Peri-operative Nerve Injuries Post-Foot and Ankle Surgery

It's important to inform patients about this common complication.

BY JACQUELINE BABOL, DPM AND JOHN STENBERG

Peri-operative nerve injury after foot and ankle surgery can vary from being temporary to being a permanent disability. Although peripheral nerve injuries are not life-threatening, they can cause a considerable decline in the patient's quality of life.[1] The AMA Guides to rating impairments rates 5% lower extremity impairment from permanent sensory impairment and dysesthesia of the superficial peroneal nerve, 0% on motor impairment of the superficial peroneal nerve, 2% lower extremity impairment from sensory loss, and 5% lower extremity impairment from dysesthesia with 0% motor loss from permanent impairment from the sural nerve.[2] While damage to the nerves peri-operatively is not a common surgical occurrence, the astute surgeon should be knowledgeable and up-to-date with current literature to be equipped re: how to avoid it and when faced with this dilemma, how to deal with it.

Co-morbidities and Factors that Contribute to Peri-operative Nerve Injury

As is true with all foot and ankle surgeries, several pre-existing co-morbidities predispose negative patient outcomes on any procedures which include peri-operative nerve injuries.

Various metabolic factors,including autoimmune disorders, long-standing diabetes and Hemoglobin A1C levels, smoking status, hypertension, and poor vascular status can predispose the patient to post-operative complications, which include peripheral nerve injuries.[3]

Environmental factors (force of surgical blade or other surgical instrument against the nerve such as a retractor or a hemostat to clamp) can easily lead to permanent nerve damage with even the most careful surgeons, due to the direct and close proximity of the cutaneous and superficial nerves to the site of surgery. Chronic pain syndromes can develop through unrecognized iatrogenic division of the nerve, overzealous compression of the nerve during wound retraction, or by unrecognized suture ligation of the nerve at the time of closure.

Direct trauma from nerve blocks by itself might cause the nerve injury. Various possible mechanisms of injury might include overstretching the nerve during retraction, compression, and ischemia during and after the surgical procedure.[4,5]

Definition

There is no straight definition or diagnosis for post-surgical nerve pain. Definitions may appear in current literature as neuropraxia, post-surgical neuroma, CRPS, and hypersensitive scar, to name a few. A review then of basic nerve injury is in order to better understand the pathophysiology of nerve injuries in surgery.

Categories of Nerve Injury

Nerve injury was classified into three categories by Seddon.[6] Neuropraxia (damage to the myelin sheath), axonotmesis (damage to the neurons), and neurontomesis (the nerve itself is torn or cut).

Although peripheral nerve injuries are not life-threatening, they can cause a considerable decline in the patient's quality of life.

Neuropraxia is an irritation to the nerve generally caused by traction or pull (i.e., retraction) that may result in transient loss of function through the axonal block without degeneration.

Sunderland[7] later further classified nerve injury into five stages based on the extent of injury around the surrounding connective tissue. Grade I corresponds to neuropraxia, Grades II to IV correspond to varying degrees of axonotmesis, and Grade V corresponds to neurotmesis (Figure 1).

The presence of an intact endoneurial tube (the deepest structure encasing the axons) more often leads to a better outcome in nerve regeneration. Thus Grade II lesions,

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which confer damage to the axons alone without any damage to the surrounding connective tissue, have optimal conditions for axonal regrowth. Grade III and IV lesions, however, not only have a disrupted endoneurial tube-making it difficult to form appropriate bands of Bungner—but also have increased scar tissue formation that can be a considerable deterrent to the growth cone, leading to disorganized outgrowth.[8]

The more distal the injury is to the neuron, the more likely it is to recover with the very proximal lesions, close to the neuronal cell bodies, often triggering programmed neuronal cell death. Gap length is negatively correlated with successful regeneration—linking the size of the injury to the fidelity of the axonal outgrowth.

The path of the growth cone may be disrupted by scar tissue, and growth cones release proteases and plasminogen activators to clear its path. This is also to clear any cell-cell or cell-matrix interactions from non-neuronal cells that are hindering its path.[8]

This motivates further investigation in finding ways to optimize recovery. Re-innervation is not synonymous with complete functional recovery. It is the emerging understanding of these along with the key role of clinically relevant factors, which stands to complete recovery from the exception to the rule. Key elements of neuroregeneration that all need to occur include completion of Wallerian degeneration (the clearing process of the distal stump), axonal regeneration, and end-organ re-innervation.[9,10]

Kenzora cites formation of post-surgical neuromas due to direct injury (transection or unintentional suturing), excessive retraction, or entrapment within scar tissue.[11] The neuroma forms within the epineurium.

History and Physical Decision-Making

The diagnosis can be made by careful history and physical examination. Post-operatively, symptoms may include numbness (hypesthesia or

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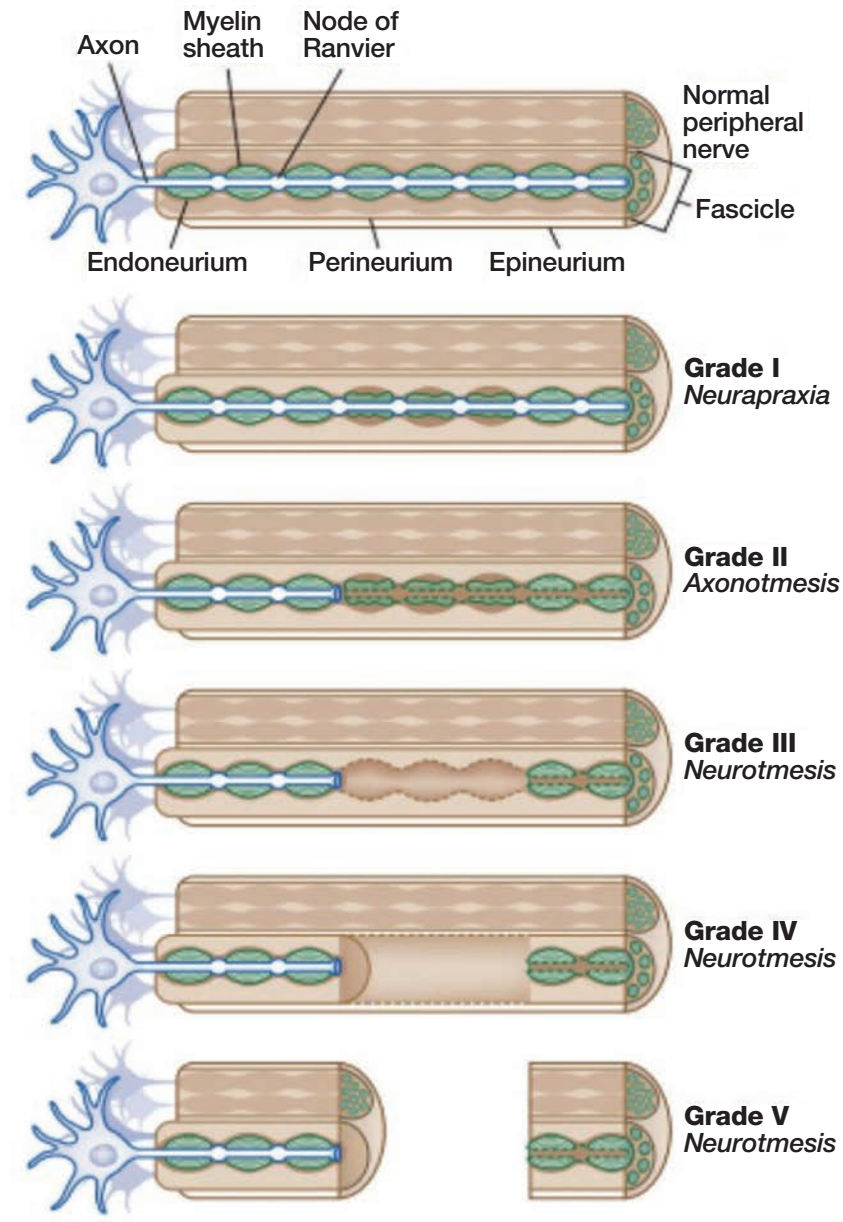
Figure 1: Classification of Nerve Injury[41]



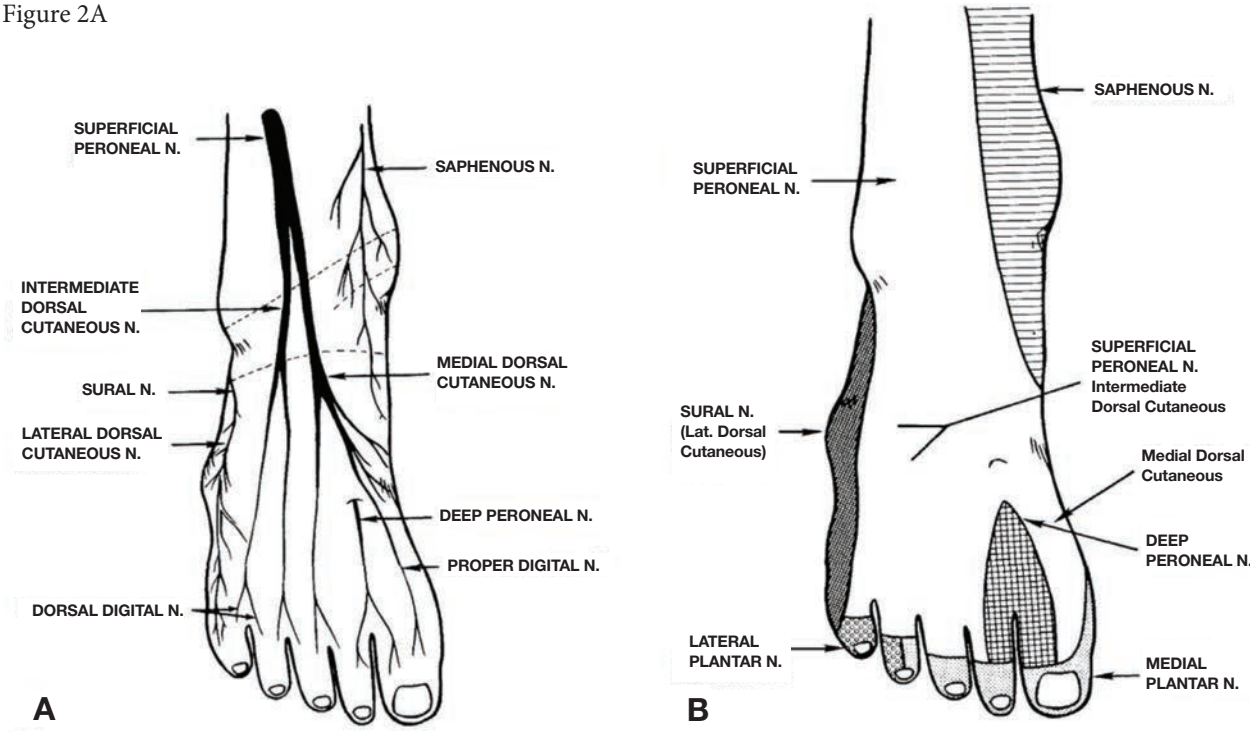
Seddon and Sunderland Classification of Nerve Injury

Seddon	Sunderland	Injury
Neurapraxia	Grade I	Focal segmental demyelination
Axonotmesis	Grade II	Axon damaged with intact endoneurium
Axonotmesis	Grade III	Axon and endoneurium damaged with intact perineurium
Axonotmesis	Grade IV	Axon, endoneurium, and perineurium damaged with intact epineurium
Neurotmesis	Grade V	Complete nerve transection
	Grade VI (MacKinnon & Dellon)	Mixed levels of injury along the nerve

Figure 1: Classification of Nerve Injury[41]

From: Tsao B, Boulis N, Bethoux F, Murray B. Trauma of the Nervous System, Peripheral Nerve Trauma. In: Daroff: Bradley's Neurology in Clinical Practice, 6th ed. 2012 p 984-1001. *(Image courtesy Cleveland Clinic, 2006. Illustrator, David Schumick, BS, CMI.)*

Figure 2A



A: Diagram of the sensory nerves innervating the dorsum of the foot. **B:** Although there is significant variability, this diagram represents the most common pattern of sensory innervation to the skin.[13,16]

Figures 2A and 2B: (A) Diagram of the most common pattern of sensory innervation of the foot.[33] Kenzora, J. (1986). Sensory Nerve Neuromas—Leading to Failed Foot Surgery*. Foot & Ankle, 7(2), 110-117. (B) A schematic representation of a variant of the sural nerve with four lateral calcaneal branches (small arrows) with the bifurcation distal to the lateral malleolus and an anastomosing branch coursing toward the fourth metatarsal (wide arrow).[40] Lawrence, S., & Botte, M. (1994). The Sural Nerve in the Foot and Ankle: An Anatomic Study with Clinical and Surgical Implications. Foot & Ankle International, 15(9), 490-494.

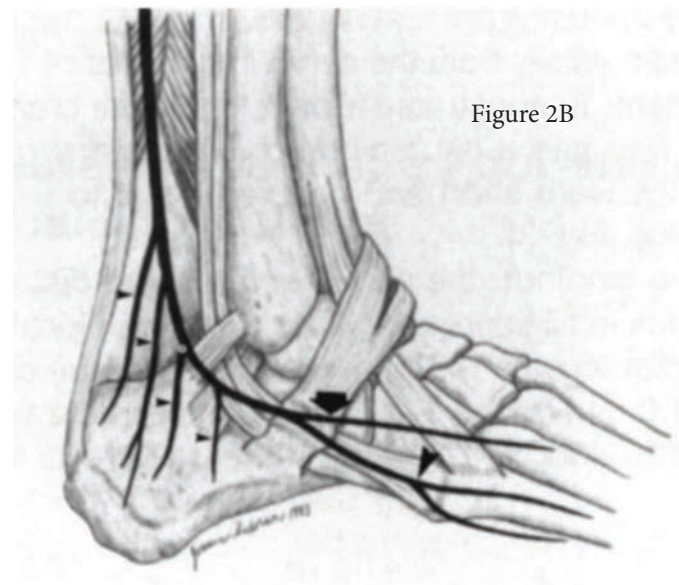


Figure 2B

A positive Tinel's sign can be elicited with pain produced with percussion of the nerve close to the incision site that can sometimes project proximally.

anesthesia) dysesthesia (unpleasant sensations), paresthesia (tingling and burning), hyperesthesia, muscle atrophy, or weakness.

A positive Tinel's sign can be elicited with pain produced with percussion of the nerve close to the incision site that can sometimes project proximally.[12-20] Some of these symptoms can be seen right after surgery and slowly dissipate within two to three months.[23,24]

The symptoms exacerbate at night, and NSAIDs and other oral medications may or may not work. When presented, it is important to map the areas of abnormal nerve sensations that may include two-point discrimination in order to determine the nerve involved.

It is important to note that muscle fibers can atrophy starting three weeks after denervation. One keynote is that the patient is usually in protected weight-bearing, and non-usage of the limb after the surgery itself may cause a slight muscle atrophy from disuse, making it difficult to assess the atrophy causation. It is

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also important to note that the sensory capability from nerve damage might take up to two years to return. This is because sensory end organs. i.e., Pacinian corpuscles, Merkel, and Meissner cells, can be viable for up to two to three years so that even if the muscle atrophies with irreversible loss of function in two years, the sensory function component will return.[21-22]

Non-conservative care usually involves nerve blocks, steroid injections, modification in the fit of the shoes to ensure they are looser, an orthotic for support. Amitriptyline, gabapentin, Lyrica (with or without NSAID) might be prescribed in an attempt to alleviate pain. Physical therapy, including the use of transcutaneous electrical nerve stimulation, also may be very helpful. PRP injections and small amounts of cortisone may be useful if the suspected cause of pain is scar tissue around the nerve.[25]

Figure 3: Arrow pointing to painful sensory neuroma after surgery.[33] Kenzora, J. (1986). Sensory Nerve Neuromas—Leading to Failed Foot Surgery*. Foot & Ankle, 7(2), 110-117.

Patients undergoing surgery should be informed of the possible limitations of the surgical procedure and that the condition might get worse with surgery. Good candidates for surgery should be patients who are not able to wear a shoe without pain, whose activities of daily living are severely compromised with serious limitations with difficulty in ambulation and in work, with failure of conservative treatments.

An understanding of nerve anatomy and landmarks can avoid iatrogenic nerve injuries. Despite various anatomical variations, there lies a rough region where the nerve would most likely be located. The sural nerve is usually in close proximity to the Achilles tendon, 7 cm above the tip of the lateral malleolus. The nerve also lies approximately 14 mm posterior and 14 mm inferior to the lateral malleolus.

Various approaches to skin incisions are cited in literature to prevent iatrogenic peripheral nerve injury.

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Pont, et al.,[26] concluded in their study that the standard orthopedic approaches to skin incisions in foot and ankle surgery are associated with consistent cutaneous risk of peripheral nerve injury. They emphasized that meticulous operative technique be employed to respect the individual nerve pattern for each patient.[26]

Various approaches to skin incisions are cited in literature to prevent iatrogenic peripheral nerve injury.

Isolation and identification of the sural nerve and its branches during surgery play an important role in preventing iatrogenic injury, keeping in mind the multitude of variations of nerve formations.

Surgical procedures with lateral incisions such as lateral ankle stabilization, Achilles and peroneal tendon repairs, subtalar arthrodesis, fracture fixation of the distal fibula, calcaneus, cuboid or at the bases of the lateral

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Figures 4A and 4B: (A) Resection of 5th metatarsal bone fragment resulted in a highly symptomatic bulb neuroma due to inadvertently cutting the lateral dorsal cutaneous nerve. (B) Treatment by an above ankle joint level resection of the sural nerve.[33] Source: Kenzora, J. (1986). Sensory Nerve Neuromas—Leading to Failed Foot Surgery*. Foot & Ankle, 7(2), 110-117.

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metatarsal.[27-29] An anteromedial portal in performing ankle arthroscopy is very close to the superficial peroneal nerve and the dorsalis pedis branch of the saphenous nerve.[30-32]

The more common nerves involved in foot and ankle surgery include the superficial peroneal, saphenous, and sural nerve with occasional overlap of these nerves depending on the placement of surgical incisions.

The incidence of sensory neuromas were reported following dorsal incisional approaches to foot surgeries. These surgeries include ganglion with or without osteophyte excisions and bunion procedures with dorsomedial incisions (Figure 2). They occur due to nerve injury by partial or complete transection of the nerve, or when the nerve is entrapped either by a suture or scar tissue.[33]

The more common nerves involved in foot and ankle surgery include the superficial peroneal, saphenous, and sural nerve with occasional overlap of these nerves depending on the placement of surgical incisions. Bai, et al.'s study show that at three months, almost normal to normal recovery of the superficial peroneal and saphenous were observed, but the sural nerve in their study had no complete recovery of sensation.[34]

Pre-operative Imaging

Ultrasonography and MRI remain the standards of choice as far as imaging modalities to determine musculoskeletal pathology. Ultrasound can also be used to aid in injections. A thorough knowledge of neuroanatomy is imperative to relate the imaging studies to the physical examination in order to obtain a proper conclusion.

Surgery

Excision of painful neuromas may be beneficial for intractable pain after failure of conservative care (Figure 3). Several techniques have been employed, namely: nerve transposition with implantation, epineural closure, neurorrhaphy, and alternate target re-innervation.[39] Current literature supports the proximal resection of the neuroma and embedding the stump into a nearby muscle. If during surgery there was no nerve lesion found, decompression or neurolysis

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is beneficial.[33] Occasionally nerve resection and grafting may be beneficial (Figures 4A and 4B).[33,35-36]

Sharp lacerations or iatrogenic transection of a nerve should be repaired immediately. If both ends are visible, a straight end-to-end apposition without tension should be performed. The proximal and distal soft tissues should be dissected to avoid tension in the section to be repaired. The principle on making sure the nerves are apposed is to allow axonal sprouting and anastomosis without axonal escape through the epineurium leading to a neuroma. 8-0 to 9-0 nylon monofilament or Prolene with taper cut needle is best to use with avoidance of malrotation of the ends achieved by matching up epineural blood vessels. Place your first and second suture at 3 o'clock and 9'oclock and cut long with the first knot tied loosely in order to ensure proper apposition as you sew the other side. Transected nerves would have a higher rate of healing when repaired immediately up to three days. If unable to perform this procedure, an immediate referral should be made.[37]

Conclusion

Cutaneous nerve injury is one of the most common but overlooked complications following foot and ankle surgery. Most surgeons are more focused on the results of the foot and ankle trauma or repair of musculoskeletal and orthopedic surgery, and treat the cutaneous nerve injury as a natural consequence of having surgery and may neglect to address this problem.

Cutaneous nerve injury is one of the most common but overlooked complications following foot and ankle surgery.

Bai, et al. did a one-year research study on sensory nerve recovery after foot and ankle surgery demonstrating that sensory function was generally restored by six months after surgery.

Painful neuromas developed between nine months to one year. There was not much difference between sensory function between nine months to a year. Their study concludes that it is prudent to inform our patients pre-operatively that sensory function may not return fully and that it might take six months up to a year if it does.

To avoid entrapment neuromas, know your neuroanatomy and the possible variations, and plan your incision away from the major nerves when possible.[33] After the initial incision is performed, use blunt spreading or scissors after spreading. Use blunt and gentle retraction. To avoid suturing the nerve, use subcuticular stitching as close to the skin edges as possible. **PM**

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References

[1] Stassart RM, Fledrich R, Velanac V, et al. A role for Schwann cell-derived neuregulin-1 in remyelination. Nat Neurosci. 2013;16(1):48–54.

[2] Linda Concchiarella, Gunnar B Andersson, Guides to the Evaluation of Permanent Impairment 5th Edition 2000.

[3] Mashour, G. (2009). Perioperative Peripheral Nerve Injuries A Retrospective Study of 380,680 Cases during a 10-year Period at a Single Institution. Anesthesiology, 111(3), 490-497.

[4] Dalton, Gail P. MD*; Wapner, Keith L. MD**; Hecht, Paul J. MD** Complications of Achilles and Posterior Tibial Tendon Surgeries, Clinical Orthopaedics and Related Research: October 2001—Volume 391—Issue—p 133-139.

[5] Welch, M.B. MD ,Brummet,C. MD, Welch,T. MD,Tremper, K. PhDMD, Shanks,A MS, Guglani,P MD , Mashour, G. MD; Perioperative Nerve Injuries. Anesthesiology 2009 111:490-7.

[6] Seddon HJ. Three types of nerve injury. Brain. 1943; 66:237.

[7] Sunderland S. A classification of peripheral nerve injuries producing loss of function. Brain. 1951;74:491–516.

[8] Geraldo S, Gordon-Weeks PR. Cytoskeletal dynamics in growth-cone steering. J. Cell Scie. 2009;122(20):3595–3604.

[9] Birch R, Bonney G, Dowell J, Hollingdale J. Iatrogenic injuries of peripheral nerves. J Bone Joint Surg Br. 1991;73-B:280–282.

[10] Khan R, Birch R. Iatropathic injuries of peripheral nerves. J Bone Joint Surg Br. 2001;83-B(7):1145–1148.

[11] Kenzora, JE. Sensory nerve neuromas—leading to failed foot surgery. Foot Ankle. 1986;7:110–117.

[12] Brash, JC: Cunningham's Manual of Practical Anatomy.12th Ed London Oxford University Press 1957.

[13] Brooks, DP: Nerve compression by simple ganglia. J.Bone Joint Surg., 34B:391-400,1952.

[14] Jahss, MH and Kusskin R: Miscellaneous Peripheral Neuropathies and neuropathy-like syndrome, In Disorders of the Foot. Jahss MH (ed) Philadelphia, W.B.Saunders,19872,Ch 44.

[15] Joplin, R.J.: The proper digital nerve, vitallium stem arthroplasty and some thoughts about foot surgery in general. Clin.Orthop.Rel.Res. 76:199-212,1971.

[16] Kopell, HP and Thompson, WAL: Peripheral Entrapment Neuropathies,M|Baltimore, Williams and Wilkins, 1963.

[17] Lusskin, R.: Peripheral neuropathies affecting the foot:traumatic,ischemic and compressive disorders,In Disorders of the Foot.Jahss,MH(ed) Philadelphia, WB Saunders,1982,Ch 42.

[18] Mathews, G.J. and Osterholm, JL: Painful Traumatic neuromas.Surg.Clin. North Am., 51:1313-1324,1972.

[19] Omer, GE: Physical diagnosis of peripheral nerve injuries. Orthop.Clin.North Am., 12:207-228,1981.

[20] Simeone, FA: Acute and delayed traumatic peripheral entrapment neuropathy.Surg.Clin.North Am,52:1329-1336,1972.

[21] Menorca RM, Fussell TS, Elfar JC. Nerve physiology: mechanisms of injury and recovery. Hand Clin. 2013;29(3):317-330. doi:10.1016/j.hcl.2013.04.002.

[22] Kiel J, Kaiser K. Tarsal Tunnel Syndrome. [Updated 2021 Aug 12]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan.

[23] Liang JQ, Chen C, Zhao H. Revision Surgery after Percutaneous Endoscopic Transforaminal Discectomy Compared with Primary Open Surgery for Symptomatic Lumbar Degenerative Disease. Orthop Surg. 2019;11(4):620–627.

[24] Mueller K, McGowan J, Kane S, Voyadzis JM. Evaluation of retraction time as a predictor of postoperative motor dysfunction after minimally invasive transpsoas interbody fusion at L4-L5. J Clin Neurosci. 2019 Mar;61:124-129.

[25] Wilson RL. Management of pain following peripheral nerve injuries. Orthop Clin North Am. 1981 Apr; 12(2):343-59.

[26] Marie-Pierre Pont, Mathieu Assal, Richard Stern, Jean H. Fasel, Cutaneous sensory nerve injury during surgical approaches to the foot and ankle: A cadaveric anatomic study, Foot and Ankle Surgery,Volume 13, Issue 4, 2007,Pgs 182-188.

[27] Lawrence, S., & Botte, M. (1994). The Sural Nerve in the Foot and Ankle: An Anatomic Study with Clinical and Surgical Implications. Foot & Ankle International, 15(9), 490-494.

[28] McMahon SE, Smith TO, Hing CB, Smith B (2011) A meta-analysis of randomised controlled trials comparing conventional to minimally invasive approaches for repair of an achilles tendon rupture. FootAnkle Surg 17:211-217.

[29] Halm J, Schepers T (2012) Damage to the superficial peroneal nerve in operative treatment of fibula fractures: straight to the bone? Case report and review of the literature. J Foot Ankle Surg 51:684-686.

[30] Takao M, Ochi M, Shu N, Uchio Y, Naito K, Tobita M, Matsusaki M, Kawasaki K (2001) A case of superficial peroneal nerve injury during ankle arthroscopy. Arthroscopy 17:403-404.

[31] Ucerler H, Kiz AA, Uygur M (2007) A cadaver study on preserving peroneal nerves during ankle arthroscopy. Foot Ankle Int 28:1172-1178.

[32] Hughes AM, Gosling O, McKenzie J, Amirfeyz R, Winson IG (2014) Arthroscopic triple fusion joint preparation using two lateral portals: a cadaveric study to evaluate efficacy and safety. Foot Ankle Surg 20:135-139.

[33] Kenzora, J. (1986). Sensory Nerve Neuromas—Leading to Failed Foot Surgery*. Foot & Ankle, 7(2), 110-117.

[34] Bai, L., Han, Y., Zhang, W., Huang, W., & Zhang, H. (2015). Natural history of sensory nerve recovery after cutaneous nerve injury following foot and ankle surgery. Neural Regeneration Research, 10(1), 99-103.

[35] Wilson RL. Management of pain following peripheral nerve injuries. Orthop Clin North Am. 1981;12(2):343–359.

[36] Kretschmer T, Heinen CW, Antoniadis G, Richter H-P, Konig RW. Iatrogenic nerve injuries. Neurosurg Clin N Am. 2009;20:73–90.

[37] British Orthopedic Association: The Management of Nerve Injuries A guide to Good practice pg 17.

[38] Iatropathic injuries of peripheral nerves. Khan R, Birch RJ Bone Joint Surg Br. 2001 Nov; 83(8):1145-8.

[39] Ives, G.C., Kung, T.A., Nghiem, B.T., Ursu, D.C., Brown, D.L., Cederna, P.S., & Kemp, S.P. (2018). Current State of the Surgical Treatment of Terminal Neuromas. Neurosurgery, 83(3),

[40] Lawrence, S., & Botte, M. (1994). The Sural Nerve in the Foot and Ankle: An Anatomic Study with Clinical and Surgical Implications. Foot & Ankle International, 15(9), 490-494.

[41] Tsao B, Boulis N, Bethoux F, Murray B. Trauma of the Nervous System, Peripheral Nerve Trauma. In: Daroff: Bradley's Neurology in Clinical Practice, 6th ed. 2012 p 984-1001.

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