Preoperative Ultrasound-Guided Wire Localization of the Lateral Femoral Cutaneous Nerve

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BACKGROUND: Difficulty and sometimes inability to find the lateral femoral cutaneous nerve (LFCN) intraoperatively is well known. Variabilities in the course of the nerve are well documented in the literature. In a previous paper, we defined a tight fascial canal that completely surrounds the LFCN in the proximal thigh. These 2 factors sometimes render finding the nerve intraoperatively, to treat meralgia paresthetica, very challenging.
OBJECTIVE: To explore the use of preoperative ultrasound to minimize operative time and eliminate situations in which the nerve is not found.
METHODS: Since 2011, we have used preoperative ultrasound-guided wire localization (USWL) in 19 cases to facilitate finding the nerve intraoperatively. Data were collected prospectively with recording of the timing from skin incision to identifying the LFCN; this will be referred to as the skin-to-nerve time.
RESULTS: In 2 cases, the localization was incorrect. In the 17 cases in which the LFCN was correctly localized, the skin-to-nerve time ranged from 3 min to 19 min. The mean was 8.5 min, and the median was 8 min.
CONCLUSION: Preoperative USWL is a useful technique that minimizes the time needed to find the LFCN. For the less experienced surgeon, it is extremely valuable. For the experienced surgeon, it can identify anatomical abnormalities such as duplicate nerves, which may not be readily recognizable without ultrasound. Collaboration between the surgeon and the radiologist is very important, especially in the early cases.

KEY WORDS: Lateral femoral cutaneous nerve, Localization, Meralgia paresthetica, Ultrasound, Wire placement

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Meralgia paresthetica refers to pain and paresthesia in the anterolateral aspect of the thigh. It can be caused by constriction, inflammation, or trauma to the lateral femoral cutaneous nerve (LFCN). The reported incidence is 4.3 per 10 000 person-years.[1] It affects predominantly overweight males and is also seen after prolonged surgery in a prone position. After a period of conservative treatment, surgery is offered to either decompress or transect the LFCN. The variable anatomic course of the nerve is well known to surgeons and anatomists.[2-7] In a previous paper, we showed that the nerve courses in its own canal, being tightly surrounded by fascia in all directions.[8] These facts can render finding the nerve intraoperatively a challenging task sometimes. If the deep fascia is not opened right on top of the nerve, it is not easy to find the nerve, because the deeper layer of the LFCN canal shields the nerve from the surgeon's eyes (Figure 1). Since 2011, we have used preoperative ultrasound-guided wire localization (USWL) of the LFCN. The main question was how easy and quick it is to find the nerve using this technique. Institutional review board approval was obtained. Protocol ID number: 2013-1411-CR001.

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METHODS (VIDEO, SUPPLEMENTAL DIGITAL CONTENT)

Seventeen patients scheduled for surgery on the LFCN underwent preoperative USWL. The patients are first brought to the first-day surgery unit for

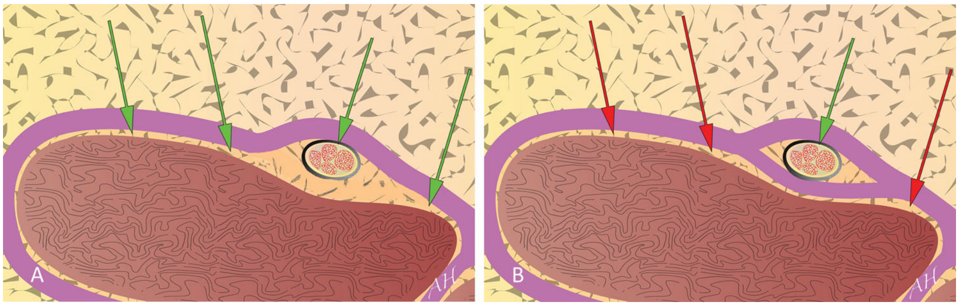

FIGURE 1. *Cross-section through the left upper thigh showing the LFCN as thought of initially, as deep to the deep fascia overlying the Sartorius muscle* (**A**)*, allowing easy access to the nerve (green arrows), and in its own canal* (**B**)*, as we described before.* **B***, being the real concept, illustrates how the deeper layer of the LFCN canal can obscure the nerve if the deep fascia is opened away from the canal (red arrows). Copyright Amgad Hanna, reproduced from: Hanna AS. The lateral femoral cutaneous nerve canal.* J Neurosurg. 2016;22:1–7.[8]

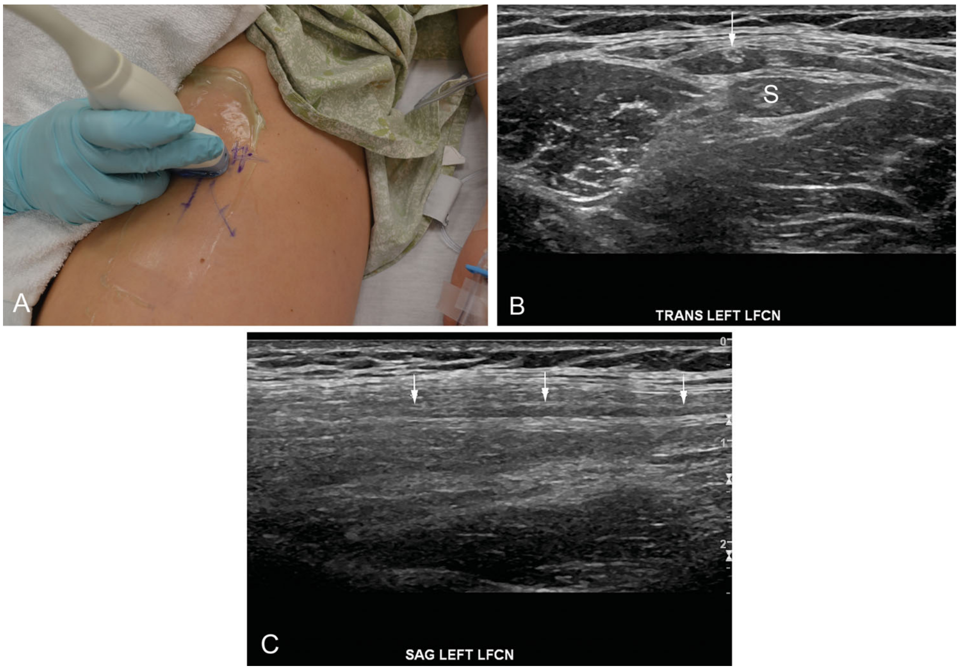

FIGURE 2. ***Step 1:*** *The LFCN is mapped in a nonsterile fashion.* (**A**)*, An uncovered US probe placed transversely over the LFCN trajectory using a gel lubricant.* (**B** *and* **C**)*, The LFCN (arrows) is mapped in its canal, transversely and longitudinally, respectively, superficial to the Sartorius muscle (S).*

their routine preoperative check and site marking. They are then brought awake to the ultrasound (US) suite, where USWL is performed under local anesthesia. Prior US studies are reviewed. The first part of the procedure is mapping the nerve; the second part is placing the wire around the nerve.

Step 1 (Figure 2)

The LFCN is mapped below the level of the inguinal ligament within its canal superficial to the sartorius muscle. Careful observation of the course and branching of the nerve laterally as it travels distally in the thigh is confirmed. In larger patients, the nerve may be difficult to localize, especially when the thigh is externally rotated. It can be helpful to follow the nerve proximally to the level of the anterior superior iliac spine (ASIS) and above the inguinal ligament for further confirmation.

Step 2 (Figure 3)

After the LFCN is identified and a skin mark is placed, the skin area is prepped and draped under standard sterile technique. The US probe and

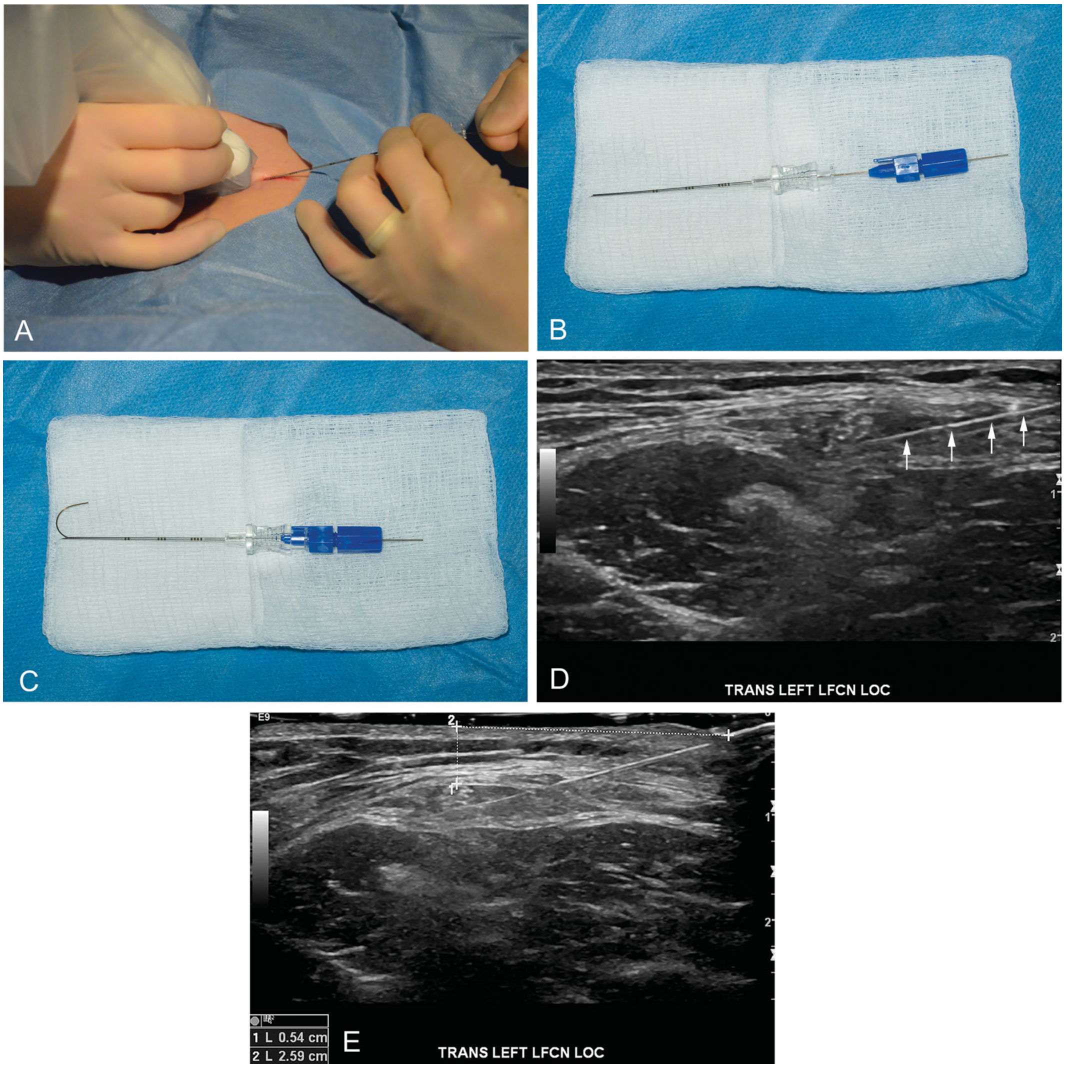

FIGURE 3. ***Step 2:*** *The area is prepped and draped.* (**A**), *A sterile cover is applied to the US probe and the gloved radiologist applies the local anesthetic and then begins placing the wire under the nerve, while observing the progress on the US screen.* (**B** *and* **C**), *Homer needle before and after deployment, respectively.* (**D**), *The wire (arrows) is observed aiming at the undersurface of the nerve.* (**E**), *At the end of the procedure, measurements are taken from the skin surface to the nerve (here, 1 = 0.54 cm). This is the depth, so the US probe should be gently applied to the skin when taking this measurement. Also, measurement is taken from the skin surface to the wire entry point (here, 2 = 2.59 cm); this denotes where the skin incision should be made.*

operator are also covered so that the entire field and wire placement are performed using a standardized sterile technique. The US probe is a high-frequency 15 to 4 MHz linear array probe (GE Healthcare, Waukesha, WI) placed at the level of the skin marker in the transverse orientation of the nerve. We typically take a lateral to medial approach to the nerve. The ideal location is between 1 and 2 inches caudal to the ASIS. Local anesthesia is performed with buffered 1% lidocaine using a 30-gauge needle. The LFCN is again visualized with US, and the location to be targeted is confirmed by the radiologist and, usually, also the surgeon. A 20-gauge, 7.5-cm wire is placed using a locking needle-wire system. We prefer using the Homer needle-wire system (Argon Medical, Plano, TX). The placement technique involves placing the J-curve of the wire just underneath the LFCN. Placing the J-curve underneath the nerve helps to ensure the needle is anchored to prevent wire migration. Once placement underneath the nerve is confirmed by US, the locking system and needle are removed over the wire, with careful attention not to dislodge the wire from underneath the nerve. Following wire placement, the distance from skin surface directly over the nerve to the nerve itself is measured using US, ensuring no compression by the US probe. Next, the distance from the skin surface overlying the nerve to the skin entry site of the

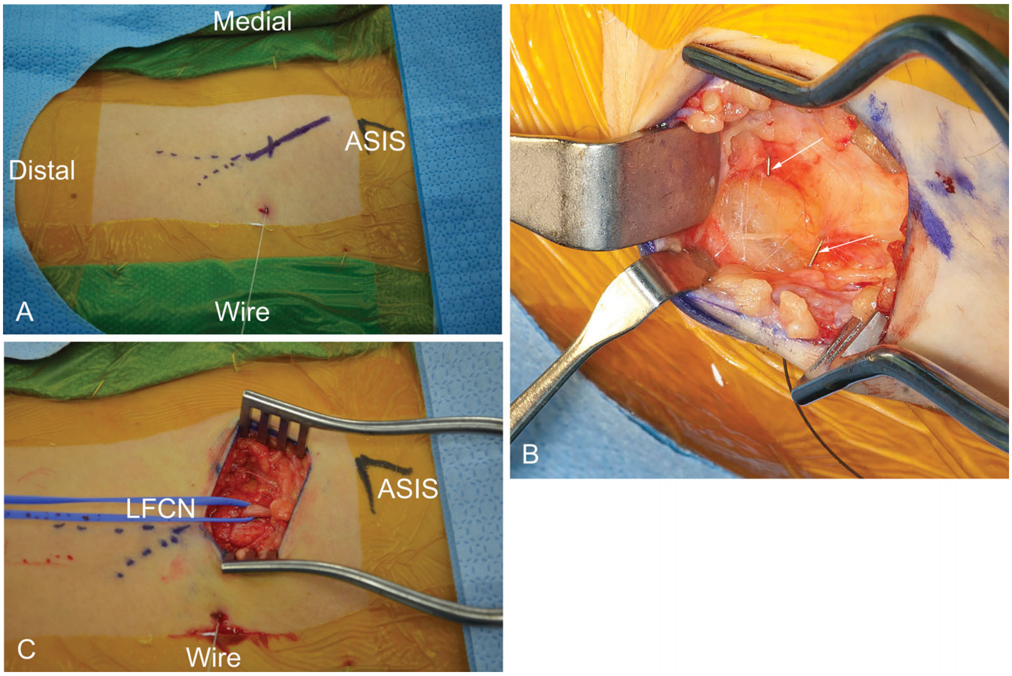

FIGURE 4. ***Step 3:*** *In the operating room, under general anesthesia, the previous dressing is carefully removed.* (**A**)*, The incision is marked based on the US mapping and measurements. The skin and wire are gently prepped and draped.* (**B**)*, The 2 limbs of the "J" of the wire are identified (arrows). The deep fascia is incised in between to find the LFCN* (**C**)*. ASIS = anterior superior iliac spine.*

wire is measured. These 2 measurements are reported to the surgeon and documented in the radiology report. The portion of the wire that remains outside of the skin surface is gently laid down against the skin surface so as to prevent wire migration. Sterile gauze and tape are then applied to keep the area clean and dry.

Step 3 (Figure 4)

The patient is then taken to the operating room, where general anesthesia is started. The dressing over the wire is carefully removed. The skin including the wire is prepped and draped, being very gentle around the wire so that it does not pull out. The incision is marked on the nerve based on the US measurement of the distance between the wire entry point and the nerve. The skin and superficial fascia are opened; the wire is then usually palpable through the fat. Spreading with Metzenbaum scissors along the wire brings it easily into vision. If a self-retaining retractor is used, it is extremely important not to distort the wire with the retractor blades. The wire is then observed as it enters the deep fascia. Occasionally the returning limb of the "J" of the wire is seen or felt through the fascia. An incision is made in the deep fascia in line with the nerve trajectory. If the 2 limbs of the "J" are seen, the incision is made in-between; if not, the opening can be made just medial to the wire, because most of the time the wire enters from lateral to medial. By this incision, the LFCN canal is open, usually revealing the fat around the nerve. Spreading along the nerve trajectory will identify the LFCN or its branches. A vessel loop is placed around the nerve. The search should continue for other branches within the wire before pulling it out. To take the wire out, the initial technique was to cut the wire in 2 pieces within the incision and then pull it out; however, it is very hard to cut the wire. It is more effective to simply use a heavy needle driver to straighten the end of the wire with one hand while the other hand pulls on the other end of the wire. The nerve is then followed proximally toward the inguinal ligament, being careful to identify other branches, because the main nerve trunk can have a very short course.

In addition to marking the skin incision time, the operating room nurse was asked to mark the time when notified by the surgeon that the nerve was found. Data were collected prospectively and analyzed retrospectively. The skin-to-nerve time is calculated by subtracting the incision time from the time when the nerve is found. There is no control group. This is a single-surgeon series (the first author).

RESULTS

Between 2011 and 2016, a total of 19 cases were operated on using this technique. The LFCN was successfully localized in 17 cases, including 1 revision. The skin-to-nerve time varied between 3 and 19 min, with a mean of 8.5 min and a median of 8 min (Table). Thirteen cases (76.5%) had a skin-to-nerve time between 3 and 9 min, with a median of 7 min. In one case, the wire pulled out during the prep, but because the incision had been marked based on the US measurements, the skin-to-nerve time was still 3

TABLE. Skin-to-Nerve Time as Recorded Prospectively by the Operating Room Nurse

Case no.	Skin-to-nerve timing (minutes)	Comments
1	14	
2	–	Incorrect localization of a femoral nerve branch
3	19	
4	15	
5	9	
6	8	
7	4	
8	9	Video recording
9	8	
10	9	
11	6	
12	–	Incorrect localization of a fascia lata strip. Scar from anterior hip surgery
13	3	Revision
14	6	
15	3	Wire pulled out after measuring, too short excursion under the skin
16	12	Wired nerve too tiny. Another nerve found more medially
17	4	
18	9	
19	7	

min. In another case, the timing was 9 min, but video recording was taken, which may have slowed down the procedure to some extent. There are 2 cases in which the localization was incorrect. The first case was the second in this series, in which the lack of experience played an important role. The wire was placed around a branch of the femoral nerve. Once this was recognized intraoperatively, the incision was undermined laterally until the LFCN was found. The second case was number 12 in this series; the patient had prior hip surgery via an anterior approach, and the LFCN was encased in scar tissue and lost its fascicular pattern. In addition, the fascia lata was scored in a longitudinal fashion, giving it a similar trajectory to a nerve; the wire was mistakenly placed around a strip of fascia lata. The skin was undermined medially until the LFCN was found. There were no cases of nerve injury, infection, or bleeding secondary to wire placement.

DISCUSSION

In a previous paper, we discussed the variability in the course of the LFCN, including the distance between the nerve and the ASIS, duplicate nerves, and aberrant origin from the femoral nerve or the genitofemoral nerve.[8] These findings are well documented in the literature.[2-7] The LFCN canal was also defined.[8] These 2 factors can make the search for the nerve intraoperatively a tedious task that can take a long time. US has been used intraoperatively to find intracranial hematomas or tumors, to guide intraventricular shunt catheter insertion, or for arteriovenous malformation resection.[9-11] USWL is a known technique in breast biopsies and soft tissue metastatic melanomas.[12-16] Spinner et al have used it to resect an accessory axillary muscle.[17] In December 2014, Levi et al report using USWL to localize 2 cases of neuroma on the infrapatellar branch of the saphenous nerve.[18] Since 2011, we have used USWL to preoperatively localize the LFCN. We first reported this technique in January 2014 to the American Society for Peripheral Nerve. This is the only series of this kind in the current literature. The goal was to minimize the operative time needed to find the nerve and eliminate situations in which the nerve is not found and the procedure aborted. Localization of the LFCN has traditionally been done with landmarks, palpation, and, occasionally, preoperative diagnostic imaging. Tinel's sign is not always present and is not very reliable in localizing the LFCN, especially in obese people.

Although we have no control group, traditionally, surgeons who operate on the LFCN are quite familiar with the difficulty they sometimes encounter to find the nerve and how time consuming it can be. Dissecting 1 or 2 cadavers before doing a case is unlikely to help, because the intraoperative anatomy could be completely different due to anatomical variabilities. Also, the epidemiological data are quite clear. Carai et al reported failure to find the LFCN in 13/148 cases (8.8%); they concluded that a systematic revision of the surgical strategy is needed and US image guidance should be used in this subgroup of patients.[3] Kliot et al have used US-guided methylene blue injection to localize nerves.[19] However, methylene blue can diffuse through the tissues rendering localization inaccurate, and the compound carries its own risks.[20] Deimel et al reported significantly improved nerve conduction studies from the LFCN when US was used to place the needle close to the nerve.[21]

Peripheral nerve cases, such as exposure of the LFCN, cannot employ technology requiring fixed points for orientation such as Stealth imaging and intraoperative navigation due to limb movement and the distortion of soft tissues. US is well suited for nerve evaluation. The nerve is typically evaluated in the transverse plane (cross-section) and appears hyperechoic relative to adjacent muscle and tendon. Nerves are often described as having a fascicular pattern that corresponds to the hyperechogenic fat surrounding the relatively hypoechoic nerve fascicles. The use of US has been demonstrated to aid in peripheral nerve diagnosis as well as preoperative and intraoperative localization.[22-27] Also, the LFCN canal is readily visualized by US.[8] US is a readily accessible and relatively inexpensive imaging modality, and it does not expose patients to radiation. Similarly, the US-guided wire technique is inexpensive, minimally invasive, and highly effective.[28] We use the Homer wire that has been used for breast lesion localization. It is strong, the "J" curve of the wire is flexible, and the wire can be retracted and repositioned as needed to ensure accurate and precise localization. The Kopan's wire tip is V-shaped, with an acute sharp angle rather than a gentle curve. It is less likely to dislodge but is hard to readjust once deployed

due to its unforgiving V-angle; it can only be removed surgically. In addition, placement is not always precisely under the small-diameter LFCN, since the deployment of the wire through the outer needle prevents the small adjustments required. Therefore, the Homer needle is preferred.

Our average skin-to-nerve time was 8 min. In most cases (76.5%), it was between 3 and 9 min. Most cases that took more than 10 min to find the nerve were early on in this series, which can be explained by the learning curve. One case later in the series took 12 min; the nerve was very tiny and difficult to find. Further searching revealed a second nerve (duplicate) more medially arising from the femoral nerve. There are 2 cases in which the localization was incorrect. The first one was the second case in this series; the surgeon was not present during the USWL, and a femoral nerve branch was mistaken for the LFCN. In retrospect, this branch was coursing medially instead of laterally. Also, the patient's thigh was externally rotated during the USWL. Therefore, we recommend positioning the leg neutrally when localizing the LFCN. It is important to build a team with a technician and a radiologist interested in nerve imaging. The presence of the surgeon during the USWL is very important, especially in early cases. The second case had a prior anterior hip surgery. The nerve was lacking the typical fascicular pattern seen on US because of scar tissue; in addition, the fascia lata was scored longitudinally, mimicking the nerve trajectory. In both cases, the skin was undermined and the correct LFCN was found. Should we have not found the nerve, we would have called for intraoperative US. In Carai's series, in the 8.8% of cases in which the nerve was not found, the procedure was aborted.[3] This should not be allowed to happen now that US is available in most institutions. In 1 of our cases, the wire pulled out; this underscores the importance of getting accurate measurements during USWL. These measurements were used to mark the incision before the wire pulled out. The skin-to-nerve time was still 3 min. We think that the wire segment inside the body was too short, which created a strong lever arm outside the skin that facilitated displacing the wire during the skin prep. It is preferable that the surgeon preps the skin and wire himself before the operation. At times, the LFCN is very superficial in location to the skin surface, which may increase the risk of wire dislodgement. Marking the nerve trajectory on the skin cannot substitute for placing the wire and/or taking the measurements, since more than often skin markings are erased during the prep. The wire is the most accurate and secure method; the measurements are a good back-up. There is also a cost benefit to our technique, because operating room charges can vary from $29 to $80/min.[29]

Even in the most experienced hands, USWL can help identify a variety of known anatomical variations, including duplicate nerves, early bifurcation, epifascial position, or exit through an iliac bone canal.[3] Likewise, USWL will likely increase the safety and success of revision cases, as scar tissue obscures the normal anatomical landmarks used in nonassisted exposures. This technique helps to focus the surgical approach while minimizing trauma to surrounding structures and tissues.[30] We have found USWL to be beneficial for incision planning, time to identify the nerve, and efficiency of dissection, all of which ensure a safe and successful surgery. Alternatively, USWL or simply US imaging could potentially be performed intraoperatively, but this requires matching the timing between the surgeon and the radiologist, which can be challenging and consumes intraoperative time, which is costlier. Some surgeons have experience performing and interpreting their own US, but this consumes operative time, and the machines in the operating room are usually not as good as the ones in the radiology department.

CONCLUSION

USWL keeps the operative time needed to find the LFCN at a minimum and also identifies anatomical variations such as duplicate nerves. USWL does not substitute for the knowledge of the anatomy but complements it. The technique is applicable to other nerves. We have used it for the ilioinguinal nerve, superficial peroneal nerve, saphenous nerve, piriformis muscle, small neuromas, small nerve sheath tumors, and foreign bodies.

Disclosures

Dr Lee is a consultant for Echometrix. The other authors have no personal, financial, or institutional interst in any of the drugs, materials, or devices described in this article. Dr Hanna received research support from the NIH, RSNA, and SSI; Mark E. Ehlers receives royalties from Elsevier.

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COMMENT

The authors present their experience with preoperative US-guided needle localization for facilitation of intraoperative identification of the LFCN. The series is original and adds to the growing body of literature describing the use of US in peripheral nerve surgery. It is well written and has useful information about US/intraoperative localization of the LFCN as well as pearls and pitfalls with the needle localization technique itself.

The paper suffers from the lack of a control group. The shortened nerve identification time could be explained at least in part by increased surgeon experience. The decrease in nerve identification time is offset by the time spent in the US suite. The authors point out that the surgeon's presence at the time of the US is important, especially with the initial cases. Therefore, this technique does not save patient or surgeon time but does save costly operating room time, as the authors note.

Theoretically, preoperative needle localization could prevent situations in which the nerve cannot be localized and the procedure has to be aborted. There were 2 cases of misidentification (11%). Interestingly, it was in the 2 situations in which the surgeon would be most interested in using the technique: (1) inexperience and (2) prior surgery in the area with scarring. In the first incorrectly localized case, the needle was placed around a branch of the femoral nerve. The potential for nerve injury in that situation is obvious. There was an additional case of needle pullout, but with preoperative US localization of the marked incision, the nerve identification was not difficult. In this small series, the rate of procedure error was higher than the reported rate (8.8%, per the authors) of aborted procedures due to an inability to locate the nerve intraoperatively. As the authors point out, intraoperative US is another option that could be used selectively in those difficult cases.

In summary, this is a nice addition to the literature of US and peripheral nerve surgery. With growing experience, the accuracy and utility of US-assisted surgery will continue to expand in the coming years.

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