolus and the greater saphenous vein is identified (Fig. 1). Care is taken not to injure branches of the saphenous nerve. The vein is ligated distally and a small longitudinal phlebotomy is made. A vein stripper guide is introduced through the phlebotomy and is advanced proximally to the predetermined length. The vein stripper guide usually can be palpated through the skin as it is advanced. A second 1-cm incision is made over the stripper proximally; the vein is

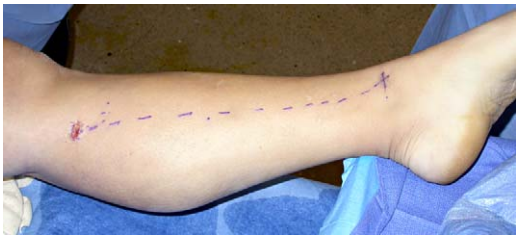

Fig. 1. The incisions used in harvesting of the greater saphenous vein in the lower extremity with a vein stripper.

ligated and cut. The vein stripper guide is advanced out of the vein through a second longitudinal phlebotomy and the appropriate sized olive (usually 9F) is attached to the guide. The graft is retrieved by slowly pulling the stripper. The rupture of lateral vein branches can be felt while pulling. After vein harvesting, the skin is closed and a compressive dressing is applied to the leg before deflating the tourniquet to avoid hematoma formation. Alternatively the vein can be harvested through a continuous incision or interrupted incisions and dissection without the use of a vein stripper. After the saphenous vein is harvested it is incised and opened longitudinally (Fig. 2A,B). The adventitia side of the vein graft is marked with a marking pen throughout its length, because it is important that the intimal side of the graft comes in contact with the scarred nerve.

One of the ends of the vein graft is tacked distal to the scarred portion of the nerve on a tissue that is not mobile, with the intima against the nerve, using a 7-0 or 8-0 nylon stitch. The wrapping proceeds circumferentially as described by Masear et al [21] from distal to proximal, while care is taken not to make the wrap too snug and thus constrict the nerve (Fig. 2C). After each complete circle on the nerve, the vein is stabilized with a loose 7-0 or 8-0 nylon stitch to the adjacent ring of vein (Figs. 2C, 3, and 4). If enough vein graft length has been obtained, each loop of the vein graft around the nerve can overlap partially the previous loop. Ensuring that the intima of the vein graft is apposed to the nerve after each loop is important. The other end of the vein graft is tacked proximal to the scarred segment of the nerve on unscarred tissue. The coverage of the scarred nerve segment must be complete and must extend slightly to an unscarred segment to prevent recurrence.

Personal series

The results of autologous vein wrapping to treat recurrent compressive neuropathy using the aforementioned technique have been rewarding [30,31]. The authors reported on 19 patients with recurrent compressive neuropathy of the median or ulnar nerve who were treated with autologous saphenous vein wrapping between 1993 and 1997. Fifteen patients had recurrent carpal tunnel syndrome and four had recurrent cubital tunnel syndrome. The mean age was 53 years (range, 28–75 years). The mean number of previous procedures was three, with a minimum of two and a maximum of five for each patient. For the median nerve these procedures included simple nerve decompression, tenosynovectomy, internal neurolysis, hypothenar fat pad flap, and local flaps. For the ulnar nerve they included in situ

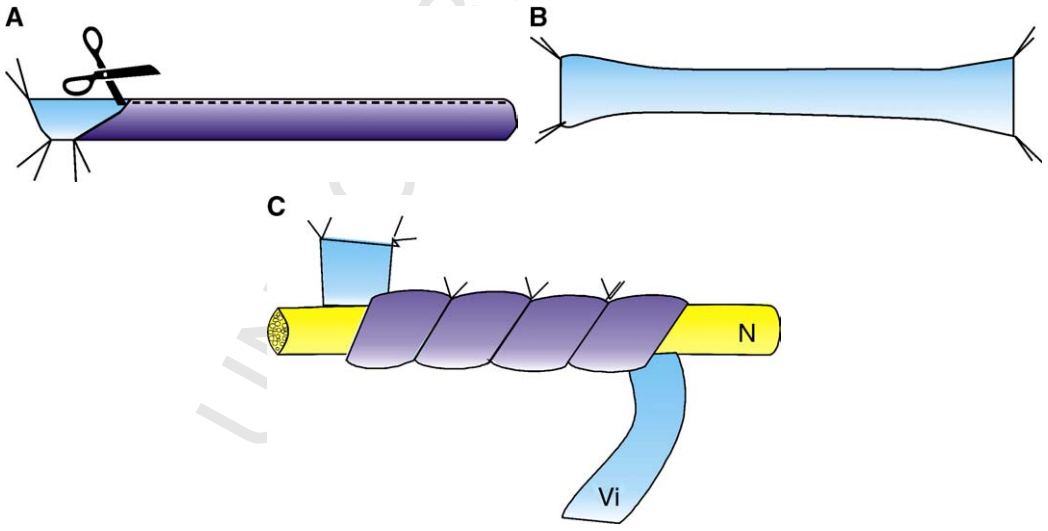

Fig. 2. Schematic of the technique used for vein wrapping of peripheral nerves. The saphenous vein is split longitudinally (*A*), and is opened to form a rectangle (*B*). The saphenous vein then is (*C*) tacked distal to the scarred portion of the nerve on a nonmobile tissue and is wrapped around the scarred portion of the nerve (N) in a spiral pattern with its intima (Vi) apposed to the surface of the nerve. Each ring of the vein is secured to the adjacent rings with a stitch.

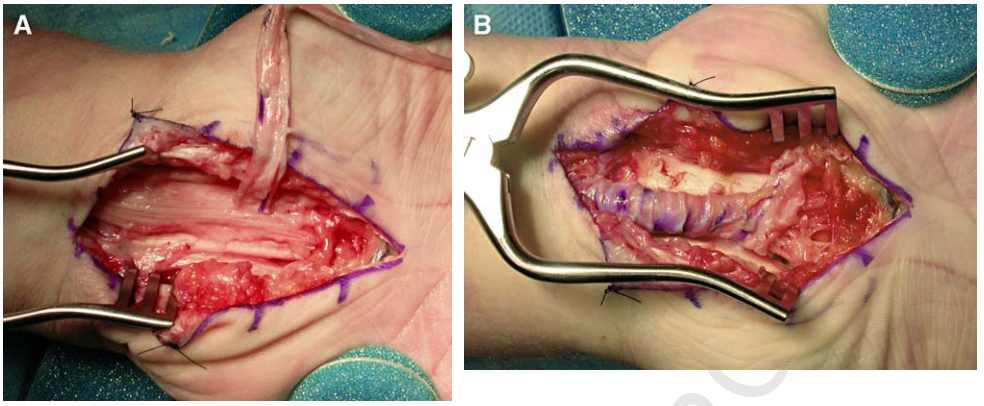

Fig. 3. Vein wrapping of the median nerve. (*A*) The median nerve is shown after neurolysis of the scarred segment. The vein graft is apposed with its intima against the surface of the nerve. Note that the adventitia of the vein graft has been marked with a marking pen. (*B*) At the completion of the procedure the entire scarred segment of the nerve has been vein wrapped.

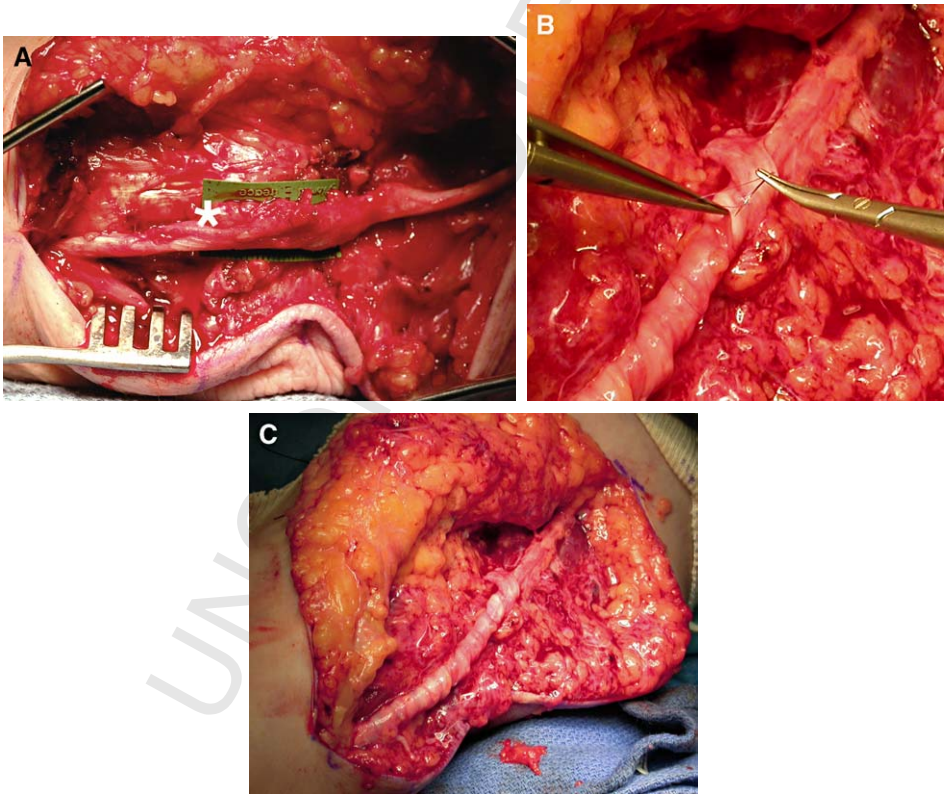

Fig. 4. Vein wrapping of the ulnar nerve. (*A*) The ulnar nerve is shown after dissection of the scarred segment. A small neuroma in continuity is seen (star). (*B*) Vein wrapping progresses from distal to proximal. Each ring of the wrapped vein is secured to the adjacent rings with a 7-0 or 8-0 nylon stitch. (*C*) The entire scarred portion of the ulnar nerve is vein wrapped and coverage extends slightly to unscarred segments proximally and distally to prevent recurrence.

decompression with or without medial epicondylectomy and subcutaneous, submuscular, and intramuscular transposition of the ulnar nerve.

The average follow-up period was 43 months (range, 24–78 months). All patients reported pain relief. On a visual analog scale all patients rated their pain between 2 and 6; their preoperative pain had been rated between 6 and 9. Sensation improved in all patients, although 16 of the 19 patients had residual numbness. Two-point discrimination improved from an average of 12 before surgery to 8 after surgery. Sixteen of the 19 patients demonstrated more than 2 mm improvement in two-point discrimination in comparison to the preoperative values. Grip strength increased from an average of 27 kg before surgery to 38 kg after surgery. Abnormal nerve conduction velocities were found in all patients in their preoperative electrodiagnostic studies. The motor nerve conduction velocity improved from an average of 41 m/s before surgery to 43 m/s after surgery in the 10 patients who had preoperative and postoperative values available. The sensory nerve conduction velocity improved from an average of 39 m/s before surgery to 43 m/s after surgery in the seven patients who had preoperative and postoperative values available. Eighteen patients stated that they would undergo the procedure again had they known the outcome in advance. No complications from saphenous vein harvesting were noted other than mild discomfort and swelling at the incision site that resolved by approximately 4 months.

Since completing the series described, the authors have performed the procedure numerous times for recurrent compressive neuropathies and severe post-traumatic nerve scarring in the upper and in the lower extremity with consistently good results.

In summary, autologous vein wrapping is an excellent option for the multiply operated patient with chronic nerve compression secondary to cicatrix formation. It is a simple technique that causes minimal complication in the donor area. In addition, the donor vein is readily available and harvesting is easy. It consistently provides pain relief and improvement of sensation. Experimental and clinical results support its use for recurrent compressive neuropathies.

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