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ORIGINAL ARTICLE - NEUROSURGICAL TECHNIQUE EVALUATION

Thread common peroneal nerve release—a cadaveric validation study

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Abstract

Objective To determine if the thread release technique can be applied to common peroneal nerve entrapment at the fibular neck.

Methods The thread common peroneal nerve release was performed on 15 fresh frozen cadaveric lower extremity specimens. All procedures were performed under ultrasound guidance and immediately underwent post-procedural gross anatomic inspection for completeness of decompression and presence or absence of iatrogenic neurovascular injury.

Results All 15 specimens demonstrated complete transection of the deep fascia of the peroneus longus overlying the common peroneal nerve. The transections extended to the bifurcation of the superficial peroneal and deep peroneal nerves. There was no evidence of any iatrogenic damage to the neurovascular bundle or adjacent tendons. The average operating time was less than 30 min.

Conclusion This cadaveric validation study demonstrates the accuracy of the thread common peroneal nerve release. Future pilot studies are warranted to ensure the safety of this procedure in the clinical setting.

Keywords Thread common peroneal nerve release · TCPNR · Interventional ultrasound · Guo Technique · Nerve decompression · Musculoskeletal ultrasound

Abbreviations

TCPNR	Thread common peroneal nerve release
CPN	Common peroneal nerve
TCTR	Thread carpal tunnel release
TTFR	Thread trigger finger release
D	Distal point
DM	Distal margin
P	Proximal point
PM	Proximal margin

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Introduction

Common peroneal (fibular) entrapment neuropathy and focal decompression were first described by Sultan in 1921 [17]. Since 1921, common peroneal nerve entrapment neuropathy has been recognized as the most common entrapment neuropathy in the lower extremity [5]. Injury to the common peroneal nerve classically causes a "drop foot" with motor weakness in dorsiflexion, eversion, and great toe extension as well as sensory changes along the lateral aspect of the leg and dorsum of the foot. Common peroneal neuropathy symptoms and physical findings may be treated with an ankle-foot orthosis, oral pain medication, a corticosteroid injection, or surgical decompression.

The goal of common peroneal nerve decompression is to restore nerve function by releasing the sites of entrapment and thereby decreasing nerve compression. The primary sites of entrapment occur as the common peroneal nerve courses around the fibular neck and are compressed by overlying fascia [8]. Following failed conservative treatments, the nerve

can be targeted for decompression with traditional open surgery [1, 2, 6, 22].

The thread technique (Guo Technique) has been successfully applied to the carpal tunnel release and trigger finger release [9–12]. In this cadaveric study, the thread technique is applied to the common peroneal nerve. The thread technique involves using an 18-gauge 3.5-in. Tuohy spinal needle attached to a 10-mL syringe filled with 0.9% normal saline or 0.5% lidocaine. This needle and syringe are then used to hydrodissect the tissue planes so that a superficial and deep pass of the needle are created and allow for a thread to loop the desired structures with each pass by feeding the thread through the needle via its entry and exit points. This study aims to demonstrate the feasibility of an ultra-minimally invasive ultrasound-guided technique to decompress the common peroneal nerve at the knee.

Methods

General

The thread common peroneal nerve release (TCPNR) procedure was performed on 15 fresh frozen cadaveric lower legs extending from knee to foot in the Department of Anatomy at the University of Minnesota in Minneapolis, Minnesota. The cadaveric specimens were obtained through the academic institution's Anatomy Bequest Program. All specimens were free from signs of trauma, deformity, or prior surgery. Using high-frequency ultrasound, all lower legs were insonated and confirmed to have normal anatomy.

Equipment

A GE Logiq e or Logiq S8 ultrasound machine fitted with a GE L8-18i-D18-MHz compact linear transducer (hockey stick probe) made by General Electronic (Fairfield, CT) was used to perform TCPNR. Other materials included an 18-gauge 3.5-in. epidural Touhy needle, a 10-mL syringe filled with 0.9% normal saline for hydrodissection of soft tissues, and a thin metal wire (Loop & Shear™, 0.009 in. in diameter and 18 in. in length; Ridge & Crest Company, Monterey Park, CA) comprising the thread encircling the tissue targeted to be cut (e.g., superficial and deep fascia of the peroneus longus (PL).

Operative technique

The lower extremity was positioned in the lateral lying position with the head of the fibula facing up. The terms proximal margin (PM) and distal margin (DM) are used to demarcate the extent of the tissue transected. The starting point (P) was marked 1 cm proximal to the PM. The path of the common peroneal nerve was scanned and outlined using a skin marker along the fibular neck as well as the separation of the common peroneal nerve into the deep and superficial branches (Fig. 1). The endpoint (D) was marked approximately 1 cm distal to the distal margin (DM). The common peroneal nerve courses lateral to the lateral gastrocnemius as the overlying popliteal fascia transitions to the fascia of the upper leg while traversing around the neck of the fibula. This anatomy is easily visualized using high-resolution ultrasound (Fig. 2a, b).

To perform the decompression, an 18-gauge needle was bent approximately 15° with the bevel concave pointing upwards and attached to a 10-mL syringe filled with 0.9% normal saline. The 18-gauge needle was inserted at P. Hydrodissection under ultrasound guidance was used to remove fascial adhesions tethering the CPN as it coursed around the fibular neck and entered the peroneal tunnel. The needle was advanced while overlying the CPN and both were deep to the deep fascia of the superficial head of the peroneus longus. During the first pass, the needle was advanced superficial to the CPN and deep to the deep fascia of the superficial head of the peroneus longus. The needle was passed distal to the bifurcation of the superficial and deep peroneal nerves at point DM and finally exited the skin at point D. The syringe was removed, and the thread was passed through the needle from proximal to distal where it exited the skin at points P and D. The needle was removed leaving the thread deep to the fascia but superficial to the CPN.

On the second pass, the same needle was used to enter at P and then was advanced while superficial to the fascia overlying the CPN which courses around the fibular neck and through the peroneal tunnel (Fig. 3). At the peroneal tunnel, a plane was hydrodissected deep to the superficial head of the peroneus longus but superficial to the deep

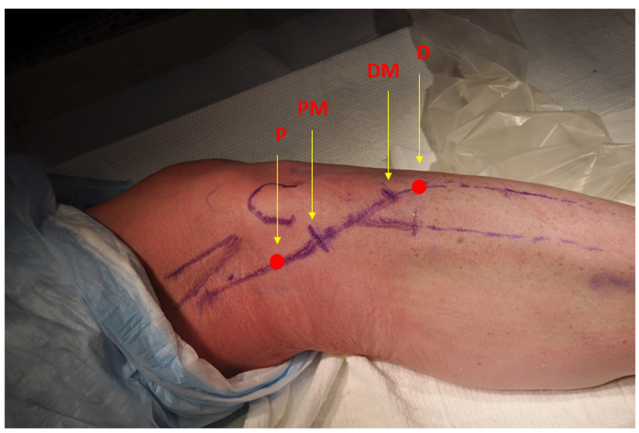

Fig. 1 Surface markings were made illustrating the proximal entry point (P), proximal margin (PM), distal margin (DM), and distal exit point (D). The course of the common peroneal nerve was marked along with the superficial and deep branches. The head of the fibular is marked as well as the biceps femoris tendon

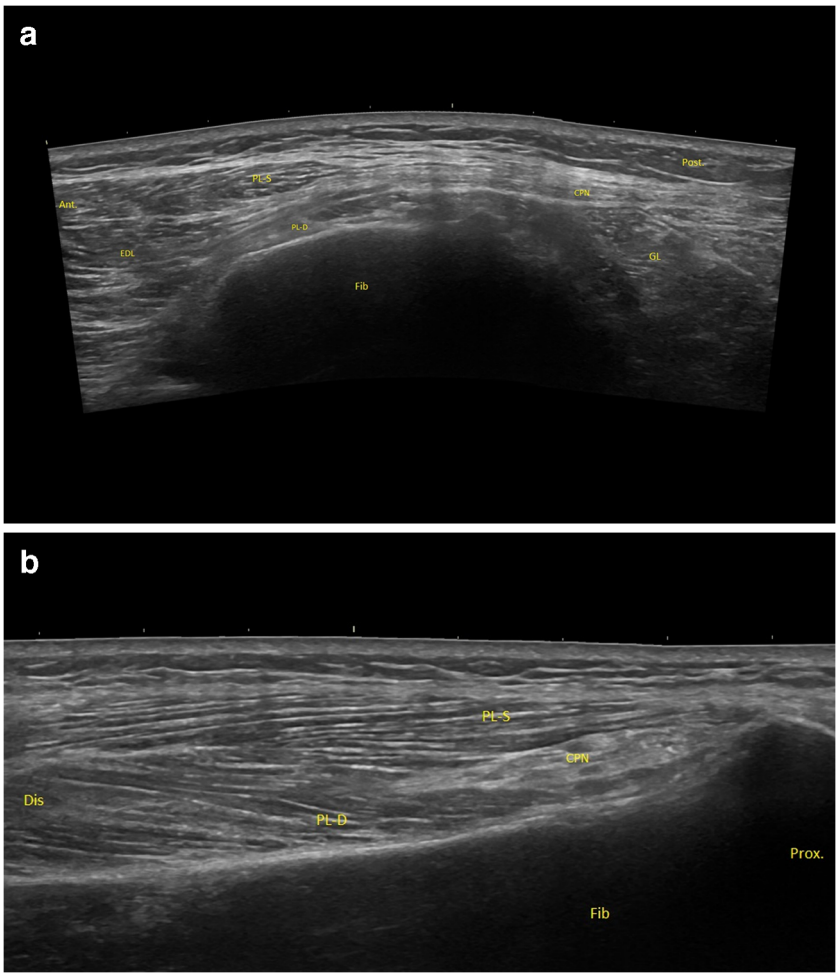

Fig. 2 **a** This figure demonstrates a view along the longitudinal axis of the common peroneal nerve (CPN) as it courses around the fibular neck (Fib) between the superficial head of the peroneal longus muscle (PL-S) and the deep head of the peroneal longus muscle (PL-D). The extensor digitorum longus (EDL) and lateral head of the gastrocnemius (GL) muscles are marked. **b** This figure demonstrates a view along the longitudinal axis of the fibula while showing the common peroneal nerve (CPN) as it pierces between the superficial head of the peroneus longus (PL-S) and the deep head of the peroneus longus (PL-D) as the CPN courses around the neck of the fibula (Fib). Proximal (Prox.) and distal (Dis) orientations were marked

fascia of the superficial head of the peroneus longus. This plane was hydrodissected further until the bifurcation of the superficial and deep peroneal nerves (DM) at which point the needle exited at point D. The syringe on the needle was removed and the distal end of the thread was placed back into the needle and passed through it (Fig. 4). The needle was removed resulting in the thread being looped around the fascia overlying the common peroneal nerve from PM to DM. With a gentle to-and-fro motion of the thread using capped 1-mL syringes as handles, the

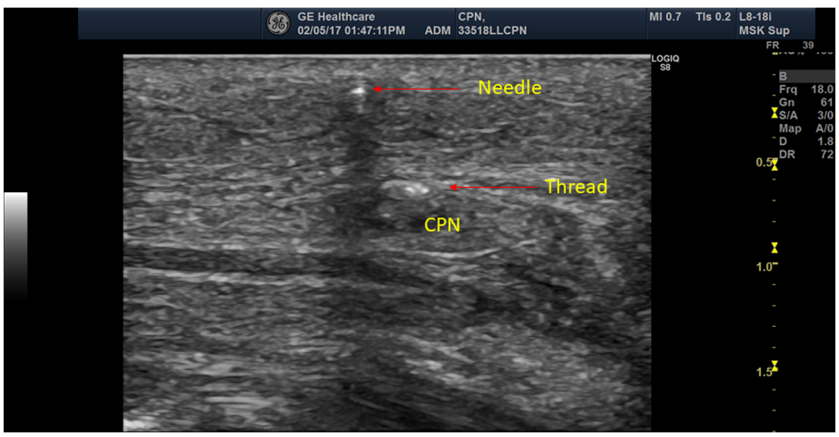

Fig. 3 This figure demonstrates a short-axis view of the superficial pass with the needle superficial to the thread and the common peroneal nerve (CPN)

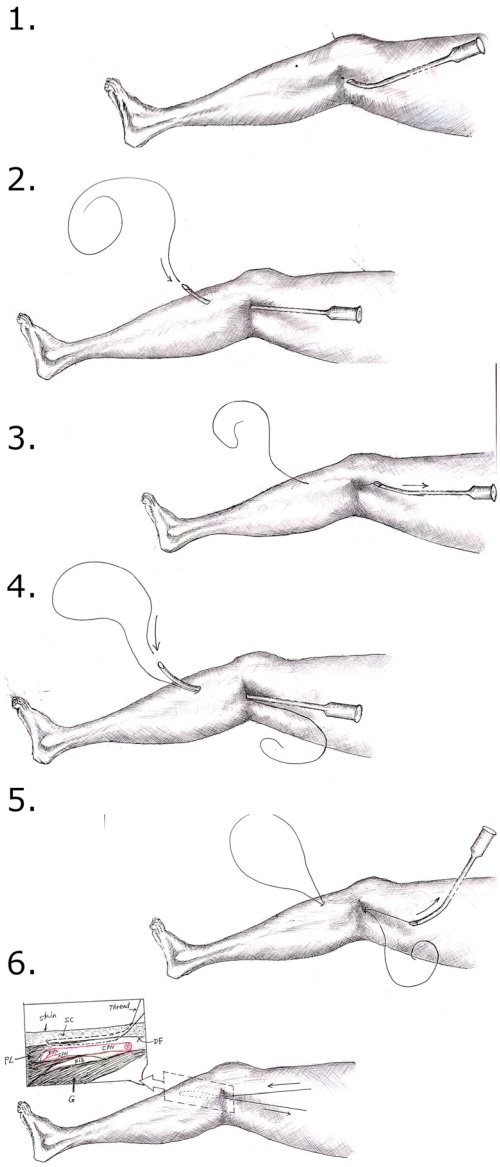

Fig. 4 The schematic drawing demonstrates six steps in performing the thread common peroneal nerve release. An area of magnification in step 6 shows that the thread has looped the overlying fascia and a portion of the superficial head of the peroneus longus muscle

thread transected the fascia overlying the common peroneal nerve. Ultrasound was then used to demonstrate complete decompression of the common peroneal nerve.

Results

Fifteen cadaveric specimens showed complete division on gross anatomic inspection by an independent observer. There were no injuries to nearby anatomical structures including, most importantly, the adjacent neurovascular structures.

Discussion

This study demonstrated a precise, reliable, and ultra-minimally invasive method of decompressing the common peroneal nerve without gross anatomic evidence of iatrogenic injury to nearby neurovascular structures (Fig. 5). This method differs from open surgery by being more targeted towards focal compression, being ultra-minimally invasive, being performed in an outpatient clinic, having no requirement for a tourniquet or local anesthesia, and allowing simple sonographic distinction between adipose tissue and the CPN. It is possible that this ultra-minimally invasive method may be better suited for the diabetic and neuropathic populations [14, 16, 21].

The common peroneal nerve has been reported to be mistaken as a lipoma and resected during open surgical procedures [4, 19]. High-resolution ultrasound has shown to safely and reliably identify the common peroneal nerve as it branches from the sciatic nerve and courses around the fibular neck through the peroneal tunnel [19]. With proper visualization under high-resolution ultrasound, complete decompression of the peroneal nerve can be achieved.

There are multiple sites of potential compression of the common peroneal nerve [3, 8]. High-frequency ultrasound provides a new dynamic in performing nerve decompression and allows more selectivity in releasing fascia and other anatomical structures [10]. Dellon discusses three important areas for decompression: the fascial layer that overlies the CPN and continues superficially to the peroneus longus; a fascial layer that is superficial to the CPN but deep to the peroneus longus (aka posterior crural septum); and a fascial layer deep to the CPN but superficial to the fibula. Mackinnon discusses these three areas, but then adds the following: the anterior crural septum (septum between extensor digitorum longs (EDL) and PL); the posterior crural septum (septum between PL and CPN); and the innominate (or "no named") crural septum (septum between tibialis anterior (TA) and EDL) [7, 15].

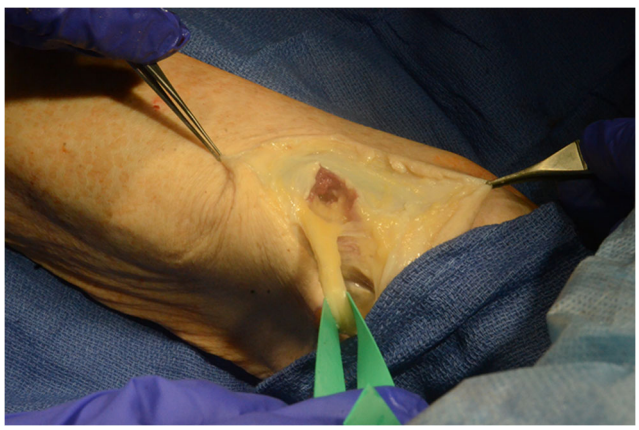

Fig. 5 This gross anatomic dissection demonstrates a complete release of the common peroneal nerve as it courses around the fibular neck

Targeting these areas collectively reduces the pressure on the CPN from ~40 to < 10 mmHg during dorsiflexion and plantarflexion [13].

The advantage of the thread procedure is that one can identify these fascial layers through hydrodissection and can selectively target part or all of them. This idea that the hydrodissection allows you to find the appropriate fascial layers marks a significant difference between open surgery and thread surgery. As such, the fascia overlying the CPN may be broadly termed as "deep fascia" which is confluent throughout the whole body and in the case of the CPN overlies, underlies, and includes the superficial head of the peroneus longus. This nascent sonographic term and longtime surgical term of deep fascia are clearly made apparent when performing procedures under high-resolution ultrasound. The whole deep fascia (broad term use) may be looped and transected to thoroughly decompress the CPN. This occurs as the needle courses immediately superficial the CPN by hydrodissection. In open surgery, the surgeon must identify all these separate fascial bands, but with the thread surgery using hydrodissection, these fascial layers are naturally separated and transected.

Layers that would be included within the "deep fascia" would be Dellon's and Mackinnon's first and second sites of compression in addition to the superficial head of the peroneus longus. This is illustrated in the schematic drawing with a magnification showing these structures (Fig. 5). The superficial head of the peroneus longus may have a fibrous attachment to the fibula or proximal muscle tissue depending on anatomical variants [18]. It is anticipated that there would be bleeding with this transection of the "deep fascia," but because of the use of cadaveric specimens here, clinical significance is unable to be determined.

Hydrodissection adds a new method of treating peripheral nerves [20]. With hydrodissection, it is possible to provide circumferential removal of adhesions to the common peroneal nerve. Likewise, by looping the overlying fascia, it is hypothesized that these additional sites of entrapment may not need to be routinely decompressed. This method of decompression should be performed only by clinicians with advanced ultrasound training.

Conclusion

This is the first cadaveric validation study of an ultra-minimally invasive approach to decompress the common peroneal nerve at the level of the fibular head. Future clinical pilot studies should evaluate its efficacy and safety.

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Compliance with ethical standards

Conflict of interest DG and DG reported that their brother JG is the inventor and patent holder of the transecting thread used in this study. All other authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (University of Minnesota/ Anatomy Bequest Program) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

Disclaimer The sponsors of this study had no role in the design or conduct of this research.

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