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Cephalic Vein Wrapping Flap (CVWF) in Superficial Branch Radial Nerve Injuries

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Introduction

Superficial Branch of the Radial Nerve (SBRN) is one of the most vulnerable nervous structures in wrist injuries. That is due to its superficial anatomical position: the radial nerve at the wrist is protected only by a thin layer of soft tissue.

The incidence of peripheral nerve injuries among the trauma population is 2 to 2.8% [1,2], they occur mainly in young men and in the most productive age group [1,3-5] becoming a social and economic issue [6]. More commonly nerve injuries are reported in the upper limbs with the most affected being digital, ulnar and radial nerves [1,3,5,7]. In the series of Noble et al. [1] radial nerve is the most frequently involved; the main etiological factors are motor vehicle accidents and lacerations with sharp objects. Kouyoumdjian, in his retrospective survey, analyzed the recurrence of SBRN injury mechanisms: penetrating trauma (glass wounds and knife), falls, vehicle accidents (car or motorcycle), and gun-shot wounds [5].

In the region where SBRN lies subcutaneously there is a major risk of traumatic or iatrogenic lesions since the nerve is protected only by soft tissue and it's very close to the radius [8]. Injury can result in discomfort like hyperesthesia, paresthesia, anesthesia and painful neuromas [8]. Dellon et al. [9] showed that SBRN injuries are very prone to develop painful neuromas which could require secondary surgical treatment [10] such as neurolysis, [11] neuroma excision, reconstruction with vein conduit [12-14], use of a protective biological membrane [15,16].

Millesi first introduced the concept of "nerve bed" in 2006 [17]. He suggested that the microenvironment that surrounds the nerve influences the healing of the nerve itself. When a trauma occur the physical insult on the perineural tissues triggers an inflammatory cascade with the release of neurotrophic factors which promotes the development of neuromas [18]. The prevention of wound and intraneural fibrosis, which acts as an obstacle in regenerating axons, is crucial in nerve regrowth. Moreover, scarring between the nerve and the surrounding tissue may reduce nerve gliding leading to pain during wrist movements. Isaacs et al. described critical features of an "ideal barrier" in order to prevent perineural scarring: Absence of rejection or inflammatory reaction, right porosity (which allows diffusion of nutrients without axonal escape), avoidance of scar-induced ischemia, promotion of nerve gliding, no donor site morbidity and minimal cost [19].

Vein wrapping has first been introduced by Masear in 1989. Masear described the use of a venous autograft placed around scarred nerves as a protective sheath after performing neurolysis [20]. A comparative study published by Eren in 2018 [21] observed that nerve fibrosis and misalignment were lower in the group where vein wrapping was performed. Both axon maturation and regrowth was increased in this group. Lavasani et al. [22] demonstrated that the vein graft directly participate in nerve regeneration by promoting axonal regrowth and remyelination. Furthermore in this study it has been observed that this effect is graft-cell dependent.

We present a novel technique to treat acute and chronic injuries of the SBRN performing Cephalic Vein Wrapping Flap (CVWF) based on its perivascular nutritional fat tissue.

Anatomy

The SBRN provides sensory innervation to the skin of the radial dorsum of the hand and the dorsal region of the proximal and middle phalanges of the radial 2 and 3 digits [23,24]. Between the middle and the distal third of the forearm the SBRN can be identified between the Extensor Carpi

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Radialis Longus (ECRL) and the Brachioradialis (BR) muscle, just under the BR. At the wrist the SBRN becomes more superficial and runs dorsal to the Radial Styloid (RS), between the first and the second compartment of the extensor retinaculum. The anatomical landmark for the SBRN is the anatomical snuffbox. At this level it splits into two branches: The lateral branch runs through the radial aspect of the thumb; the medial branch divides just above the trapeziometacarpal joint in two branches: the ulnar one runs towards the second finger and the radial one runs on the ulnar aspect of the thumb. At the wrist the radial artery is intimately associated with the medial branch of the SBRN in most cases (48%), thus it can be involved in SBRN traumatism. The cephalic vein is part of the superficial venous system of the upper extremity, it emerges on the dorsal venous network of the hand and runs along the radial part of the wrist; it travels on the volar-radial aspect of the forearm and arm, all the way up to the subclavian vein.

Anatomical studies conducted by Robson et al. [25] demonstrate the close relationship between the cephalic vein and the SBRN in most cases (80%), both proximally and distally to the RS.

Indications and Contraindications

Most injuries of the SBRN can be treated with the CVWF technique in alternative to "classic" vein wrapping graft. Furthermore a vein wrapping flap can be performed in acute traumatic injuries involving nerves that lay close to venous structure of similar calibre. Due to its proximity with the cephalic vein, acute injuries of the SBRN are an ideal indication for this technique.

In chronic lesions, in which the main discomfort complained by the patient is due to neuroma and scarring between the nerve and the surrounding tissue, the CVWF can be used after performing neurolysis as a protective sheath around the neuroma to prevent direct mechanical stimulation and to promote nerve gliding.

Major forearm trauma may be a relative contraindication to this technique. The dissection of cephalic vein may be challenging in presence of secondary scarring of the surrounding tissues.

Nevertheless the relative constant anatomy of the SBRN and cephalic vein [26] makes this surgical technique reliable and applicable in most patients.

The CVWF can be used in association with other techniques (i.e. muscle in vein) for reconstruction of nerve injuries in presence of a nervous gap.

In acute lesions without identification of nerve interruption during surgical exploration, there is no indication to surgical treatment.

In Table 1 we summarize different types of nerve injuries classified according to timing and type of defect in relation to indications of CVWF technique.

Technique

Suspect of SBRN lesion is based on clinical evaluation in presence of paresthesia or ipo/anesthesia over the dorsum of the first web space, pain and positive Tinel sign as a result of a traumatic neuroma. Suspected lesions of the SBRN have indication to surgical exploration. The procedure can be performed under wide awake local anesthesia with no tourniquet technique (WALANT) in operative theatre as a day hospital procedure or in outpatient setting, under surgical loupes magnification (3.5x). The procedure begins either with the exploration of the wound in acute setting or scar tissue excision in chronic setting. SBRN injury is usually associated with a wound or a scar located on the dorsal radial aspect of the wrist or in proximity of the trapeziometacarpal joint. Usually we extend the approach proximally and distally to allow a better identification of damaged structures. Incisions are made in a zig-zag pattern in order to prevent scar retraction.

Table 1: Indications for CVWF technique.

SBRN lesion		Acute	Chronic
In continuity		✖	✓
No continuity	No gap	✓	✓
	With gap	✓*	✓*

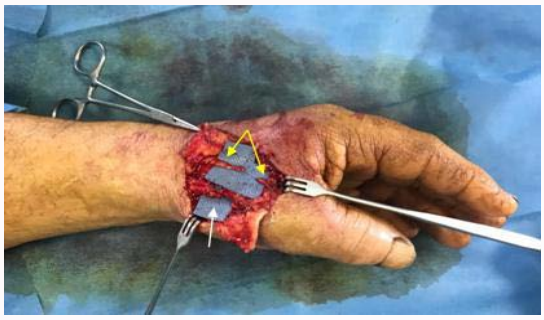

Figure 1: Dissection of SBRN with neurolysis and isolation of the proximal and distal nerve stump (yellow arrows). Identification of cephalic vein (white arrow).

Figure 2: Cephalic VWF (yellow arrow): dissection and harvest of CVWF with perivascular tissue connections.

The SBRN is identified and neurolysis is performed until approximately 1 cm of the proximal and distal nerve stumps are isolated to obtain a direct neurorrhaphy without nerve devascularization. Harvesting of the CVWF is performed: further dissection of the surrounding tissue is performed until the cephalic vein is isolated; the vein is dissected only for half circumference in order to preserve connections with the perivascular tissue; dissection is carried out until a tract of 8 mm to 12 mm of cephalic vein is isolated; the isolated segment of the cephalic vein is ligated and sectioned in the proximal and distal extremity; tributaries veins, if present, are ligated too (Figure 1).

In acute or chronic setting neurotmesis the proximal or distal nerve stump is passed all the way through the venous conduit (Figure 2). The epineural neurorrhaphy is performed using a 9/0

Figure 3: SBRN neurorrhaphy covered by CVWF (yellow arrow).

Figure 4: Custom made post-operative splint.

non absorbable monofilament (Dafilon, B. Braun, Melsungen AG). The CVWF slides over the nerve to cover the neurorrhaphy (Figure 3). In case of neuroma-in-continuity, we preserve the continuity of the nerve; the CVWF is harvested in the same way as previously described, but the vein is splitted longitudinally, fit sleeve-like over the nerve and sutured back with a continuous pattern in Dafilon 9/0.

The flap can be fixed to the nerve with two Dafilon 9/0 stitches, but usually we prefer to avoid this in order to prevent further traumatism on the nerve that may trigger the formation of neuromas. We prefer to use instead fibrin glue (Tisseel, Baxter S.p.A) to fix and isolate the CVWF from surrounding tissues.

In case of acute or chronic lesion in which a direct neurorrhaphy in not possible the CVWF could be used in association with other reconstructive technique such as the muscle in vein.

Patient can be discharged the same day of the procedure with a broad spectrum antibiotic prophylaxis (Amoxicillin + Clavulanic acid 875/125 mg) 3 time a day for 7 days after the surgical procedure. Post-operative care includes immobilization of the wrist in moderate adduction and extension for 15 days. Rehabilitation is recommended to prevent further scar adhesions with the use of a removable protective splint for one month (Figure 4).

Outcomes

Compared to vein wrapping graft, the VWF could promote a better nervous healing. The "classic" vein wrapping is a barrier conduit that is placed around a healing nerve as a tissue graft. Well known issues about tissue grafts are scarring and consequent contraction. Therefore the contraction of the vein could result in collapse of the conduit compromising the axonal regeneration through the injured zone.

CVWF is a good option compared to vein graft: even if the final result is similar, perivascular flap tissues maintain the conduit trophism and could hypothetically provide a better "nerve bed" than the one obtained with the vein wrapping graft improving nerve gliding. Furthermore this technique is cost effective comparing to other alternative allograft conduit commercially available (bovine collagen, porcine small intestine submucosa, HA-CMC film, human amniotic membrane).

CVWF satisfies "ideal barrier" qualities: no inflammatory reaction, no rejection, very low donor site morbidity, no cost. No donor site morbidity such as hand edema has been recorded.

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