



28th Annual Gabor Racz Advanced Interventional
Pain Conference and Workshop
Budapest, Hungary **August 25-27, 2025**

Peripheral Nerve Evaluation and Regenerative Therapy

George C. Chang Chien DO, FIPP, CIPS
GCC Institute



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Medical Director Pain Management

- Ventura County Medical Center

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Instagram: [RegenMedDoctor](#)



Conflicts of Interest

- None



Current diagnosis and limitations

History and Physical exam

- neuropathic pain may be vague “non-textbook”

Edx – Limited sensitivity, specificity

- Sensitivities ranging from 49% to 84%.
- NCS generally show high specificity 95-99%.

Imaging

- MRI - limited resolution, signal similar to surrounding soft tissues, limited to larger nerves.
- Expensive, time consuming



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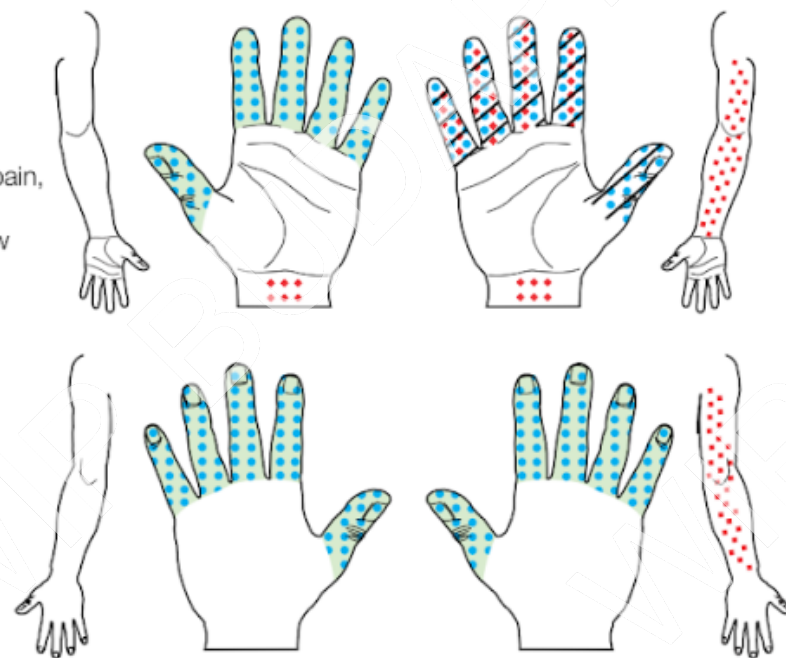
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It's always frustrated me that our patients don't come in color co



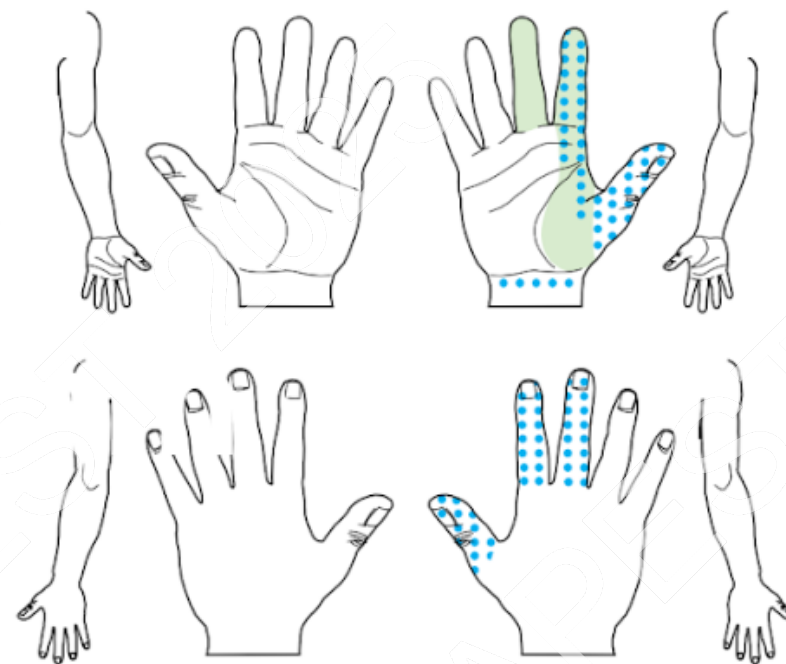
A Classic Pattern

Symptoms affect at least 2 of digits 1, 2, or 3. The classic pattern permits symptoms in the fourth and fifth digits, wrist pain, and radiation of pain proximal to the wrist, but it does not allow symptoms on the palm or dorsum of the hand.



B Probable Pattern

Same symptom pattern as classic, except palmar symptoms are allowed unless confined solely to the ulnar aspect. In the possible pattern, not shown, symptoms involve only 1 of digits 1, 2, or 3.





US pros

We can use ultrasound to evaluate the morphology of the nerve in it's course

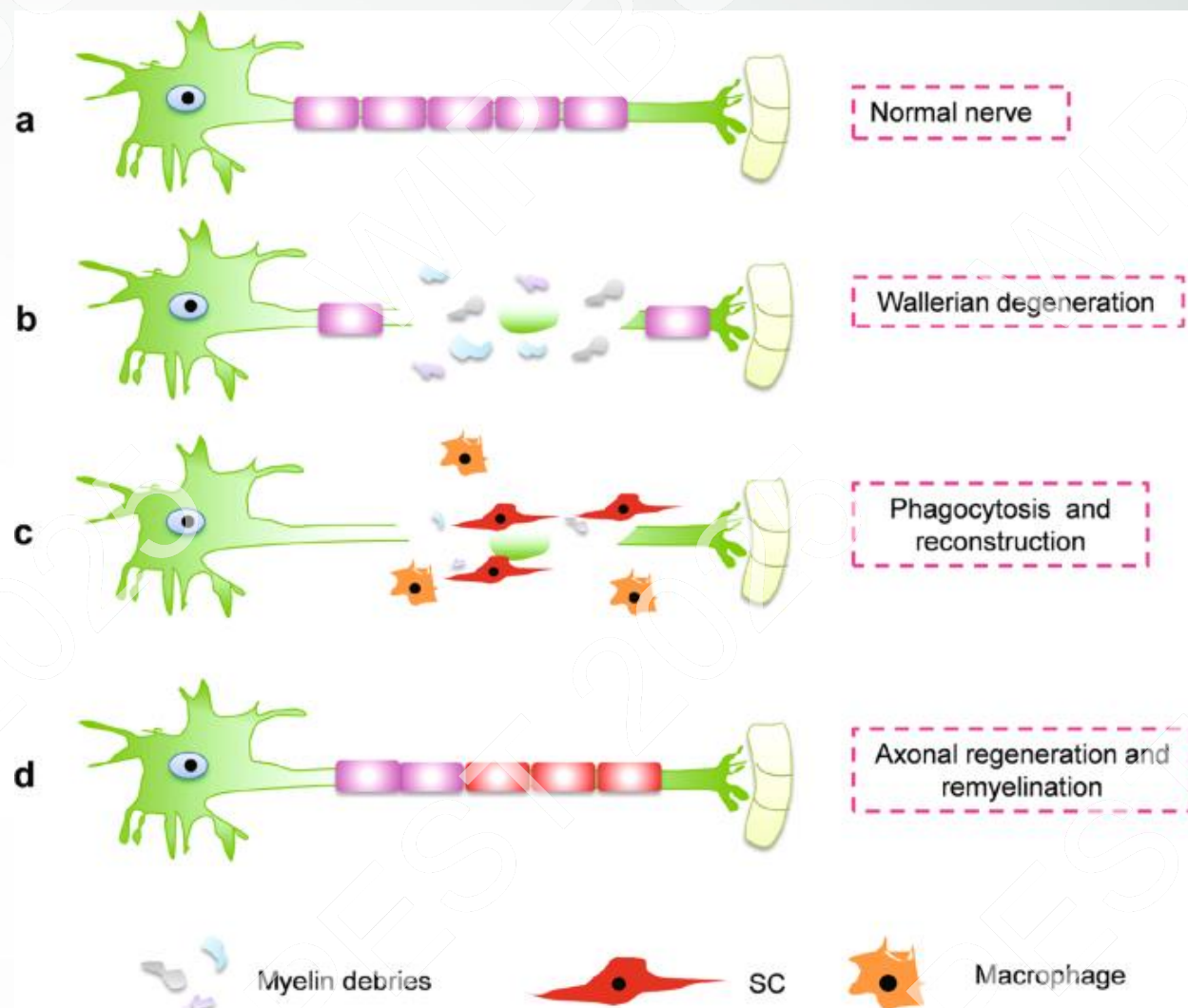
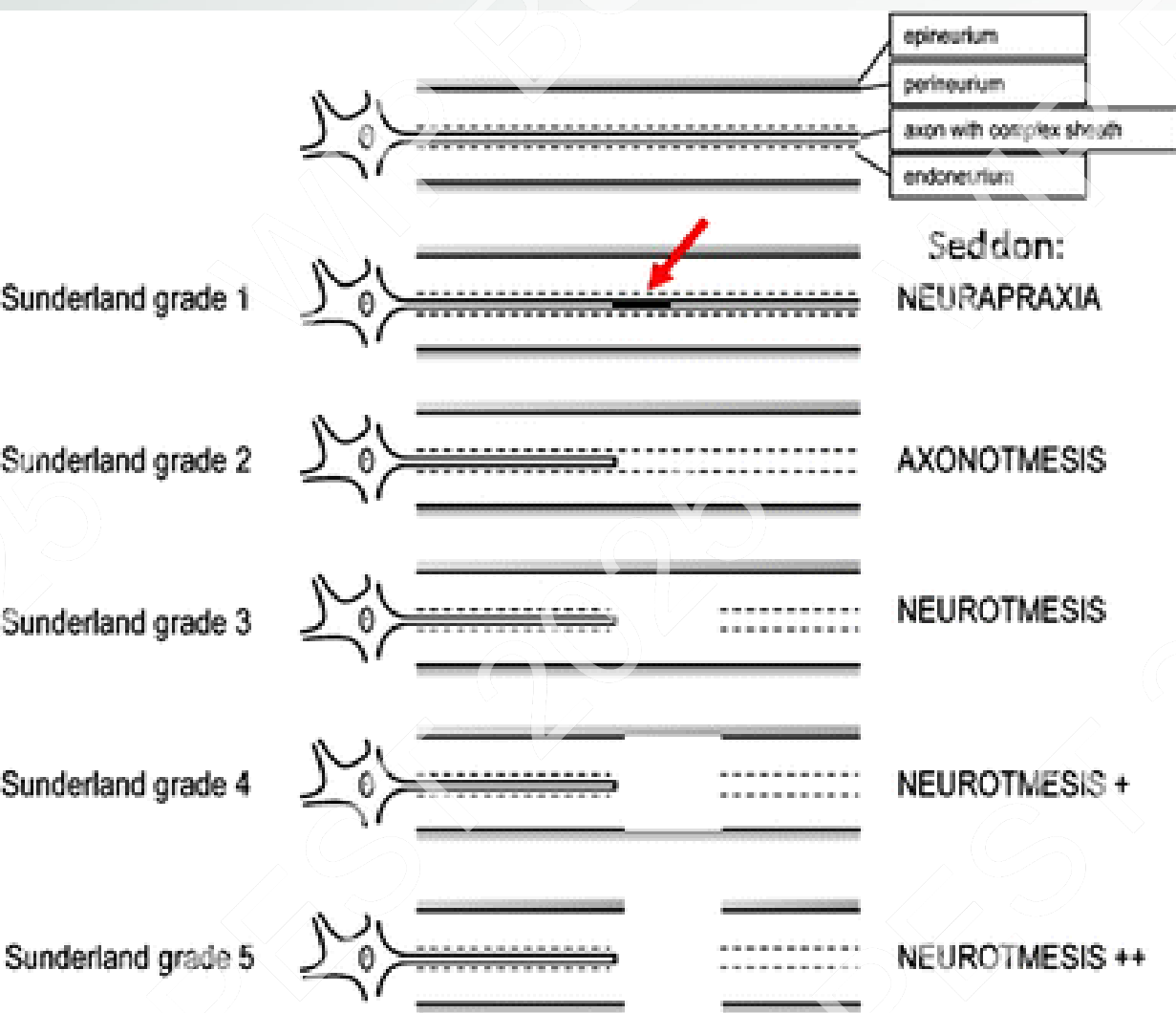
We can visualize direct causes of nerve irritation/impingement

static lesions
(cysts, bone, hardware, etc)

dynamic
(muscles, vasculature, tendons, etc)



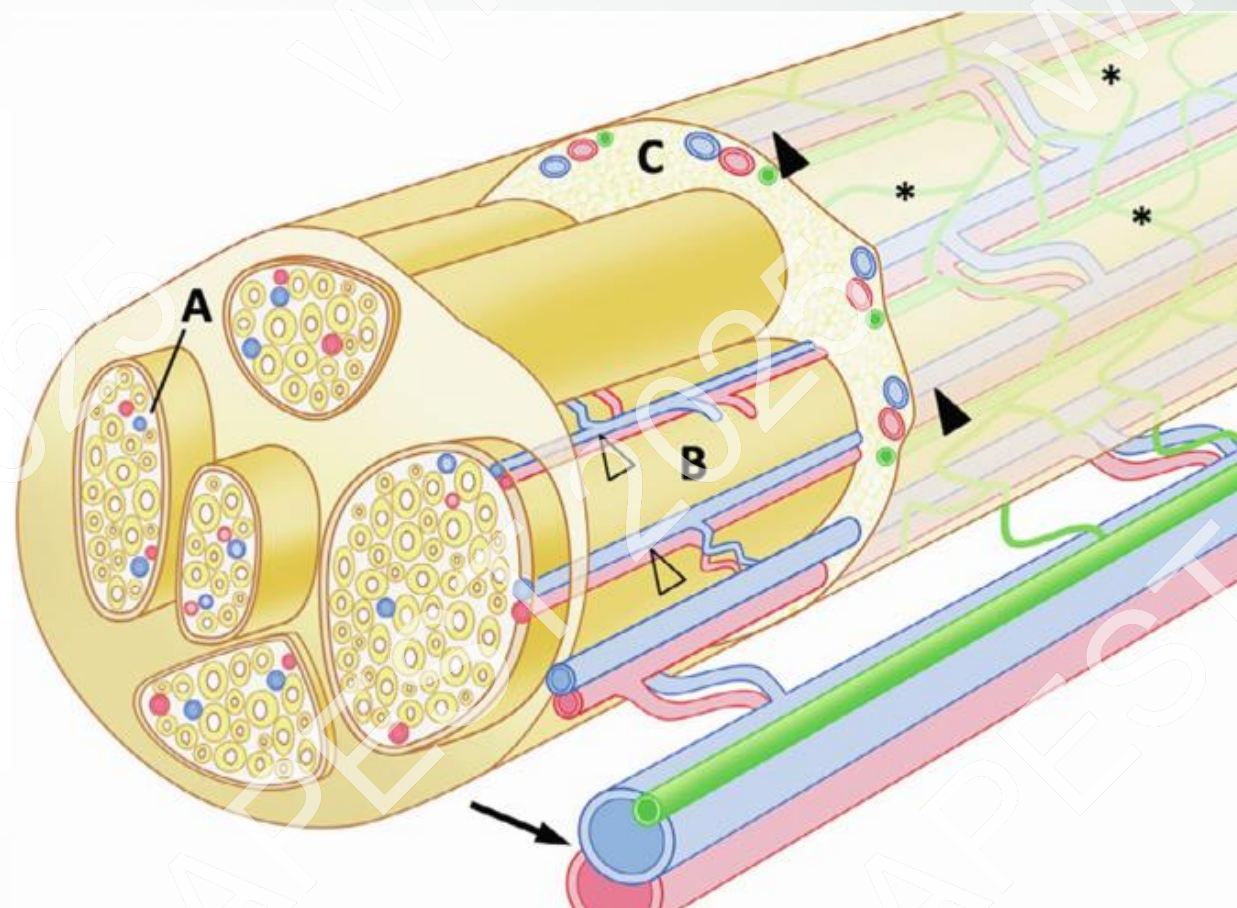
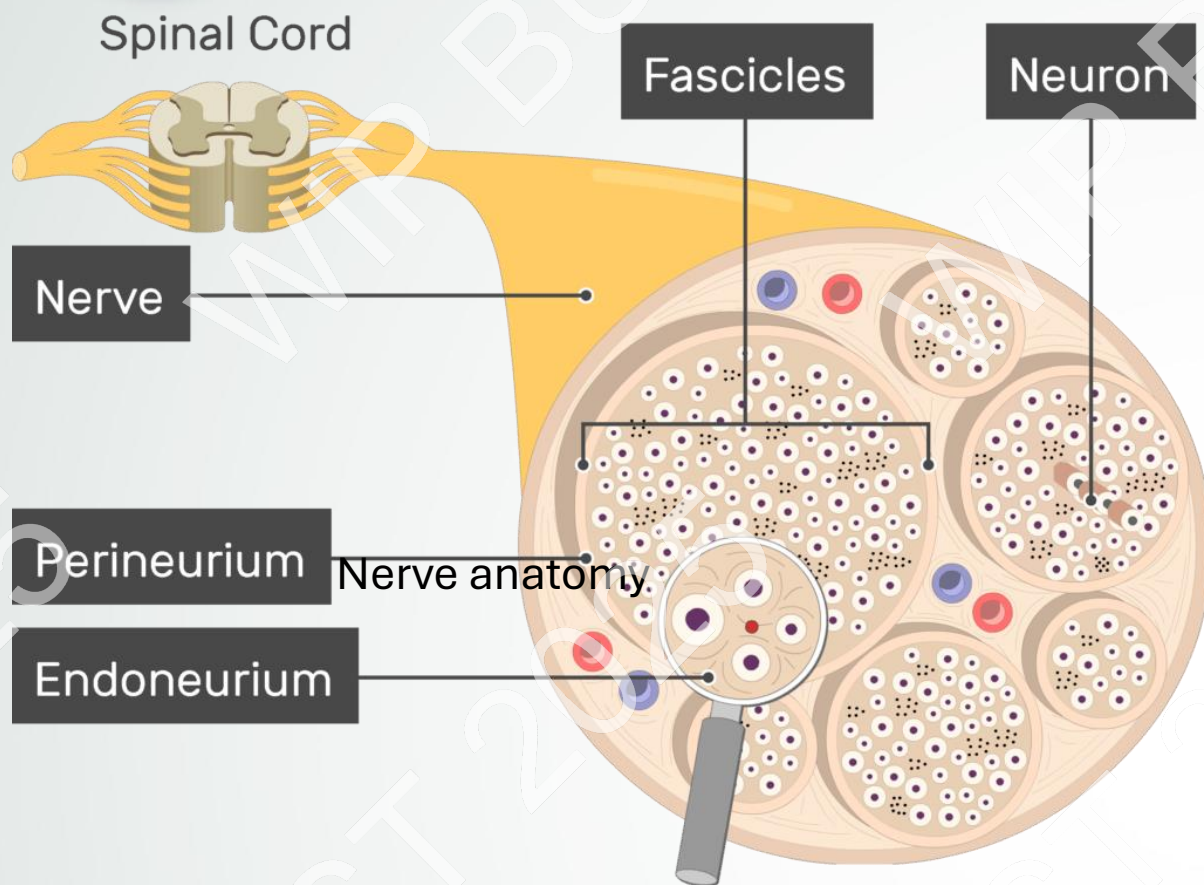
How do nerves get injured?



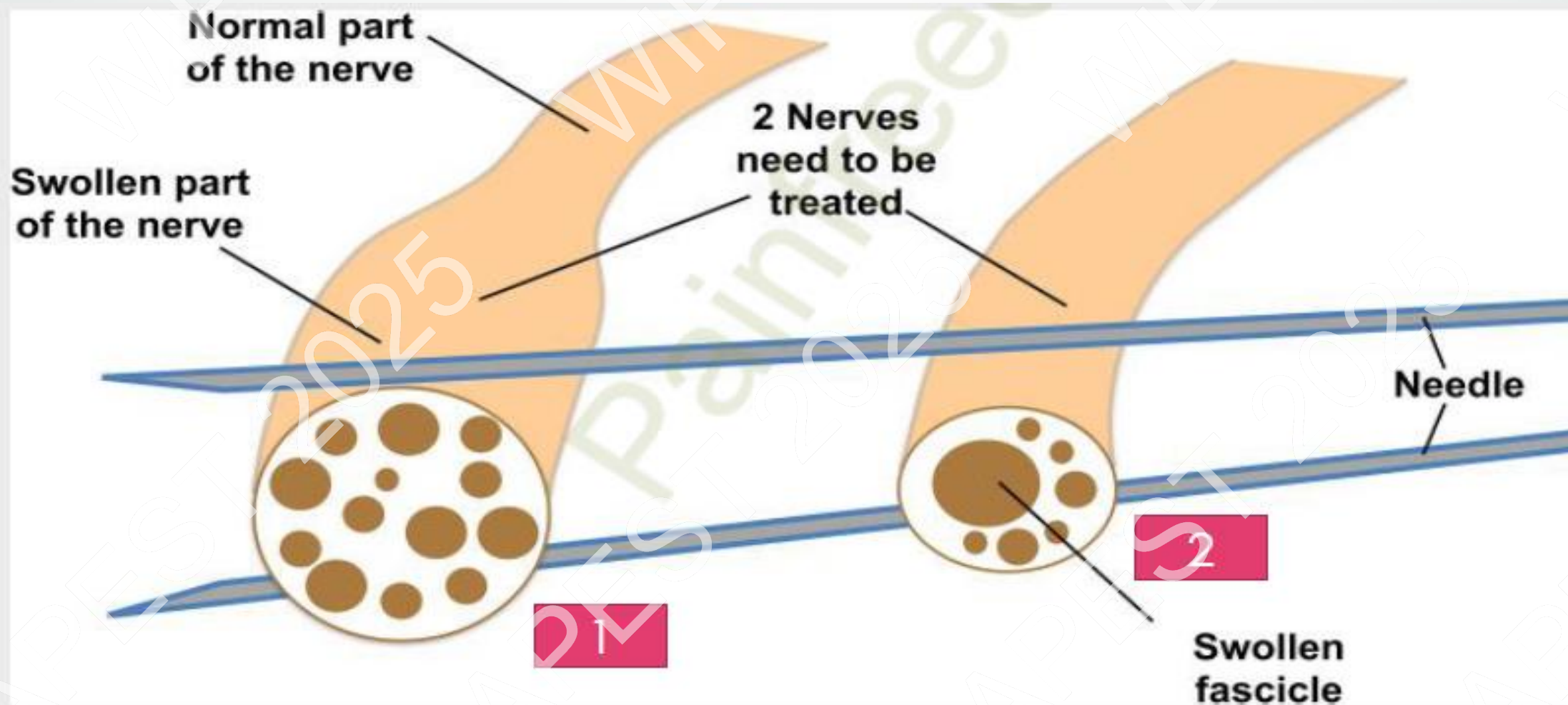


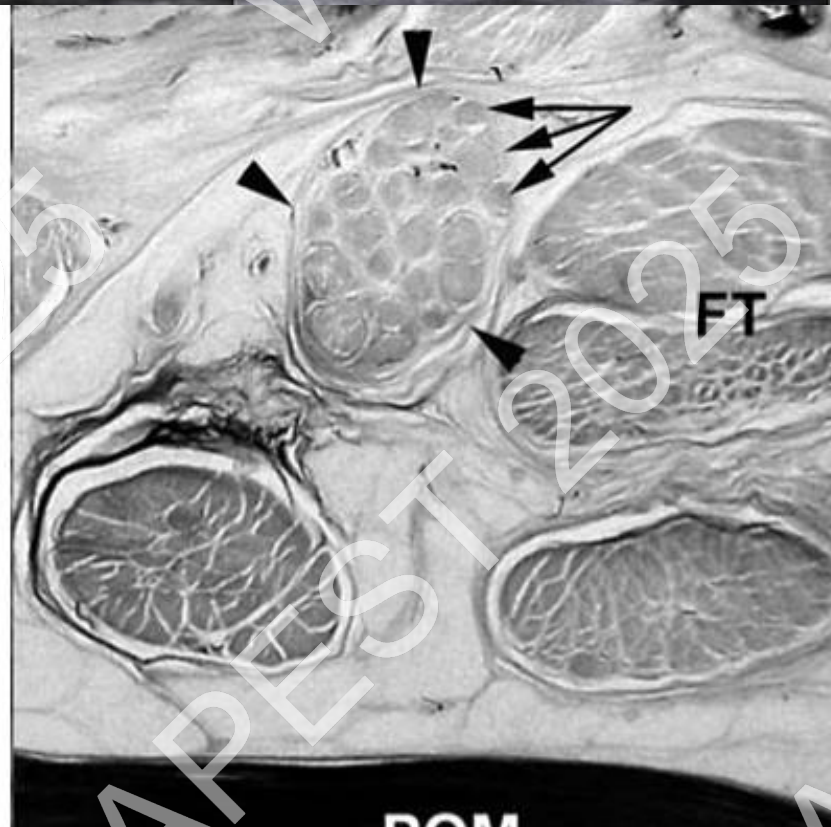
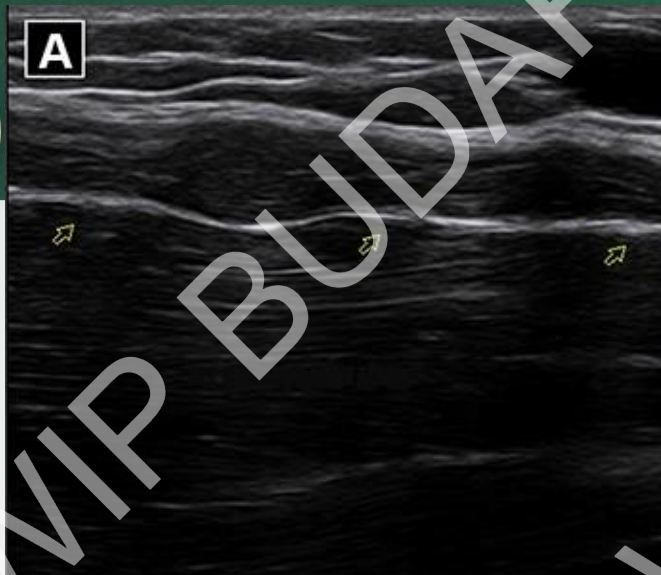
What is this mechanism of injury in a COMPRESSIVE Neuropathy?

- Ischemia!
- Compressive mononeuropathy – **like a tourniquet**
- Normal axonal function is disrupted
- Blood flow within the nerve is impaired



Entrapments lead to changes in the nerve







How do peripheral nerves heal?

- Compared to the central nervous system (CNS), peripheral nerves have a remarkable ability to regenerate and remyelinate.
- This regenerative capacity to a large extent is dependent on and supported by Schwann cells, the myelin-forming glial cells of the peripheral nervous system (PNS).
- Schwann cells are critical in the removal of the degenerated tissue, which is followed by remyelination of newly-regenerated axons.
- The endogenous regenerative capacity of Schwann cells is enhanced through interventions such as exercise, electrical stimulation or pharmacological means. Alternatively, Schwann cells derived from healthy nerves, or engineered from different tissue sources have been transplanted into the PNS to support remyelination.



- These data are consistent with previous studies on vascular regrowth in animal models of sciatic nerve crush injury and transection (Podhajsky and Myers, 1993, 1994). The vascular response to crush and transection injury is composed of two phases. The early phase comprises the first week after injury and is characterized by an increase in blood vessel size, with the blood vessel number remaining unchanged. Then, during the second phase, from 1 to 6 weeks after injury, an increase in the number of vessels is observed. The first phase of the vascular response is related to the recruitment of macrophages and the clearance of degenerating axons and myelin sheath debris produced by Wallerian degeneration, while the second phase is associated with nerve regeneration and is comprised of cellular proliferation, axonal elongation and myelination (Podhajsky and Myers, 1993, 1994).

Neural Regeneration Research

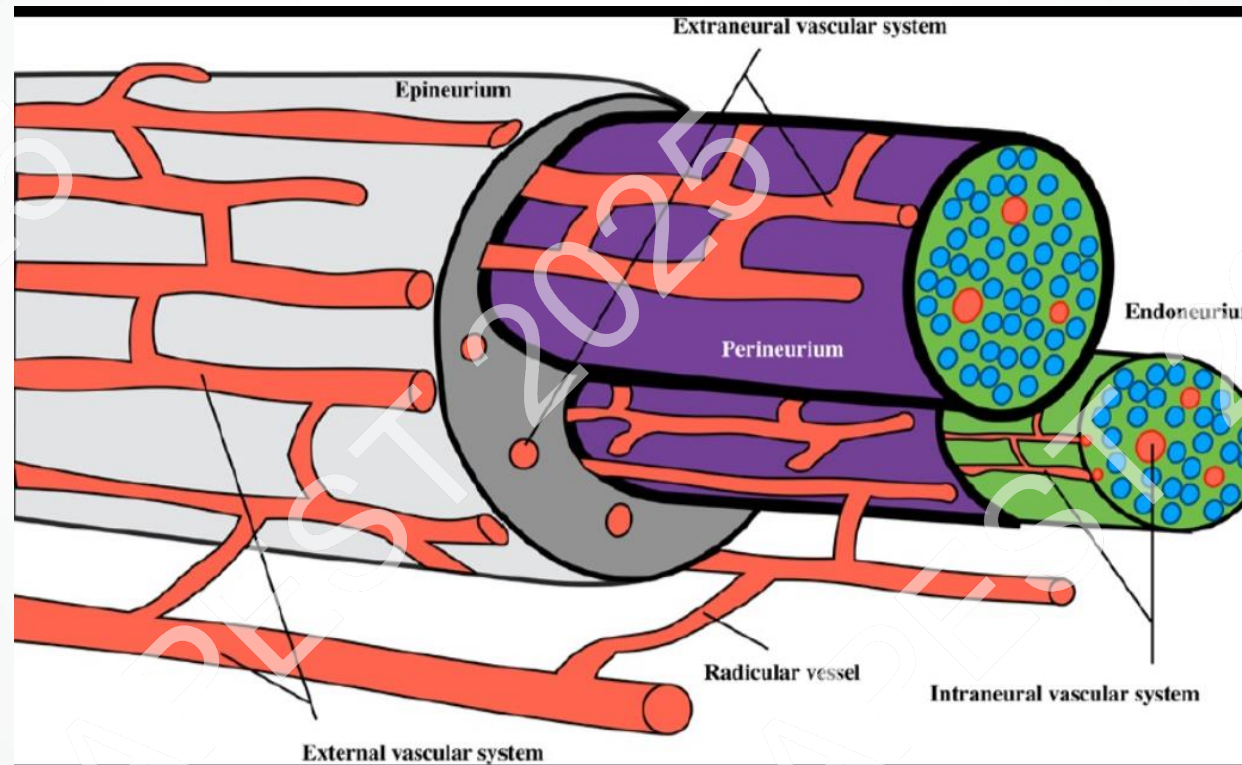
Peripheral nerve regeneration and intraneural revascularization

Caillaud, Martial¹; Richard, Laurence²; Vallat, Jean-Michel²; Desmoulière, Alexis¹; Billet, Fabrice PhD^{1,*}

[Author Information](#) ☺

Neural Regeneration Research 14(1):p 24-33, January 2019. | DOI: 10.4103/1673-5374.243699

Data supporting the role of revascularization need for nerve to heal





After peripheral nerve damage, the size of blood vessels of the INV system increases due to the effects of neuropeptides such as SP and CGRP. Vasodilatation, associated with the release of monocyte chemoattractant protein-1 by SCs, allows macrophage recruitment. Migrating and resident macrophages then secrete VEGF. This growth factor then stimulates neo-angiogenesis which supplies the oxygen and nutrients required for the formation of “bands of Büngner” by SCs. However, the molecular interactions between SCs, macrophages and endothelial cells of neo-vessels still remain to be elucidated. In conclusion, this review highlights the importance of revascularization in nerve regeneration. It therefore seems appropriate to intensify research in this area to provide a better understanding of revascularization after nerve injury and additionally to discover new therapeutic avenues.



Factors Influencing Regeneration:

- Distance of the injury:**

The further the injury site from the nerve cell body, the more difficult and prolonged regeneration becomes.

- Severity of the injury:**

More severe injuries, such as complete nerve transection or crush injuries, may require surgical intervention.

- Age and overall health:**

Younger individuals and those with better overall health tend to regenerate more effectively.

- Presence of growth factors:**

Schwann cells release growth factors that promote regeneration, and these factors can be supplemented with therapies.

- Scar tissue formation:**

Scar tissue at the injury site can impede the regenerating axons from reaching their targets.

- Timing:**

Early intervention and appropriate rehabilitation strategies can significantly improve outcomes.



What do Autoimmune neuropathies show us?

inherent repair capacity of the PNS is evident in chronic conditions such as hereditary neuropathies which can involve **hyperproliferation of Schwann cells and onion bulb formations**, the results of **repeated remyelination efforts**.



Signs of Pathology

Cross sectional
area

- Edema of the nerve

Hypervascularity

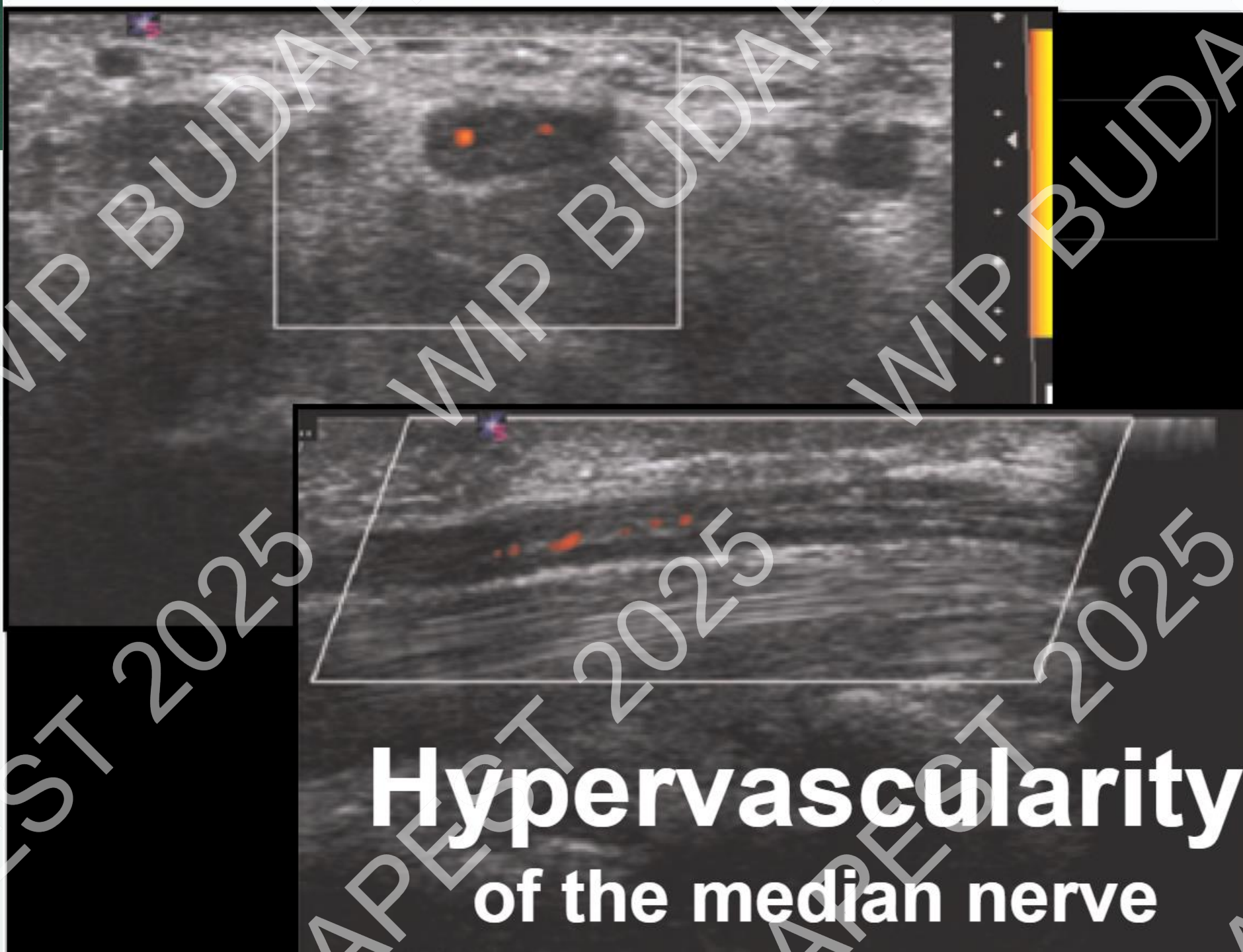
Hypoechogenicity
of the nerve

Thickened,
hyperechoic
epineurium



R.MED.N_

Hypoechogenicity of the median nerve



**Hypervascularity
of the median nerve**



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diagnostic criteria

Cross
sectional
area

CSA ratios



Cut
off
values
for
CSA

CSA carpal tunnel inlet >
 10.5MM^2

- 100% specificity and 83.12% sensitivity.

CSA ulnar nerve at cubital tunnel
medial epicondyle 10–10.5
 mm^2 sensitivity (80.4%)

Every 1mm increased Diagnostic
Odds Ratio 36%



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Median Nerve

MEDIAN NERVE



COMMON SITE OF ENTRAPMENT

- SUPRACONDYLAR PROCESS
- STRUTHER LIGAMENT
- LACERTUS FIBROSUS
- PRONATOR SYNDROME
- FDS SUBLIMUS BRIDGE SYNDROME
- GANTZER'S NERVE ENTRAPMENT
- ANTERIOR INTEROSSEUS SYNDROME (KILOH NELFIN SYNDROME)
- CARPAL TUNNEL SYNDROME
- PALMAR BRANCH ENTRAPMENT
- RECCURENT MOTOR BRANCH ENTRAPMENT

MEDIAN NERVE

PERONEOUS NERVE

profundus I & II

Sensory

Second lumbrical





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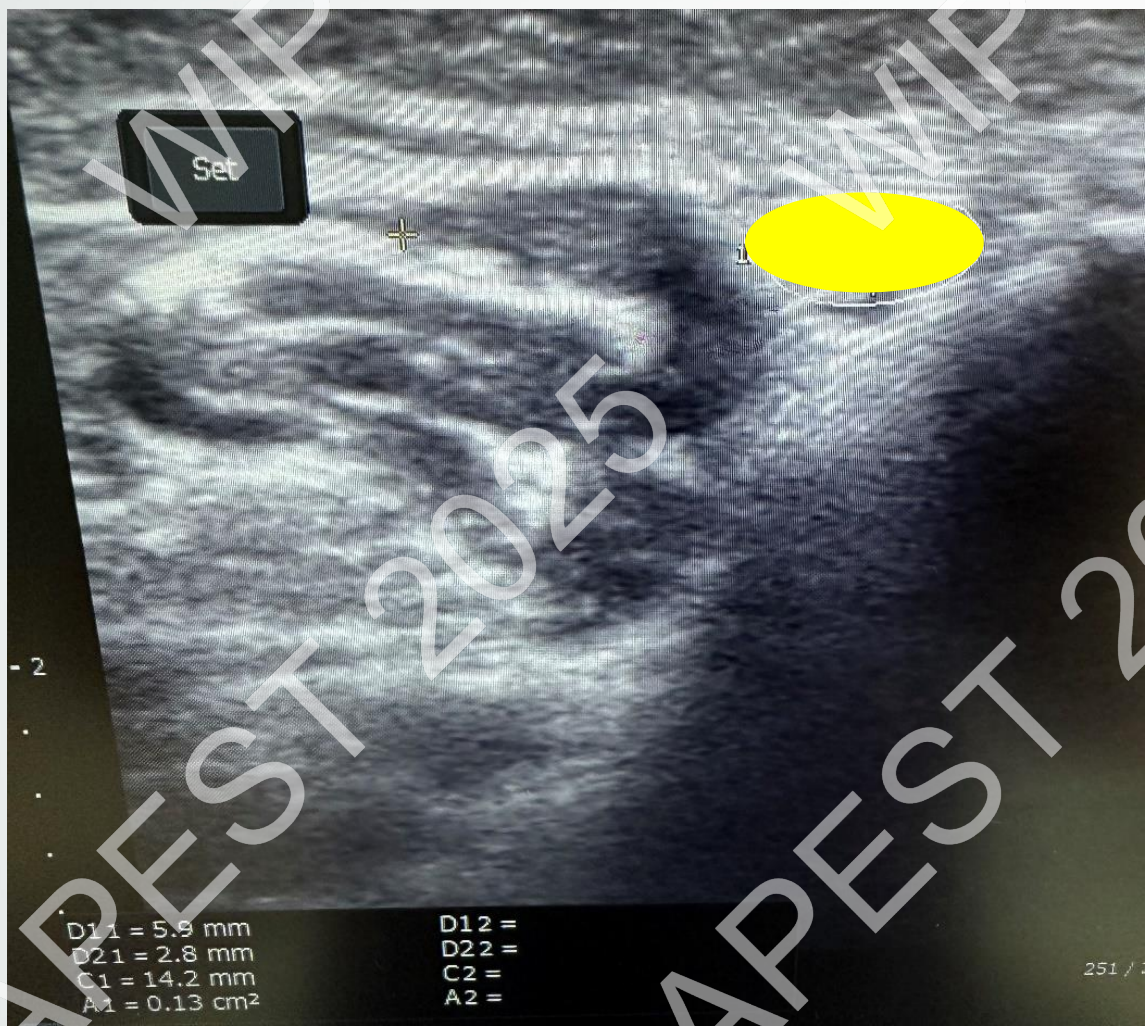


Canal tunnel injection





Unilateral nerve side to side comparision





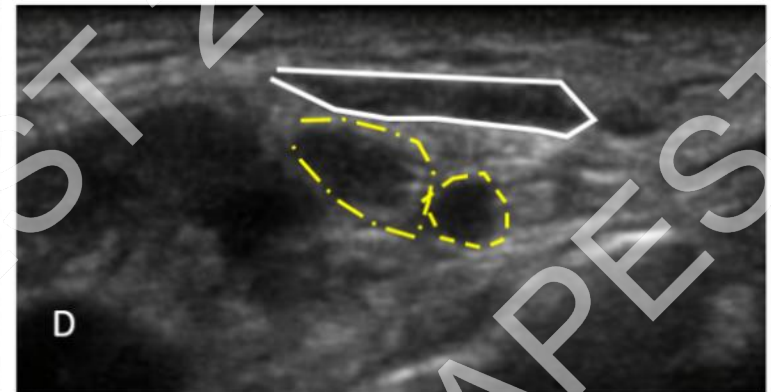
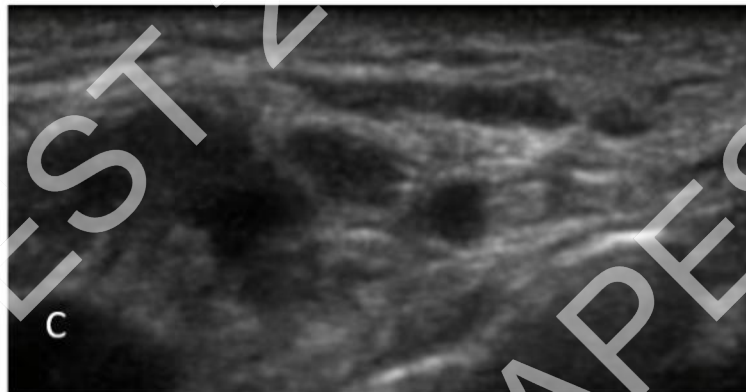
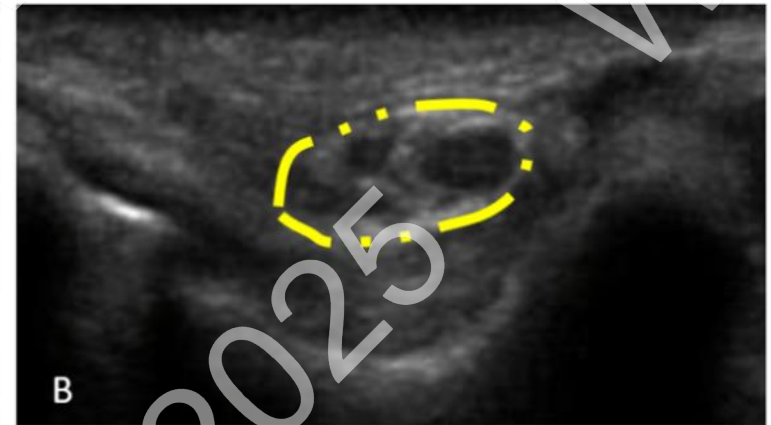
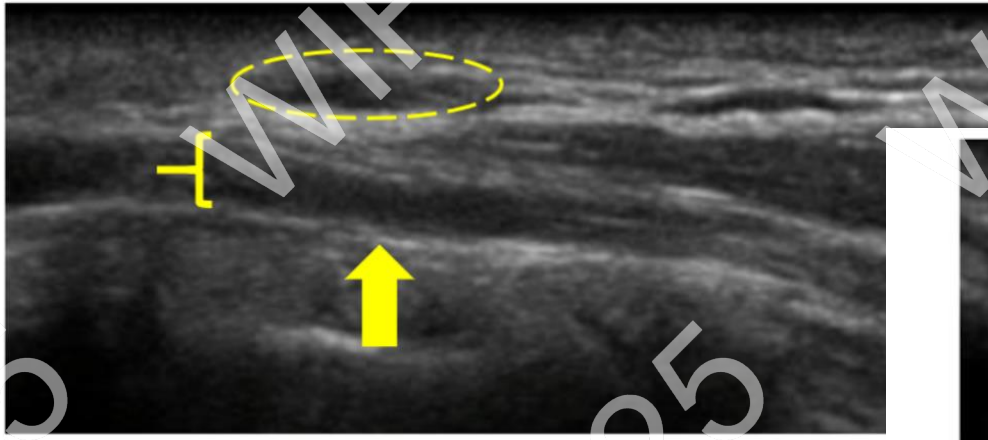
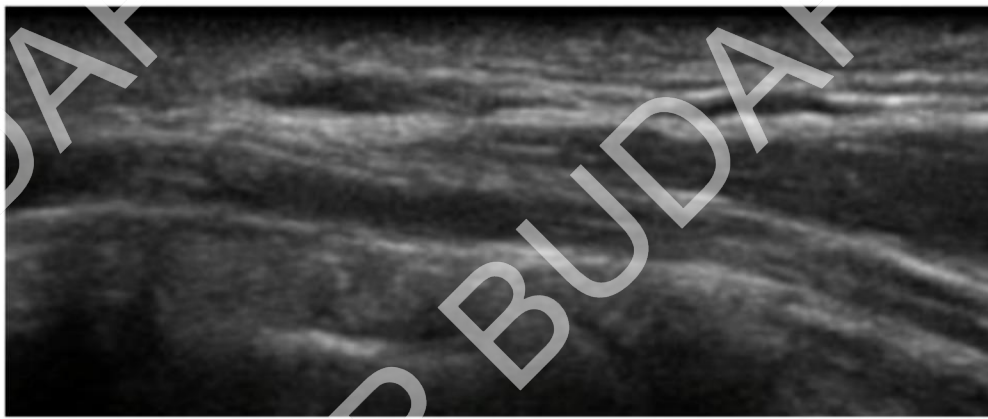
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Neurology

Ulnar nerve compression



Interventional

2025





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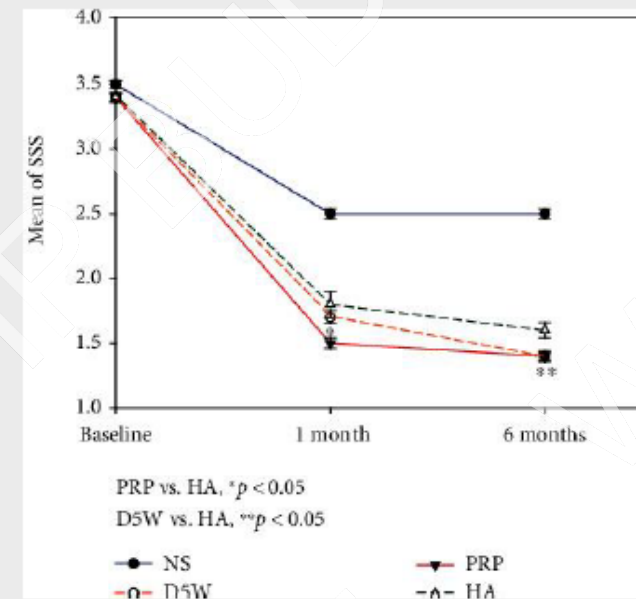
Comparative Study > Biomed Res Int. 2022 Feb 17;2022:9745322. doi: 10.1155/2022/9745322. eCollection 2022.

Novel Motor-Sparing Ultrasound-Guided Neural Injection in Severe Carpal Tunnel Syndrome: A Comparison of Four Injectates

Yung-Tsan Wu ^{1 2 3}, King Hei Stanley Lam ^{4 5 6 7 8}, Chia-Ying Lai ¹, Si-Ru Chen ¹, Yu-Ping Shen ¹, Yu-Chi Su ¹, Tsung-Ying Li ^{1 2}, Chueh-Hung Wu ^{9 10 11}

Conclusion

1. Among the four neural injectates, **single doses of PRP, D5W, and HA were more efficient than NS** as regards symptomatic and functional improvement, as well as decreased CSA of MN, for severe CTS
2. For symptom and functional improvement, **single injections of PRP and D5W seemed more effective than that of HA within 6 months** postinjection. Moreover, PRP and D5W had similar effects, although PRP was slightly better than D5W
3. For reducing CSA, **PRP and HA seemed more effective than D5W**. HA was the most effective at the 1st-month postinjection (HA > PRP > D5W), and PRP was the most effective at the 6th-month (PRP > HA > D5W).



The symptom severity score (SSS) (mean $\pm$ standard error) between postinjection and baseline in the four groups at each time point. Patients in the 5% dextrose water (D5W), platelet-rich plasma (PRP), and hyaluronic acid (HA) groups have more significant improvement compared to those in the NS group at all measured time points.





Mechanisms of Wharton's Jelly-derived MSCs in enhancing peripheral nerve regeneration

[Young Ho Shin](#), [Soon Jin Choi](#) & [Jae Kwang Kim](#) 

[Scientific Reports](#) **13**, Article number: 21214 (2023) | [Cite this article](#)

3268 Accesses | **4** Citations | **1** Altmetric | [Metrics](#)

Abstract

Wharton's jelly-derived Mesenchymal stem cells (WJ-MSCs) play key roles in improving nerve regeneration in acellular nerve grafts (ANGs); however, the mechanism of WJ-MSCs-related nerve regeneration remains unclear. This study investigated how WJ-MSCs contribute to peripheral nerve regeneration by examining immunomodulatory and paracrine effects, and differentiation potential. To this end, WJ-MSCs were isolated from umbilical cords, and ANGs (control) or WJ-MSCs-loaded ANGs (WJ-MSCs group) were transplanted in injury animal model. Functional recovery was evaluated by ankle angle and tetanic force measurements up to 16 weeks post-surgery. Tissue biopsies at 3, 7, and 14 days post-transplantation were used to analyze macrophage markers and interleukin (IL) levels, paracrine effects, and MSC



Intra-neural injection?

- Intraneural injection of local anesthetic was described as a safe practice in regional anesthesia.
- Does injecting into a nerve – make sense?



High injection pressure at the onset of injection may indicate an intraneural needle placement and lead to severe fascicular injury and persistent neurologic deficits.

Critique

Peripheral nerve injury is rare following regional anesthesia, making the incidence difficult to assess with confidence. Symptoms of nerve injury are primarily sensorial (pain, tingling, or paresthesias), but can include any combination of motor or sensory deficits depending on the nerve involved and severity of the injury. It is not always clear whether a nerve block is the cause of a patient's symptoms. Most nerve injuries are believed to occur secondary to intraneural injection, which can be categorized as extra fascicular or intrafascicular. Intrafascicular injections, particularly at a high pressure, are felt to result in greater risk of nerve damage. To minimize the incidence of intrafascicular injection, injection of anesthetic should be halted if the patient feels a paresthesia (shooting pain), or if the pressure required for injection is greater than usual. The use of standard, longer-beveled needles may increase the likelihood of intrafascicular injection with clinical nerve injury compared with the use of short-beveled needles. Nerve injury can also occur as a direct effect of local anesthetic drugs. All local anesthetics have been shown to cause neurotoxicity in vitro at clinically relevant concentrations, but the relevance of these findings to clinical practice is unclear. Preexisting nerve pathology (including diabetes) may make a nerve more susceptible to injury, however it is unlikely that patient's uncontrolled hypertension contributed to his nerve injury.

Reference

Jeng CL, Torrillo TM, Rosenblatt MA. Complications of peripheral nerve blocks. *Br J Anaesth*. 2010 Dec; 105 Suppl 1: i97-107. [PMID: 21148659](#)

Lee LA. [Complications associated with regional anesthesia: review of ASA closed claims](#). *The Anesthesia Patient Safety Foundation Newsletter*. 2004; 19(1): 5-6.

Mesenchymal Stem Cells Enhance Nerve Regeneration in a Rat Sciatic Nerve Repair and Hindlimb Transplant Model

[Damon S. Cooney](#), [Eric G. Wimmers](#), [Zuhaib Ibrahim](#), [Johanna Grahammer](#), [Joani M. Christensen](#), [Gabriel A. Brat](#), [Lehao W. Wu](#), [Karim A. Sarhane](#), [Joseph Lopez](#), [Christoph Wallner](#), [Georg J. Furtmüller](#), [Nance Yuan](#), [John Pang](#), [Kakali Sarkar](#), [W. P. Andrew Lee](#) & [Gerald Brandacher](#) 

Rats undergoing sciatic nerve cut-and-repair and treated with either local or systemic injection of MSCs had significant improvement in the speed of recovery of compound muscle action potential amplitudes and axon counts when compared with negative controls. Similarly, rats undergoing allogeneic hindlimb transplants treated with local injection of MSCs exhibited significantly increased axon counts. Similarly, systemic MSC treatment resulted in improved nerve regeneration following allogeneic hindlimb transplants. Systemic administration had a more pronounced effect on electromotor recovery while local injection was more effective at increasing fiber counts, suggesting different targets of action.

Our studies demonstrated that local or systemic MSC treatment accelerated the functional recovery and increased the number of nerve fibers distal to the site of repair.

Intraneural Platelet-Rich Plasma Injections for the Treatment of Radial Nerve Section: A Case Report

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traumatic peripheral nerve palsy Forty-eight hours after injury, an end-to-end suture was performed without a microscope. Three months after the surgery, (EMG) showed right radial nerve neurotmesis with no tendency to reinnervation. Four months after the trauma, serial intraneural infiltrations of PRP were conducted using ultrasound guidance.



Figure 2. US-guided plasma rich in growth factors injection for the radial nerve. The procedure was performed in sterile conditions in an outpatient setting. The multi-frequency linear probe was aligned with the long axis of the radial nerve, and a 22-gauge needle (25 mm) was inserted into the radial nerve. The accuracy of platelet-rich plasma (PRP) infiltration was confirmed by direct visualization by US imaging.

WIP

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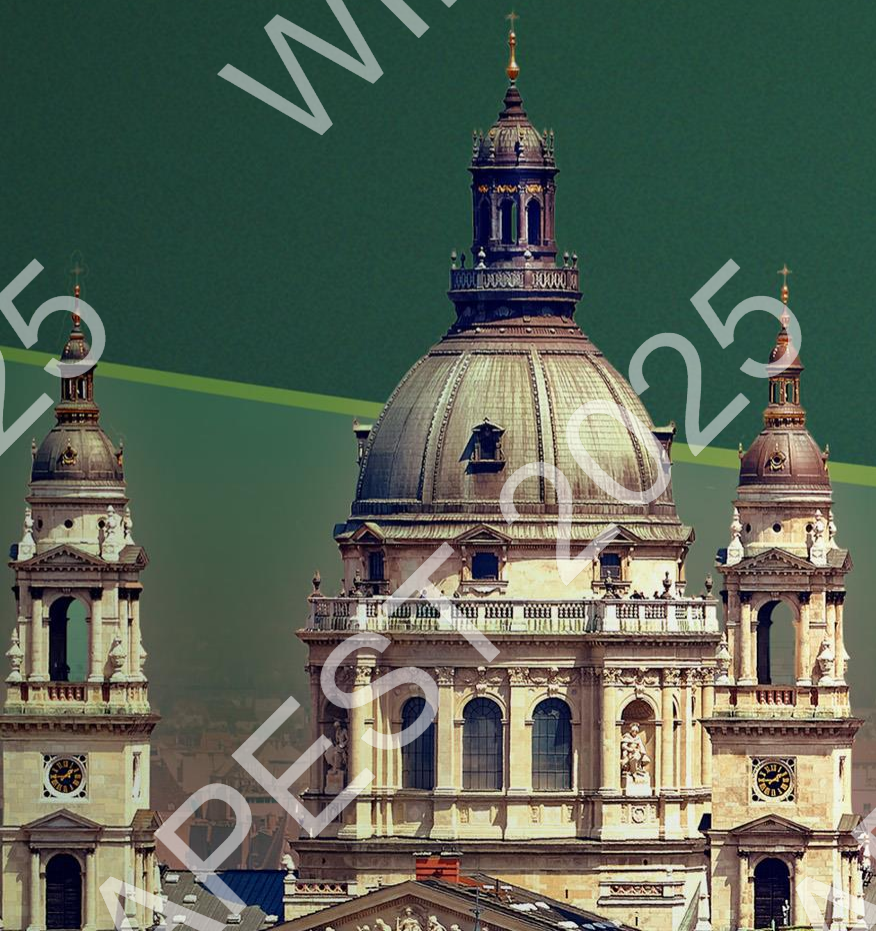


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